



Extinct Isotopes and the Age of the Earth

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Abstract

Twenty-four extinct isotopes are presented for consideration from the recent creation worldview. These are radioactive isotopes which have decayed to abundances below the threshold of detection, leaving measurable daughter products in the process. The isotopes have half-lives ranging from 100,000 to 100 million years, measured at today's decay rates. They are used in current naturalistic debates over solar system origin theories, with little resolution of the problems. Three possible creationist explanations for the evidence of missing isotopes are discussed: basic errors in our understanding of nuclear physics; an original, mature creation of the extinct isotope daughter products; and accelerated nuclear decay in the past. There is an expectation of evidence in nature for this latter explanation.

Keywords

Accelerated nuclear decay, Extinct isotopes, Half-life, Isotopes, Radioactivity, Supernova

Introduction

There are 92 natural elements listed in the periodic table, and about 30 man-made, short-lived elements. Each of these chemical elements is found to occur in additional sub-varieties called isotopes that differ in the number of neutrons within their nuclei. For example, there are three isotopes of carbon, ^{12}C , ^{13}C , and ^{14}C , that hold 6, 7, and 8 neutrons respectively. Many isotopes appear to be stable, including the ^{12}C and ^{13}C varieties of carbon. In contrast, other isotopes, such as ^{14}C , are unstable, or radioactive. The hundreds of radioactive isotopes have a great range of half-lives ranging from mere nanoseconds to billions of years. Some of the short-lived isotopes can be produced in the laboratory. Others are generated continuously by the radioactive decay of longer-lived isotopes, or, as in the case of ^{14}C , made by nuclear reactions in nature.

The topic of this paper is a particular group of “missing isotopes.” They also are called fossil, missing, primitive, or extinct isotopes that presumably existed in the past, but are now absent. That is, their current abundances have fallen below the ability to detect them. How do we know that they were once present? The main evidence consists of excessive amounts of stable daughter isotopes, found chiefly in meteorites. These daughters presumably result from the decay of earlier parent isotopes that are no longer present in nature. Some researchers broadly state that every element in the periodic table has a history of multiple, earlier isotopes that are now extinct (Wiens, 2002). However, the standard definition of an extinct isotope requires that its past radioactive

decay produced measurable, unambiguous daughter products (Kohman, 1961). Over 20 extinct isotopes have been identified in recent decades. Several articles review the status of extinct isotopes (Brown, 2007; Faure, 1986; Gopalan, 2005; Kohman, 1954; MacPherson, Simon, Davis, Grossman, & Krot, 2005).

The extinct isotopes generally have half-lives in the range of 10^5 – 10^7 years (Figure 1). They give evidence of having completely decayed away, apparently having passed through 10–20 half-lives. In fact, radioactive isotopes with half-lives less than about 80 million years are not found in nature, except for the examples which are continuously generated, such as ^{14}C (Dalrymple, 1991). As an analogy for the extinct isotopes, suppose one enters a room and finds an assortment of hourglasses, all completely run down with sand resting in the bottom half of the glass.

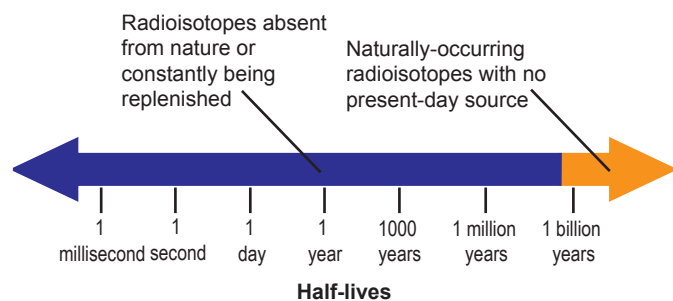


Figure 1. Illustration of the absence in nature of isotopes with a half-life less than about 80 million years. Note that the horizontal time line is logarithmic (adapted from Wiens, 2004).

Assuming the hour glasses initially were active with falling sand, the obvious assumption is that sufficient time has passed for them to empty.

Extinct isotopes previously have been recognized as a challenge to young earth creation (Dalrymple, 1991; Dean, 2003; Wiens, 2002). This challenge awaits a response. A credible interpretation of extinct isotopes is needed in the worldview of a recent supernatural creation.

Research History of Extinct Isotopes

Joly (1923) first reported physical evidence for extinct isotopes. Within certain rock minerals, he found microscopic pleochroic halos, or radiohalos, that did not have known parent isotope sources. Creation scientist Robert Gentry (1986) continued these studies, and pleochroic halo anomalies still exist with unknown parent isotopes. In most cases, however, the finding of particular daughter products is the evidence offered for extinct radioactive isotopes. Such data was first reported in 1960 when the isotope xenon-129 was found in the Richardton meteorite (Reynolds, 1960). "Primitive" chondritic meteorites are thought to most nearly represent the original accretion components of the solar system. Richardton, the stony chondrite variety, was observed to fall in North Dakota in 1918. About 100kg of the space rock were recovered. The internal ^{129}Xe is a daughter isotope which forms from the decay of the parent iodine-129. No remaining ^{129}I , with its half-life of 15.9 million years, was found in the meteorite. Isotopes of short-lived parents are referenced to an appropriate stable isotope since isotope ratios can be measured to high precision. For evidence of ^{129}I , for example, one looks for an anomalously high ratio of ^{129}Xe to ^{127}Xe . In many meteorites, ^{129}Xe is as much as 30 times more abundant than expected, as compared to ^{127}Xe (Dalrymple, 1991, p.384). The excess ^{129}Xe is then interpreted as former ^{129}I and reported in the literature as the ratio of ^{129}I to ^{127}I . Recognized extinct isotopes are listed in Table 1 together with their daughter products, type of decay, stable reference isotopes, and half-lives. The table shows two entries for reference isotopes. The first is the isotope measured as a ratio to the daughter isotope, that is., ^{127}Xe to ^{129}Xe . The second reference isotope

listed is typically reported in the literature as a ratio with the extinct isotope, that is, ^{129}I to ^{127}I .

A Current Debate

There is an ongoing secular debate regarding the origin of the solar system. Some scientists believe that a large, primordial nebula of gas and dust was compressed into the sun and planets by density waves arising from a dramatic, nearby supernova event (Dickin, 1995; Zinner, 2003). Other experts reject this supernova suggestion as very unlikely. Instead, they suggest that gravity, acting alone, was sufficient to collapse the early solar system nebula (McKeegan, 2000; Shu, Shang, & Lee, 1996). Extinct isotopes have been used to support both sides of the issue of solar system origin.

The model of solar system origin with a supernova trigger is the current majority view. A supernova explosion includes the rapid collapse of the iron core of a large star. This collapse in turn causes an extremely high flux of neutrons passing outward through the star debris, reaching 10^{20-30} neutrons/cm³. In what is called the rapid "R-process," unstable neutron-rich nuclei are built up by bombardment of star debris by

Table 1. Summary of extinct isotopes. Taken from the National Nuclear Data Center, Brookhaven National Laboratory. <http://www.nndc.bnl.gov/chart/>. Retrieved May 24, 2007. The nuclear decays include the emission of an alpha particle (α), electron (β), or positron (β^+).

Atomic Number	Isotopes Parent→Daughter	Decay Mode	Stable Reference Isotopes	Half-life (Millions of years)
10	$^{10}\text{Be} \rightarrow ^{10}\text{B}$	β	^9Be , ^{11}B	1.51
13	$^{26}\text{Al} \rightarrow ^{26}\text{Mg}$	β^+	^{27}Al , ^{24}Mg	0.717
17	$^{36}\text{Cl} \rightarrow ^{36}\text{Ar}$	β	^{35}Cl , ^{38}Ar	0.301
20	$^{41}\text{Ca} \rightarrow ^{41}\text{K}$	ϵ	^{40}Ca , ^{39}K	0.102
25	$^{53}\text{Mn} \rightarrow ^{53}\text{Cr}$	ϵ	^{55}Mn , ^{54}Cr	3.74
26	$^{60}\text{Fe} \rightarrow ^{60}\text{Ni}$ (via ^{60}Co)	2β	^{56}Fe , ^{59}Ni	1.5
40	$^{93}\text{Zr} \rightarrow ^{93}\text{Nb}$	β	^{90}Zr	1.53
41	$^{92}\text{Nb} \rightarrow ^{92}\text{Zr}$	ϵ	^{93}Nb , ^{90}Zr	34.7
43	$^{97}\text{Tc} \rightarrow ^{97}\text{Mo}$	ϵ	^{96}Mo	4.21
"	$^{98}\text{Tc} \rightarrow ^{98}\text{Ru}$	β	^{102}Ru	4.2
46	$^{107}\text{Pd} \rightarrow ^{107}\text{Ag}$	β	^{108}Pd , ^{109}Ag	6.5
53	$^{129}\text{I} \rightarrow ^{129}\text{Xe}$	β	^{127}I , ^{129}Xe	15.7
55	$^{135}\text{Cs} \rightarrow ^{135}\text{Ba}$	β	^{133}Cs , ^{137}Ba	2.3
62	$^{146}\text{Sm} \rightarrow ^{142}\text{Nd}$	α	^{144}Sm , ^{144}Nd	103.0
64	$^{150}\text{Gd} \rightarrow ^{146}\text{Sm}$	α	^{160}Gd , ^{152}Sm	1.79
66	$^{154}\text{Dy} \rightarrow ^{150}\text{Gd}$	α	^{164}Dy , ^{158}Gd	3.0
72	$^{182}\text{Hf} \rightarrow ^{182}\text{W}$ (via ^{182}Ta)	β	^{180}Hf , ^{183}W	8.9
82	$^{205}\text{PbI} \rightarrow ^{205}\text{Tl}$	ϵ	^{204}Pb , ^{204}Tl	17.3
92	$^{236}\text{U} \rightarrow ^{232}\text{Th}$	α	^{238}U	23.42
93	$^{236}\text{Np} \rightarrow ^{232}\text{Th}$	various		0.153
"	$^{237}\text{Np} \rightarrow ^{229}\text{Th}$	$2\alpha, \beta$		2.144
94	$^{244}\text{Pu} \rightarrow$ fission fragments	α	^{238}U	80.0
"	$^{244}\text{Pu} \rightarrow ^{232}\text{Th}$	$3\alpha, \beta$	^{238}U	76.0
96	$^{247}\text{Cm} \rightarrow ^{235}\text{U}$	$3\alpha, \beta$	^{238}U	15.6

the high neutron flux (Cowan & Thielemann, 2004). The “R” stands for rapid. It is suggested that the radioactive isotopes made in such a supernova process then were mixed into the collapsing solar system cloud. For the extinct isotopes to become embedded in meteorite material before their complete decay, this model calls for solar system formation to occur within a few tens of thousands of years of the supernova collapse. In evolutionary terms, this is an extremely rapid scenario. Two particular extinct isotopes appear to support solar system origin by supernova action. First, the nickel-60 daughter of the extinct isotope iron-60 is found in meteorites, and ^{60}Fe is thought to form only during a supernova explosion event. ^{60}Fe cannot be produced by intense solar radiation alone (Zinner, 2003). Further, the aluminum-26 is detected in abundance in the plane of the Milky Way Galaxy (Gehrels, Fichtel, Fishman, Kurfess, & Schonfelder, 1993). This ^{26}Al is assumed to result from supernovae in our galaxy. The magnesium-26 daughter of the extinct isotope ^{26}Al also is commonly found in solar system meteorites. Other isotopes in Table 1 assumed to form by supernova events include ^{53}Mn , ^{129}I , ^{146}Sm , and ^{244}Pu (Zinner, p.265).

A minority of cosmologists rule out a nearby supernova event during the solar system’s origin because of its extremely low probability. Supernova events are rare in the entire galaxy, let alone in the near vicinity of the solar system (DeYoung, 2006). The injection of supernova debris into the solar system nebula is also doubtful (Meyer & Clayton, 2000, p.151). The non-supernova model for solar system formation also calls upon extinct isotopes for support, in this case, beryllium-10. Unlike the heavier elements, atoms of lithium, beryllium, and boron are not made by nuclear fusion within stars. Instead, these elements are thought to form primarily by high-energy collisions in space. It is thus suggested that the early solar nebula went through an energetic phase whereby high-energy particles were radiated outward. Interactions of this solar radiation with nearby gas and dust particles then built up the short-lived isotopes, that have now become extinct. Other isotopes in Table 1 assumed to form by a particle interactions include ^{41}Ca , ^{107}Pd , and ^{182}Hf (Zinner, 2003, p.265) The preceding discussion is not meant to support either naturalistic view for solar system origin, whether a nearby supernova trigger or spontaneous nebular collapse. Neither model fits the worldview of a recent supernatural creation. The point is that there are basic conflicts and unanswered questions in all naturalistic theories of solar system origin. Likewise, creationists need not apologize for unanswered questions in their origin models. At the same time, of course, such questions need to be addressed.

Young Earth Options

How can extinct isotopes be explained by young earth creationists? That is, how can we avoid the conclusion that hundreds of millions of years necessarily passed while these “short-lived” isotopes were slowly extinguished? Three possible approaches will be described and evaluated here. First, some might assume that the nuclear data is wrongly interpreted. That is, the so-called daughter isotopes did not actually result from the decay of parent nuclei over millions of years. However, although there are uncertainties in nuclear science, daughter isotope production is not one of them. Many parent-daughter nuclear reactions are precisely verified in the laboratory. This includes all of the nuclear decay examples listed in Table 1 (Dalrymple, 1991, p.384). Nuclear reactions are not arbitrary. Instead, they follow conservation rules involving energy, electrical charge, spin, and other nuclear parameters.

As a second possible explanation for the extinct isotopes, perhaps the daughter isotopes in meteorites and elsewhere were created much as we find them, without their resulting from the gradual decay of parent nuclei. This is a difficult explanation to either defend or refute. The extent of the maturity of the earth and cosmos at their creation is an ongoing topic of creationist discussion. In the “mature” or “fully functioning” creation view, one can speculate on the extent to which “apparent age” details were imbedded into the fabric of creation. Would it be deceptive to instantly create daughter elements which normally arise over a long time period from radioactive parent nuclei? There is no definite answer to this question, since the Creation is described as fully functioning. For all we know, created details such as isotope abundances might be essential to the integrity and stability of the universe. One can only conclude that a mature creation is consistent with biblical data.

A third and final explanation for today’s absence of extinct isotopes involves the occurrence of accelerated nuclear decay at one or more points in history. This option is suggested by the results of the multi-year RATE research program, Radioisotopes and the Age of the Earth (DeYoung, 2005; Vardiman, 2005). One RATE interpretation of various geologic data is that during the year-long flood of Noah’s day, nuclear decay was accelerated by the equivalent of hundreds of millions of years decay at today’s measured rates. This timescale equals 10–20 half-lives of most of the radioactive parent nucleus in Table 1, providing a mechanism for their complete extinction. RATE data indicates that the Genesis Flood event was a time of unprecedented rates of change in many variables including tectonics, volcanism, precipitation, erosion, sedimentary deposition, fossilization, and in addition, nuclear decay. As the RATE researchers realize,

major unanswered questions arise from the radical suggestion of worldwide and cosmological accelerated nuclear decay. How did this shortening of half-lives take place? From a theological viewpoint, why did it occur? How were tremendous amounts of heat dissipated from such an accelerated decay event? The questions await answers, along with further evidence for accelerated decay. Incidentally, meteorites generally show evidence of intense early heating and melting, which might provide clues.

Further Studies

Extinct isotopes have been used to challenge young earth creation. However, they may instead reveal details of the creation model. Little data has been collected for several of the isotopes listed in Table 1. Ongoing research results in the literature need to be monitored and interpreted. There may also be found evidence for additional extinct isotopes. Models of the complex thermal history of meteorites may help us understand their history, along with possible accelerated nuclear decay.

Conclusion

Many extinct isotopes give evidence of substantial nuclear decay in the past. The isotopes give every indication of having been depleted by passing through multiple half-lives of time. Secular cosmologists have applied this data to questions concerning solar system origin in the distant past. In contrast, creationists are challenged to explain the evidence for depleted radioactivity on a short timescale. One possible mechanism is the occurrence of one or more episodes of accelerated decay in the past. Recent RATE research gives additional lines of evidence for accelerated nuclear decay. We do not yet have a clear picture of accelerated decay, or understand its mechanisms.

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