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C1020 – June 2, 2010 -- Helium Diffusion In Zircons

You know, there's some new attempt to get around the straightforward reading of Genesis each week. Now we've got a group called BioLogos founded by Dr Francis Collins. Collins was appointed by President Obama to be director of the National Institute of Health. Collins is famous for his oversight of the Human Genome Project. He's a professing believer and he coined the term BioLogos to "define the conclusions he reached about how life, or *bios*, came about through God's word, or *logos*. DNA, therefore, may be considered God's language."ⁱ So for Collins, when it says Jesus Christ is the logos that means Jesus Christ is DNA. Here's what they believe. Listen closely, "We believe that the Bible is the inspired Word of God. We also believe that evolution, properly understood, best describes God's work of creation."ⁱⁱ So it's another accommodation strategy. The language of Genesis is not the language of evolution. Anyone who can't see this either does not understand Genesis or evolution. And now Bruce Waltke is a part of this very influential group. Waltke has been all over the board. I said in the 1960's he got into his ruin-reconstruction thing, now he's into the BioLogos thing. Alright, we could go on with accommodation attempts but we're moving on.

Last week we looked at the question, "How should Genesis be read? How should the early chapters of Genesis be interpreted?" And to answer that question we turned to the NT to see how Jesus and the apostles understood Genesis. We said, after 2000 years of trying to understand Genesis maybe Jesus and the apostles give us some controls for how to interpret. What we found was that they understood it quite literally. They thought that Gen 1 and 2 were a single account of creation without contradictions. They thought that God created

different kinds. They thought Adam and Eve and Satan and Cain and Abel were real people. They built the doctrine of marriage and the doctrine of the woman's role in the church out of Genesis, so this isn't just theoretical, this is practical. They also held to a global flood of Noah and a literal ark when God judged the entire planet. So if Jesus and the apostles didn't have a problem with Genesis, why are we having problems with Genesis? Something is coming from outside of the Scriptures and bending our interpretation. But if we claim to be followers of Jesus shouldn't we follow Jesus' interpretation of Genesis? If Jesus tells us earthly things and we can't believe Him, how are we ever going to believe Him when He tells us spiritual things? How are you going to tell children that Jesus has saved you from your sins when finally it all comes down to whether we're going to let the word of God interpret the world around us or the world around us interpret the word of God.

This week I want to close this discussion by listening to 5 minutes of Dr Steven Boyd. Dr Boyd is at the Master's Seminary in California, he's a specialist in biblical Hebrew, Semitic Languages and Old Testament Studies. His interest was in studying the linguistic characteristics of Gen 1:1-2:3 and comparing that with poetic and narrative texts in the rest of the Hebrew Bible and concluding whether Gen 1:1-2:3 was indeed poetry or narrative. It's a technical statistical study so I wanted you to hear him summarize his work.

B. Scientific Age of the Earth

Alright, today we want to get into some of the science, particularly the area of radioisotope dating. Most people have heard radioisotope dating but most people don't know what it is. All we know is that when National Geographic or CNN or an evangelical theologian says this rock has been dated to 3.85 billion years that is like playing the Ace of Spades, suddenly we're dealing with an incontrovertible truth. Radioisotope dating has become the icon of evolution and so that's why we're addressing it. We're told that radioisotope dating has established the absolute age of the earth to be 4.5 billion years old. The Bible says the age of the earth is 6,000 years old. That's quite a difference. So we want to at least understand, on an elementary level, what radioisotope dating is, what assumptions are involved and the kind of science it is.

It's important to understand what science is and the limitations of science. Then we'll turn to recent discoveries of radioisotope dating and how these discoveries have cast doubt on the validity of radioisotope dating.

1. What is Science?

Let's start with a definition of science. We live in a scientific age. Science rose in the west, in Europe, it grew out of a definite life and world view that came from the Bible. It grew out of the Protestant Reformation. Science could never have gotten started apart from a Christian base. And to show this we want to quote from two pagan philosophers. Many of you were around in the 1960's when J. Robert Oppenheimer was popular. Oppenheimer was a Harvard Graduate, an American theoretical physicist and director of the Manhattan Project that resulted in the first nuclear weapons. He said, "Christianity was needed to give birth to modern science."ⁱⁱⁱ Here's another quote, this one from Alfred North Whitehead. Whitehead was a famous mathematician and philosopher. He worked with Bertrand Russell in the early 1900's. He said Christianity is the mother of science because of "the medieval insistence on the rationality of God..."^{iv} Without this belief the incredible labors of scientists would be without hope." Now why are they saying this? Why must Christianity be the base for science? Because science could never get off the ground apart from it. On the pagan base there is no rational God, no orderer of the universe and therefore no reason to expect to find a rational, ordered universe. Christianity gives a base because a rational God is there and therefore we would expect to find rationality in the universe. It's important to remember this because today we live in a post-Kantian climate where science is pitted against faith, the secular against the sacred and yet the beginnings of science stemmed from those of faith. Science could never have gotten started simply by a secular life and worldview. So that's the origins of modern science. It grew out of Christianity. Yet somewhere along the way it strangely boomeranged back and now science is attacking its mother, Christianity. Try that point out when someone tries to attack the Bible from science.

Now to a definition of science. It may not be the best definition of science but it is a modern one. Science is a limited way of knowing the material world. Let's break that down. Science is a way of knowing, it's an epistemology, and the way of knowing is something called the scientific method. We want to look at the scientific method a moment because that's the main tool or method they use to know things, we're told. Another thing that's admitted in the definition is science is limited. Science is limited to its sphere of interest, to its sphere of exploration. What does science limit itself to? The material world. So they're not dealing with things like angels, spirits, etc...those are the immaterial things. They'll talk about the soul but not in the way you think, they think of the soul as a material entity.^v It doesn't matter what the scientist thinks about the immaterial world, he may or may not think the immaterial world exists. But when it comes to science, it is exclusively limited to the material world.

Now you may think that science has come to know almost everything about the material world. That's the sense you get from the media and popular magazines. But I want to quote several remarks made by Richard Feynman. How many of you have heard of Richard Feynman? Feynman was a physicist. Paul Davies says there have been three major icons in the realm of physics. Sir Isaac Newton, Albert Einstein and Richard Feynman. "Richard Feynman has become an icon for late twentieth-century physics." So that's why I'm quoting Feynman. He is the elite of the elite in the physics world. He says, "...we do not yet know all the basic laws [of physics]: there is an expanding frontier of ignorance." "We do not know how the universe got started, and we have never made experiments which check our ideas of space and time accurately." "It is important to realize that in physics today, we have no knowledge of particles inside the nucleus, and we have formulas for that, but we do not have the fundamental laws. We know that it is not electrical, not gravitational, and not purely chemical, but we do not know what it is." "We do not understand the conservation of energy." "We do not know the patterns of motions that there should be inside the earth." Now I just show you that there are other "we do not knows," many other "we do not knows." So don't think science has figured everything out. What is projected on the popular level is that this is solved. But in reality one question solved generates 100 new questions.

As Feynman said: there is an expanding frontier of ignorance. This cuts down to size the popular claims about science.

2. The Scientific Method

Now, let's look at the method science uses to know things about the material world. This is called the scientific method. And it's very important you understand the limitations of the scientific method. 1) it must be observable, if you can't observe it it's not open to investigation. 2) testable, if you can't set up an experiment to falsify it then it fails this criteria. And 3) it's repeatable, it has to be duplicatable in any experimental laboratory in the world. This is hard, empirical science or what I call observational science (aka operational science, Popperian science after Karl Popper).

Now looking at those three criteria lets just think of the theory of evolution: Macroevolution, that all cellular organisms stem from a single cell millions of years ago. Think about that and ask yourself, is that researchable by the scientific method? Can I observe that? Test that? Repeat that? On the question Karl Popper famously stated, "I have changed my mind about the testability and logical status of the theory of natural selection; and I am glad to have an opportunity to make a recantation." "Darwinism is not a testable scientific theory, but a metaphysical research program."^{vi} That is, evolution is just a larger life and world view, a philosophy of life. He did not think it was hard-empirical science, or what we'll call laboratory or operational science. Evolution is soft science, or what is sometimes called historical science.

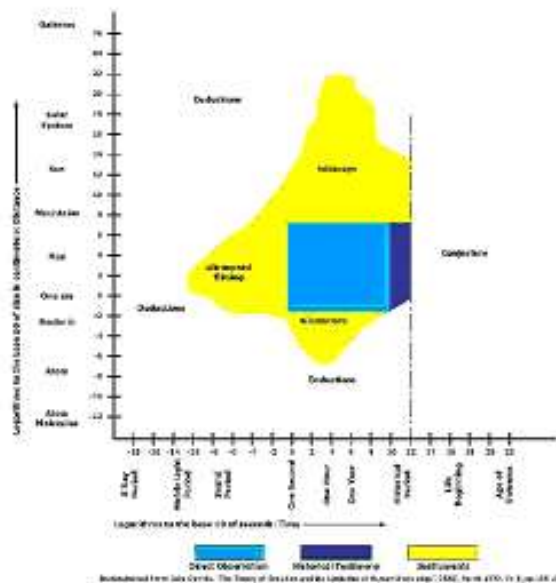
3. Two Kinds of Science

So let's think, I've brought up two kinds of science, hard and soft, observable and historical. There are others but for our interests those are two categories of science we want to grab a hold of. When you watch TV or read magazines this distinction is not made and so they project the same level of certainty regarding soft, historical science as they do hard, observational science. So, on one side we have hard science, that's what's done in the laboratory, it's observable, it's testable, it's repeatable, it can be investigated according to the scientific method, it's

interested in present tense questions. Soft science deals with questions of history, how to write a natural history, it's deductive, it is not testable, repeatable or observable, they are past tense questions.

a. Hard Science (Observable)

Let's look at hard science. Hard science is what we can observe in the present, test in the present and repeat in the present. Therefore operational science can only tell us about the present. It cannot tell us about the past. Some of you have seen this diagram.



Notice the light-blue shaded area, the rectangular box in the center. We're going to call that direct experience, what we can directly observe, where we can set up experiments and run tests and record the results. Look at the horizontal axis where it says "One Second" and move over to the "Historical Period". That's the only zone where humans have direct observation. Anyone want to argue with that? It has to be locked inside those bounds; you can't get any direct observations outside of that period. Now look at the vertical axis; at the bottom we see "One Centimeter" direct observations go a little bit below one centimeter, up to, say, the scale of "Mountains." That's direct observation. Now, just outside the blue box we have the yellow areas. These are extensions of our direct observations by using advanced tools. You can extend your observations up with the telescope, you can see vast distances into space, see other galaxies, you can extend the observations to the left with high speed digital photography, you can freeze high speed things

like bullets going through armor and it's amazing to see what happens in milliseconds. You can extend your observations down with the microscope; you can use the Scanning Electron Microscope and see cellular detail, the bacterial flagellum, nuclear pores, amazing complexity. But observe the right side of that diagram. Apart from the short historical period and observations recorded in history, beyond that, there's no way to go to the right. Just notice that. There's not a scientific tool known to man that goes to the right side of that diagram, and that's the problem we have whenever we go to construct a natural history, a history of the universe, a history of the earth. We are limited to our direct experience, to extensions of our experience by instrumentation and to historical documents. But we can't go to the right of that line. We would have to build a time machine to go back there and retrieve the data.

Now observe something else. Suppose the blue square that I've drawn is all of your knowledge at a given time, let's say its 7:15pm, today, June 2, 2010, and that's all your knowledge; you're on the knife edge of time and that blue box represents your data set. At 7:20, five minutes from now you'll add a little bit more data to that. Five minutes from now, 7:25, you add more data. At the knife edge of time as the clock ticks, what's happening to your data set as far as observation? It's enlarging. So we have this dilemma, how do you know in advance that the next piece of data, the newest piece of data, won't totally invalidate everything else you've ever known? Historically this is what led philosophers into skepticism, David Hume and later John Dewey. Because if you admit that you can never have all the data, then you have to admit that all your conclusions are merely tentative. ALL of your conclusions are merely tentative, subject to change when the next piece of data comes in. Do you really think that? Do you really know what you think you know? What if there's another piece of data out there that you haven't come into contact with yet that overturns everything you think you know? What this does is it totally destroys any hope of having knowledge, period. In order to have knowledge of anything I can't have this. So what do I have to do if I'm a non-Christian person? What do I do to save myself in my thought life? What I have to do is I have to have something that is constant. Right? I've got to assume something is constant. If I have constants then I feel more

certain. But where do I get my constants from? Think about it for a minute. They can't come from experience, because experience only tells me what is right now, it doesn't tell me what the next piece of data is going to be, it doesn't tell me what it was before historical records, so I can't be sure if what I observe right now is constant. What paganism has to do is force the constant to be located down in natural law, down in the creation. That's what's wrong in physics, in biology, in chemistry, because they insist on doing this, and if you think about it, this dogma that we have these constants that are inviolable, we don't really know that do we? What is it? A guess, it's sheer conjecture. And it's sheer arrogance to claim that we know these are constants on the basis of a finite set of data.

b. Soft Science (Historical)

So question - applying what we've learned here - is evolution in its macro-sense, (macroevolution means that all of life has arisen from a single cell). a question that can be answered by hard science? Evolution from a single cell is far beyond the observation of any human being. So macroevolution is a past tense phenomenon.^{vii} No one has ever observed a single instance of macroevolution. So evolution is not hard science. Evolution is soft science. And soft science involves a number of highly questionable assumptions. We just covered a very serious one. Natural laws are constant. You don't know that. How could anyone know that? What would someone have to know to know that? Everything. They'd have to have universal experience. They're blue box would have to cover all of space and time. Whose blue box does that? God's. God knows. Who has spoken to us and given us the true history of the universe? God has. And He says in 2 Peter don't buy into the constancy of so-called natural law. He warns us against that. If you do buy into it you end up wiping out all the miraculous, intervening works of God in history.

2. Radioisotope Dating

a. What kind of science is it?

Now take the question of radioisotope dating, the icon of evolution. How long has radioisotope dating been around? Since around 1900. So we've got 100 years of experience with radioisotope dating. The blue box for radioisotope data covers 100 years. And we're told that radioactivity gives the history of life an "absolute calendar of the earth." That claim isn't my imagination, it is commonly claimed to give us an absolute calendar. This is like the holy grail of modern geology and evolution and that's why we're questioning it. We're told that radioisotope decay rates are constant through space and time. What kind of claim is that? It's an unobserved claim, it's an untestable claim, it's not hard science, it's soft science, they don't really know that, they're guessing so they can construct a natural history of the earth.

So radioisotope dating is taking the present data and extrapolating back in time to give an absolute age. We go out and we measure present decay rates, not a problem. Then we extrapolate backwards, that might be a problem. This is crucial to understand because the public has been told that radioisotope dating is sure, it's absolute, that they can tell us, within minor error constraints, the age of a rock or fossil based on radioisotope dating. This is what we want to investigate.

b. What is radioisotope dating?

Radioisotope dating is not how you get a date with a girl out on a rock. If it were you'd lose half your life. Alright, what really is a radioisotope?^{viii} Radioisotopes are like a child on Caprisun, four cookies, ice cream and a piece of cake - very unstable and bouncing off the walls and everybody is happy when that child is stable and asleep. Well, radioisotopes are like that, they're elements that are unstable because they are at high energy levels but they emit energy by releasing certain particles until they become stable. That's called the decay chain. But in the radioisotope world it's the parent element that's unstable and the daughter element that is stable. Those are the names for them, the parent and the daughter. For example, C14 decays into N14. So C14 is the parent and N14 is the daughter.

Now, each radioisotope decays at a certain rate or what is called half-life (in the present.) We don't know what these rates were in the past.

But we do know what they are in the present. We actually don't know when a particular particle is going to be released, we can't predict that, so we take an average and that's what is called half-life. So if the radioisotope is C14, the half-life is 5,730 years. So at t_0 , when an organism dies, the organism has 100% C14 and 0% N14. At t_{5730} the organism would have 50% C14 and 50% N14. At t_{11460} the organism would have 25% C14 and 75% N14. At t_{17190} the organism would have 12.5% C14 and 87.5% N14 and this would go on until C14 was negligible and certainly undetectable. In the case of C14 we are limited to about 60,000 years. So C14 is worthless, people would say, for dating anything more than ~60,000 years. There are other radioisotopes and other radioisotopes have different half-lives. Some very short, in the milliseconds; others with very long, billions of years, but all are measurements taken within this blue box.

c. What are the assumptions of radioisotope dating?

There are three. I'll give you an acronym; always, always learn the assumptions because if the assumptions are wrong then the conclusions are wrong. The acronym is CIA.

1) **Constant Rate of Decay** – It is assumed that the rate of decay measured in the present has always been the rate of decay in the past. Forever and always. If that changed in the past and the decay rate was faster or slower then you're going to be wrong on the age.

2) **Initial Quantity of Daughter Atom Known** – It is assumed that the initial quantity of the daughter atom in the rock can be known. If you don't know how much daughter is there initially, let's say you're assuming there is no daughter but there was some daughter, then the age is going to be greater than reality because you're counting the daughter that was initially there as decay product when it's not.

3) **Alteration of Parent-Daughter Atoms Has Not Happened** – In other words, it's a closed system; no parent or daughter atoms from outside the rock have entered or exited the rock except by radioactive decay. If you did have parent or daughter atoms enter or exit then

those atoms can't be counted and used in the calculations and your age will be wrong again.

1. Helium Diffusion in Zircons

Now, let's test some of the assumptions. Today we just want to test the first assumption: Constant Rate of Decay. Is the rate of decay constant or is there evidence of changing rates of decay? The work I'm going to be sharing with you has all come out in the last five years. So I'm trying to stick with the most recent research. In the late 1990's a research team was put together at the Institute for Creation Research. The team was called RATE, which is an acronym for Radioisotopes and the Age of The Earth. "The main purpose of the RATE Project was to investigate radioisotopic processes and rock-dating methods to determine why the conventional model for the age of the earth is not consistent with a young-earth time frame." In other words, why is the world saying the earth is 4.6 billion years old and the Bible is saying the earth is 6,000 years old?

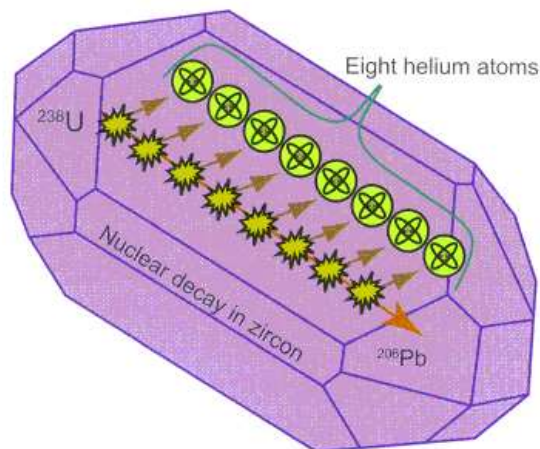
The first piece of work I'll be explaining was done by Dr D. Russell Humphreys.^{ix} Dr Humphreys received his Ph.D in physics from Louisiana State University in 1972. After which he worked for several years for GE, designing and inventing equipment and researching high-voltage phenomena. In 1979 he went to work at Sandia National Laboratories in nuclear physics, geophysics, pulsed-power research and theoretical atomic and nuclear physics. He's won several awards both secularly and in creationist circles. He's also written *Starlight and Time* for those of you interested in the issue of how you can have distant starlight in a young universe. He's now Physicist at the Institute for Creation Research. His work on the RATE project concerns helium diffusion in zircon crystals.

a. Amounts of Pb206 in the granite shows 1.5 billion years of radioactive decay have occurred

These are zircon crystals. They're microscopic, you can't see this with the naked eye.



These crystals were recovered from a borehole near Los Alamos, NM, in hot pre-Cambrian rock; these are, according to evolutionists, the oldest rocks, before life began, there are hardly any fossils in these rocks. So we extract these zircons out of the biotite. Biotite is the flecks of black mica in granite. If you've seen someone's granite countertop with these black flecks, the black flecks may be biotite and inside the biotite are these zircon crystals. And inside the zircon crystals is radioactive Uranium, ^{238}U . It is common to find radioactive ^{238}U in zircon crystals. That's why you may have heard of granite countertops in your kitchen giving off radiation and them being dangerous. It's because of the radioactive ^{238}U in the black flecks. So he's interested in the $^{238}\text{U} \rightarrow ^{206}\text{Pb}$ decay chain. ^{238}U decays to ^{206}Pb and He .^x So the parent is ^{238}U and the daughters are ^{206}Pb and He .



Nuclear decay makes He within zircons.

The half life of ^{238}U is 4.47 billion years (at present decay rates). That is, it takes 4.47 billion years for half of the ^{238}U to decay into ^{206}Pb and He . They measured the amount of ^{206}Pb in the zircon and established that 1.5 billion years of decay had occurred. And that's true, as far as we can tell. 1.5 billion years of radioactive decay has occurred. You say, well, then the granite rock must be 1.5 billion years old. That's what uniformitarian scientists concluded from this.

b. Large amounts of He⁴ in the granite shows the billions of years of decay happened not long ago

However, remember, there's another daughter element, He. He is released as an alpha particle. Eight He atoms are released into the zircon or surrounding biotite lattice during this decay chain. And the He begins to leak or diffuse out of the cell rock.

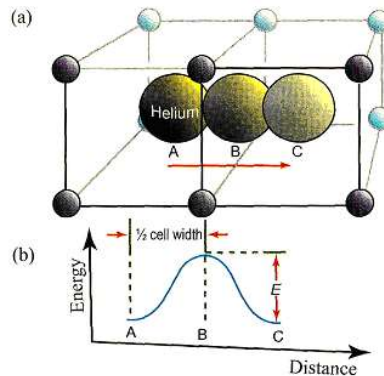


Figure 4. Helium atom moving through a crystal.

Why would it do that? Because He is what chemists call a 'slippery gas.' They use it to check for leaks in vacuum sealed lab systems. He is perfect because it escapes very easily. If you've ever had a birthday party with He balloons what happened about 2 days after the party to those balloons, they were hanging in mid-air or they were on the floor. What happened to the He? Did it just go bad? No, elements don't go bad, what happened is the He escaped through the pores in the balloon. That's why it's called a slippery gas, it doesn't like to stick around, its very light and it will find a way out. This Precambrian rock was hot and so uniformitarian scientists didn't expect to find any He in the rock. We can calculate, in the lab, rates of He escape in rocks of different temperature. This rock was hot and the hotter the rock the faster the He diffuses out of the rock because the *activation energy* needed for the He atom to move through the lattice is reached more often. So there shouldn't be any He left in the rock after 1.5 billion years. None. Absolutely none detectable. But they found large concentrations of He.^{xi} What does this mean? This means that it is true that lots of decay had taken place. But it also meant that the decay had

taken place over a shorter period of time, otherwise the He couldn't still be in the rock.

c. Conclusion is that Accelerated Decay must have occurred on one or more occasions in the past.

So we have two things here; one 1.5 billion years worth of decay evidenced by the amounts of Pb206. But at the same time lots of He which inadvertently indicates lots of decay, but the fact that it's still there in the hot granite indicates that the 1.5 billion years worth of decay didn't happen 1.5 billion years ago. So what Dr Humphrey's suggested is that 1.5 billion years of decay did take place, but at an accelerated rate. So that puts into question the first assumption, Constant Decay Rate. If Ur238 decays at a constant rate with a half life of 4.468 billion years then there should be lot of Pb but no He in the rock. Since we find lots of Pb and lots of He then the decay rate of Ur238 must have been accelerated in the past.

d. Experimental data confirm young earth creation not old earth uniformitarianism

So here's what he did. He experimentally measured the rate of He release from granite at different temperatures and he plotted that on a graph. That's the blue or purple dots, the experimental data.

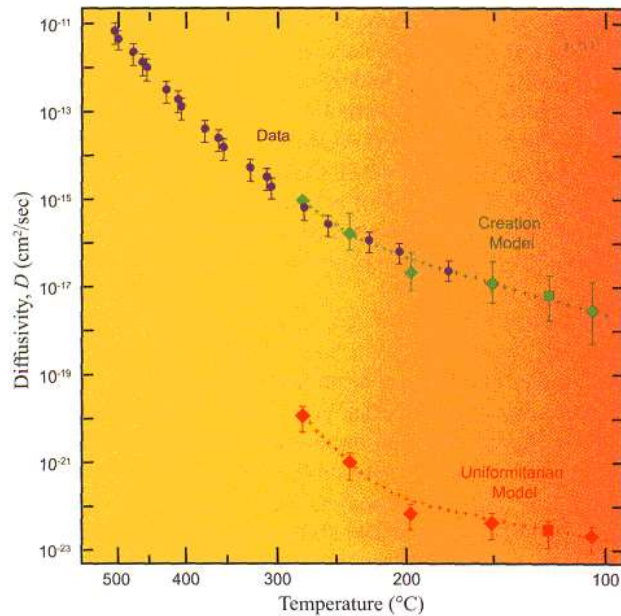


Figure 2. Comparison of diffusivity between Creation and uniformitarian models in zircon as a function of temperature. The upper dashed line shows the theoretical diffusivity needed for the Creation model of 6000 years. The lower dashed line shows the theoretical diffusivity needed for the uniformitarian model of 1.5 billion years. The red diamonds are calculated values of diffusivity using measured He concentrations and temperatures from *Gentry et al.* [1982], and the blue dots and green diamonds are from *Humphreys* [2005] for the same Jemez granodiorite.

Then he came back and he said, alright, now I know how much He is in the rock, so if the rock really is 1.5 billion years old then what must the rate of He diffusion be to have that much He remaining in the rock? So he did those calculations and that's the red dots down here, that's the uniformitarian model, this is what the model would predict as far as rate of release for He. That's really slow diffusion; the rock would have to be at liquid Nitrogen temperatures to diffuse that slowly. Nobody accepts that. Then he said, alright, the biblical model of creationism says the earth is ~6,000 years old, so if the earth is 6,000 years old and I have this much He left in the rocks then what would be the rate of He diffusion have to be? And then he plotted that on the graph, that's the green data points. Look at the correlation? We've got a 100,000 factor difference with the uniformitarian model; we've got a near perfect, well within standard deviation, correlation with the biblical model. The biblical model predicts that at present He diffusion rates the amount of He left in the rock would be the amount that we actually find in the rock with a percentage error of +/-2000 years.

So according to Humphrey's at some point in past earth history the decay of ^{238}U was accelerated. His suggestion is that during high

energy events such as the Creation and the Flood the rates were accelerated. A brilliant piece of work.

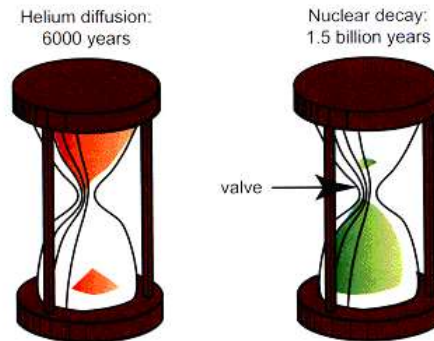


Figure 18. Two hourglasses representing two methods of dating zircons. "Valve" represents nuclear decay acceleration.

But see, an evolutionary scientist wouldn't even look for He there because it's impossible even to conceive they would find any. It would just be a waste of time. That's why I say that your presuppositions do affect how you interpret data; not only how you set up the experiment and what you might look for, but also what data you'd be interested in seeing. The guy who originally saw the high concentrations of He, Dr Robert Gentry of Oak Hills Laboratory was a creationist and he said, hey, what's He doing in there, that's not supposed to be there.

All this to say, we can handle the data. We're not afraid of the data. Our model can account for the data. By saying this we're not saying unbelievers have to buy our position and that they'll convert to Christ by hearing about helium diffusion from zircons. All we're asking is how does your evolutionary model account for helium in those zircons. See how you push, you just jab at them a little bit and make them defend their position, make them give an account for what they believe in. They're always pushing us to give an account, push back a little because what that does is it exposes unbelief for what it really is, vanity, a lot of Helium and baloney talk.

The other reason this is so powerful is because now you can tell your kids, your parents, your brother, we believe the earth is 6,000 years because God says so, and when we creationists go out and analyze the earth under the spectacles of all the high tech scientific machinery

we're solving the discrepancies. Our faith is bolstered because we see. Yes, Grand Canyon is less than 6,000 years old, and yes, every fossil on earth is less than 6,000 years old. And we're going to show this by a number of different experiments that have clarified the discrepancy.

ⁱ <http://www.biologos.org/about>

ⁱⁱ <http://www.biologos.org/about>

ⁱⁱⁱ J. Robert Oppenheimer, "On Science and Culture" *Encounter*, 19(4):3-10, 1962.

^{iv} Alfred North Whitehead, *Science and the Modern World*, (1925) pp. 3-4, 12-13

^v A more elaborate definition which includes historical aspects: "Science is the concerted human effort to understand, or to understand better, the history of the natural world and how the natural world works, with observable physical evidence as the basis of that understanding. It is done through observation of natural phenomena, and/or through experimentation that tries to simulate natural processes under controlled conditions."

<http://www.gly.uga.edu/railsback/1122science2.html#WHATISSCIENCE>

^{vi} http://en.wikipedia.org/wiki/Karl_Popper

^{vii} Can micro-evolution (an observable phenomena) be extrapolated to macro-evolution (an unobserved idea)? "The central question of the Chicago conference was whether the mechanisms underlying microevolution can be extrapolated to explain the phenomena of macroevolution. At the risk of doing violence to the positions of some of the people at the meeting, the answer can be given as a clear, No." Roger Lewin, "Evolution Theory under Fire," *Science*, Vol.210, 21 November 1980, p. 883. Macroevolution requires a vertical change in the complexity of certain traits and organs. Microevolution involves only horizontal (or even downward) changes—no increasing complexity. "One could argue...that such 'minor' changes, extrapolated over millions of years, could result in macroevolutionary change. But the observational evidence will not support this argument..." Michael Thomas, "Stasis Considered," *Origins Research*, Vol. 12, Fall/Winter 1989, p. 11.

^{viii} Naturally occurring radionuclides fall into three categories: primordial radionuclides, secondary radionuclides and cosmogenic radionuclides. Primordial radionuclides originate mainly from the interiors of stars and, like uranium and thorium, are still present because their half-lives are so long that they have not yet completely decayed. Secondary radionuclides are radiogenic isotopes derived from the decay of primordial radionuclides. They have shorter half-lives than primordial radionuclides. Cosmogenic isotopes, such as carbon-14, are present because they are continually being formed in the atmosphere due to cosmic rays.

^{ix} All data from here on out comes primarily from Vardiman, Snelling, Chaffin, *Radioisotopes And the Age of the Earth, Vol II*, (The Institute for Creation Research, 2005), pp 25-100, 739-742.

^x Pb isn't found in these crystals initially because when the crystals form the lattice is too tight, Pb is too big, it doesn't fit, so we basically start with all Ur238 and it decays in the zircon crystals down to Pb.

^{xi} This He was not due to contamination from the surrounding rocks. Dr Humphrey's measured the amount of He in the surrounding rocks and found it at much lower levels, the intensity grew around the Zircon crystals in conformity with predicted patterns of diffusivity.

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