the Earth might not have recovered. Venus and Mars are possibly examples of each of these scenarios.

Planetary scientists think that while the Earth and Venus are very similar, Venus' closer proximity to the Sun gave that planet an initial temperature higher than that of the Earth that led to a runaway greenhouse effect. As a result, today Venus has the hottest surface temperature in the solar system. Conversely, Mars is a very cold planet today, yet there is abundant evidence that, early in its history, liquid water once flowed on its surface, indicating that Mars was much warmer. Most researchers say this happened about 3.8 billion years ago. However, at that time the Sun would have been 25% fainter than today. Therefore, the early faint Sun paradox provides a very different problem for Mars: why was that planet much warmer when the Sun was at its faintest?

With the obviously disastrous results on our nearest planetary neighbours, how did the Earth avoid a similar fate? How did the Earth's atmosphere manage to evolve in such a delicate fashion? One possibility is that it just happened that way. The geological and biological processes removed greenhouse gases at exactly the same average rate to compensate for the increased solar luminosity. What would be the probability of this happening by chance?

Because the evolution of such a delicate balance is so improbable, some have suggested that the Earth's biosphere behaves as a giant single organism. This pantheistic idea, seriously proposed by scientist James Lovelock, has been dubbed the Gaia hypothesis, after the goddess of the Earth. Repelled by the teleological connotations, many scientists reject the Gaia hypothesis, opting for the appeal to chance.

Of course, another logical possibility is that the solar system is only thousands of years old. In this case, there is no paradox to explain because the Sun has not been around long enough to increase much in luminosity. Many may object that we know that the Sun is 4.6 billion years old, but that is not true. There is no direct way of measuring the age of the Sun. Our understanding of the Sun's structure does not permit a precise calculation of how bright a 'zero age' Sun should be compared with a 4.6-billion-year-old Sun. All that we can conclude is that the older Sun should be brighter than the younger Sun. The 4.6-billion-year age comes from the alleged age of meteorites, and it is assumed that the Sun is the same age. Of course creationists reject the billion-year age for meteorites as well.

So, the early faint Sun paradox is evidence that the Sun, and therefore the solar system, is young and consistent with the 6,000-year age of the solar system as recorded by Biblical chronology.

References

1. Faulkner, D.R., The young faint Sun paradox and the age of the solar system, *Impact* (ICR) **300**, 1980.
2. Lenton, T.M., Gaia and natural selection, *Nature* **394(**6692):439–447, 1998.
3. Sagan, C. and Chyba, C., The early faint Sun paradox: organic shielding of ultraviolet-labile greenhouse gases, *Science* **276**(5316):1217–1221, 1997.
4. Sagan and Chyba, Ref. 3 and references 13, 14, 17, 18, and 19 cited therein.
5. Oard, M.J., *An Ice Age Caused by the Genesis Flood,* Institute for Creation Research, El Cajon, CA, 1990.

Billion-fold acceleration of radioactivity demonstrated in laboratory

John Woodmorappe

Owing to the significance of its information, this article was pre-posted on the AiG website (http://www.answersingenesis.org/docs2001/0321acc_beta_decay.asp), on 21 March, 2001. It is reprinted here with a few statements of additional information. Since its appearance on the AiG website, this article has been widely quoted and relied upon, in word and in print, sometimes without proper attribution to its source.

Our understanding of ostensibly long-lived radioactive 'clocks', in the light of the Creationist-Diluvialist paradigm, must necessarily consider both geologic and physical factors. Among the latter are decay-rate changes, and these may include a variety of superimposed processes occurring at the same or at different times in the several-thousand year history of the universe.

Up to now, creationist research has summarized evidences of small decay-rate changes, as well as theoretical analyses suggestive of the possibility of more extreme changes in radioactive decay rates (the latter usually dependent upon corresponding changes in fundamental physical constants).[1]

Here I report the experimental demonstration of radioactive decay-rate acceleration by an astonishing nine orders of magnitude. It requires special conditions but, in and of itself, no alteration of known physical constants.

This acceleration can occur under beta (negatron) decay. During β decay itself, a neutron changes into a proton, electron and electron-antineutrino, and the electron is expelled as a negative beta particle (β^-—often written without the negative sign, but sometimes it is necessary to distinguish it from

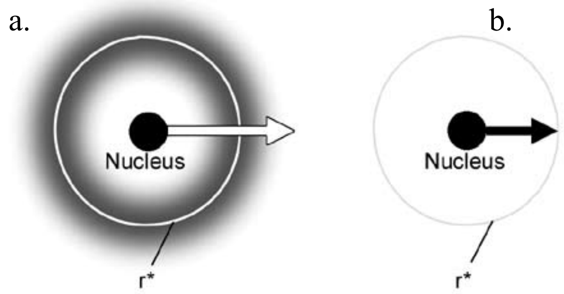

Figure 1. *(a) Atom showing the 1s electron orbital. The orbital is full. (b) The same atom in a completely ionised state. The atom has been stripped of its electrons. The energy required to escape an atom when the electron shell is filled (a) is greater than the energy required for the electron to jump to a vacant spot in an electron shell (b). r* is the distance from nucleus where finding an electron is most probable. For a 1s orbital* $r^*=a_o/Z$ *where* a_o*=Bohr radius ≈ 52.9pm; Z=atomic number.*

the rarer positive beta or positron decay β^+). Because the protons in the nucleus and the β particles have opposite charges, they attract each other, and the β^- must therefore acquire sufficient kinetic energy to overcome this attraction in order to escape the nucleus. This has been likened to a particle having sufficient energy to crash through the walls of a well.[2] In some β^- emitters, the successful escape of a β-particle into the continuum is a relatively infrequent occurrence—hence the inferred long half-life of the nuclide.

Accelerated β decay

The foregoing discussion assumes that electrons surround the nucleus, which of course is nearly always the case. For over 50 years, however, some theoreticians had suggested that negatron decay could be altered in the case of a nucleus bereft of its electrons (as occurs in a plasma state). Perhaps the β-particle attempting to leave a bare nucleus would have to overcome a much lower threshold of kinetic energy than if the electrons were present. In this case the fleeing β^- particle could take refuge in a vacant electron orbital around the nucleus instead of attempting to escape all the way into the continuum. This process is called *bound-state* β^- *decay* (or β_b decay). Subsequently, theoretical analyses[3] suggested that a significant perturbation of radioactive decay rates could occur in the nuclides of 25 different elements as a consequence of β_b decay.

Experimental demonstration of the actual existence of β_b decay, however, did not occur until the 1990s. ^{163}Dy, a stable nuclide under normal-Earth conditions, was found to decay to ^{163}Ho, with a half-life of 47 days, under the bare-nucleus conditions of the completely ionized state.[4] More recently, β_b decay has been experimentally demonstrated in the rhenium-osmium (^{187}Re-^{187}Os) system. (The Re-Os method is one of the isotopic 'clocks' used by uniformitarian geologists[5] to supposedly date rocks.) The experiment involved the circulation of fully-ionized ^{187}Re in a storage ring. The ^{187}Re ions were found to decay to a measurable extent in only several hours, amounting to a half-life of only 33 years.[6] This represents a staggering billion-fold increase over the conventional half-life, which is 42 Ga! (Ga = giga-annum = a billion (10^9) years).

A Creation Week scenario

Now, let us visualize the following situation at the beginning of Creation Week. As God creates the atoms, which will subsequently be assembled into all of the matter that will constitute all of the objects in the physical universe, He first creates them all in a completely ionized state (i.e. nuclei alone). This plasma persists for several hours on the First Day, during which time b_b decay freely takes place under the bare-nucleus conditions of all of the atoms. This process, though, is insufficient by itself to generate billions of years' worth of excess ^{187}Os.[7] However, if there were a simultaneous weakening of the presently-existing nuclear force, as suggested by Humphreys,[8] the Re-Os 'clock' would be accelerated another few orders of magnitude. Not only the Re-Os 'clock' but probably many other radioactive (and even stable) nuclides would experience appreciable amounts of β_b decay under the bare-nucleus conditions of the plasma. We note that the potential or actual β_b decay gives a large 'head start' to extreme accelerations of radioactive decay. Thus, the postulated weakening of the nuclear force[7] may need to be far less drastic than originally supposed (when assumed to be acting upon non-ionized atoms) to generate billions of years' worth of decay products in several hours.

It turns out that β_b decay is not the only mechanism by which some ostensibly long-age 'clocks' can experience major accelerations in radioactive decay rate. Consider the lutetium-hafnium (^{176}Lu-^{176}Hf) system, which is relatively new, and which is infrequently used by uniformitarian geologists to supposedly date rocks.[9] At very high temperatures, part of the ^{176}Lu decay to ^{176}Hf bypasses the conventional slow route, and goes into an isomeric state, which has a half-life of only 3.68 hours.[10] In other words, part of the ^{176}Lu decay experiences an alternative decay mode to ^{176}Hf, which represents, in effect, a shortcut that is 14 orders of magnitude faster than the conventional ^{176}Lu decay (half-life = 41 Ga). Moreover, in this particular instance, no changes in the nuclear force are necessary. Extreme temperatures suffice, and the greater they are, the shorter the effective half life of ^{176}Lu decay to ^{176}Hf. In terms of specifics, at temperatures below about 200 million K, the half-life remains unperturbed at 41 billion years. But, over the interval of 200 to 300 million K, the effective half-life drops precipitously (by nearly ten orders of magnitude), and then begins to level off asymptotically at still higher temperatures. Thus, at 600 million K, the effective half life of ^{176}Lu is only about 8 days![11] This is sufficiently short that if, as discussed earlier, all of the atoms in the universe had been created in a very hot state—which just means very high kinetic energies— (and maintained that way for several hours on the First Day) all of the excess ^{176}Hf found in the entire universe would have been generated within that short period of time.

The rapidly-accumulated products of the accelerated radioactive decay subsequently became part of every object in the created universe, albeit at differing concentrations. During the remainder of the Creation Week, as God cooled and organized the plasma into solid celestial objects, such as planets, the excess radiogenic isotopes became partitioned into the relevant mineral phases, perhaps according to accelerated geochemical processes. The modern uniformitarian geologist misreads this deployment of the radiogenic isotopes as isochrons indicative of up to billions of years to time. This span of time never happened.

This exciting demonstration that isotopic 'clocks' can be accelerated at least a billion-fold is good news to creationist scholars. It raises fundamental questions about the temporal stability of isotopic 'clocks'. What *else* have we failed to consider in terms of the physics of radioactive decay? The myth of the virtual invincibility of radioactive decay to external forces has been decisively shattered, and the door to further research has now swung wide open.

References

1. Chaffin, E.F., Theoretical mechanism of accelerated radioactive decay; in: Vardiman *et al.*, *Radioisotopes and the Age of the Earth*, Institute for Creation Research, El Cajon, California and Creation Research Society, Missouri, 305–331, 2000.
2. Alpha (α) decay has also been likened to particles bouncing around inside a well (a potential energy well created by a combination of the nucleus's positive charge and the 'strong' nuclear force) until some of them acquire sufficient kinetic energy to jump through one of its walls: Humphreys, D.R., Accelerated nuclear decay: a viable hypothesis? in: Vardiman *et al.*, Ref. 1, pp. 333–379. This is the standard Gamow theory, and is often referred to as *quantum mechanical tunneling*. In α-decay, the electrons are largely irrelevant. Humphreys suggests, based on an application of the standard theory, that a small diminishing of the nuclear potential, however, has allowed α-decay to be accelerated a billion-fold or more.
3. Takahashi, K. *et al.,* Bound-state beta decay of highly ionized atoms, *Physical Review* **C36**(4):1522–1527, 1987.
4. Jung, M. *et al.,* First observation of bound-state β^- decay, *Physical Review Letters* **69**(15):2164–2167, 1992.
5. Woodmorappe, J., *The Mythology of Modern Dating Methods*, Institute for Creation Research, El Cajon, California, 1999. See pages 25, 49, 67–68 for the many fallacies of the Re-Os dating method.
6. Bosch, F. *et al.*, Observation of bound-state β^- decay of fully ionized ^{187}Re, *Physical Review Letters* **77**(26):5190–5193, 1996. For further discussion of this experiment, see: Kienle, P., Beta-decay experiments and astrophysical implications; in: Prantzos, N. and Harissopulus, S., *Proceedings, Nuclei in the Cosmos*, pp. 181–186, 1999.
7. Note that bound-state β_b decay accelerates the Re-Os 'clock' by 9 orders of magnitude. However, in order to compress 4.5 Ga worth of 'normal' radioactive decay into the several hours of the First Day of Creation Week, the Re-Os 'clock' would need to be accelerated by another 5 orders of magnitude.
There has been some concern expressed that radioactive decay would be inconsistent with God creating the universe 'very good'. There is always the danger of reading too much into the 'very good' statement, and the context indicates that 'very good' refers to the absence of suffering and death for man and other sentient creatures prior to the Fall. Radioactive decay does not, of course, have anything in common with the death and decay of sentient beings. Moreover, radioactive decay involves the transformation of one nuclide into another, and does not have any connotation of imperfection in the Creation.
8. Humphreys, Ref. 2, p. 362.
9. For a discussion of some of the flaws already evident in the new Lu-Hf dating method, see Woodmorappe, Ref. 5, p. 68.
10. Kappeler, F., Beer, H. and Wisshak, K., S-process nucleosynthesis—nuclear physics and the classical model, *Reports on Progress in Physics* **52**:1006–1008, 1989.
11. Klay, N., *et al.*, Nuclear structure of ^{176}Lu and its astrophysical consequences, *Physical Review* **C44**(6):2847–2848, 1991.

End-Mesozoic extinction of dinosaurs partly based on circular reasoning

Michael J. Oard

Creationists are well aware that rocks are often dated by the fossils they contain. The evolutionists also tell us it is a hard 'fact' that dinosaurs became extinct at the end of the Mesozoic. This has given vent to many dinosaur extinction hypotheses, including catastrophic events such as the popular meteorite extinction hypothesis.[1] After the dinosaurs disappeared from the scene with a blast, the large mammals took advantage and evolved into the unoccupied niche. So goes the story.

A recent article reveals how evolutionists arrive at their nice clean scenario using circular reasoning.[2] In China and Peru, tracks were found that were assumed to be made by dinosaurs. The date assigned to the strata was, of course, Mesozoic, namely Cretaceous. The tracks in Peru looked like they belonged to tiny hadrosaurs. However, a reanalysis of the tracks has strongly suggested that the tracks were made by mammals, but not the tiny mammals assumed to have lived in the Cretaceous. This was based on comparing similar mammal tracks from the United States and Europe that are 'well dated' as early Tertiary, namely Eocene. Guess the new age assigned to the Chinese and Peruvian track strata? It is *early Tertiary*, since the tracks are considered the most reliable age indicator in the strata. Of course, we now are told that the previous age assignments were poorly constrained.

The use of tracks to correlate strata across the world is not foolproof. The article claims that some mammal tracks, some dinosaur tracks, and certain bird tracks are similar, which is due to the obscure mechanism of *convergence*, whereby similar environments produce similar biological structures. Convergence or parallel evolution has never made any sense