# THE *RATE* PROJECT CLAIMS

By Rodney Whitefield, Phd.



## 22,000 °K? Really?

The RATE project book *Radioisotopes and the Age of the Earth (volume II),*[1] claims evidence for an episode of "accelerated radioactive decay occurring about 4,000 years ago." Several immediate physical consequences of this model, that they admit in the book, are:

1. A computed 22,400 **°K** adiabatic temperature rise in temperature computed for granite rock.[2] (The surface of our sun is about 6,000 **°**K.)
2. Death by a massive dose of radiation from the accelerated decay of Potassium 40 contained in the bodies of living creatures. [3]

Evidence advanced to support the accelerated decay claim is derived from data reported by R. V. Gentry in 1982, regarding lead and helium retention in zircon crystals.[4, 5] Data contained in Gentry's published papers and in the *RATE* book (volume II) are sufficient to show that the data does not support the interpretation being claimed, as will now be explained.

### The Principle Claim

The principle claim is that zircon crystals, taken from rock 960 meters below the surface, still contained a 0.58 fraction of the total amount of helium that would have been generated in 1,500 million years by the radioactive decay of the Uranium (U) and Thorium (Th) contained in the zircons. Uranium-Lead dating gave 1,500 million years as the age of the rocks at all the depths being considered.

The argument advanced by *RATE* is that the rate at which helium diffuses from zircon is so fast that the helium contained after 1,500 million years should have been **much less** than that measured, and so the zircons must be much younger that 1,500 million years. The claimed 0.58 retention fraction was based on an *estimate* of the amount of helium generated by the radioactive decay of the Uranium and Thorium in the zircons. The *estimate* was too low, leading to an over-estimate of the retained fraction.

### Analysis of the Claim

The estimate of $\mathbf{Q}_0$, the total amount of helium which was to have been generated by the radioactive decay, was computed from the measured lead content of zircons at the 2,900 meters depth. It was then *assumed* that this value would properly specify the expected helium content of zircons at **all** depths. Gentry's own data is sufficient to disallow that assumption.

Gentry heated zircons from the 960 meters depth and measured the amount of helium these contained and divided that amount by the $\mathbf{Q}_0$ value determined from the zircons at 2,900 meters (more than 1 mile deeper) to obtain the 0.58 retention fraction. The derived 0.58 retention fraction is also **not** consistent with other data reported by Gentry.

A reading of the 1982 paper "*Differential Lead Retention in Zircons*," reveals that Gentry did measure the U and Th content of <u>some</u> zircons at the 960 meters depth, and the U and Th content of <u>some</u> zircons at the lower depths of 3,930 and 4,310 meters. The reported U and Th content values for 3,930 and 4,310 meters can be averaged and compared with the averaged values reported for the 960 meters depth. When this is done the result indicates the Uranium and Thorium content at 960 meters is **9.17** times greater than the averaged content at those lower depths.

Applying this factor to increase the amount of helium to be expected at 960 meters, one obtains a smaller retained helium fraction of 0.062.[6] The reduction in the fraction retained comes about because the radio-active decay of 9.17 times more U and Th generates 9.17 as much helium. Applying this information alone, the retained helium fraction 0.58 used by *RATE* at 960 meters would be reduced to 0.063 (i.e. 0.58/ 9.17 = 0.063) and the helium diffusion age would be approximately 95 million years.

An improved estimate can be similarly computed using the measured U and Th content of the zircons at the 2,900 meter depth, the same values used by Gentry. This estimate indicates **8.5** times more helium at the 960 meters depth than at the 2,900 meters depth, and an estimated fraction of 0.068 for the retained helium (i.e. 0.58/ 8.5= 0.068)[7]. Both retention factor estimates contradict the *RATE* assertion of too much helium in the zircons and also contradicts *RATE's* conclusions. Using the improved estimate of 0.068, the time at which the zircons at 960 meters started retaining helium computes as approximately 102 million years. (i.e. 1,500 million x 0.068 = 102 million years).

As a consequence of the above, the *RATE* claim of excess helium in the zircon at 960 meters is found **not** supported.

### Age Consistency with Other Data

The 102 million year age estimate is consistent with other data available for the rock from the drill bore, as will now be explained. Zircon is a crystal which will incorporate U and Th into its crystal lattice but which (when forming) excludes lead (Pb). The Pb which results from the radioactive decay of U and Th remains in the zircon provided the temperature is below about 800 °C.
Measurements of the U, Th and the Pb content yield the

time at which the zircon cooled below about 800 °C. The helium generated by the radioactive decay will escape the zircon until the zircon cools below about 170 °C. As a consequence, the helium age of a zircon indicates the time when the zircon temperature cooled to below about 170 °C. The cooling age is **not** the time at which the zircon crystal formed.

The "hot rock" thermal power project which bored the hole in the rock also measured apatite fission track cooling ages at various depths.[8] Apatite is a major constituent of human teeth. (*RATE* accepts fission track data as evidence of the amount of radioactive decay which has taken place.) The apatite fission track age found at 790 meters dated 66.8 million years, and at 1,130 meters an age of 55.1 million years was found. These measurements allow the age at the 960 meters depth to be inferred as about 62 million years.

Apatite fission track ages require the apatite be below 125 °C, and therefore reflect the time at which the apatite cooled below 125 °C. As the rock cooled, one would expect the time at which the rock reached 170 °C would be before the time at which it had cooled below 125°C. As a consequence, the 102 million year cooling age date for the zircon is consistent with the 62 million year apatite fission track cooling age. Sphene fission track data indicate that the rock had not been hotter than about 250 °C for the last 1,300 million years. Sphene (also called Titanite) retains fission tracks for temperatures lower than 250 °C.

### What About the Other Helium Data Claims?

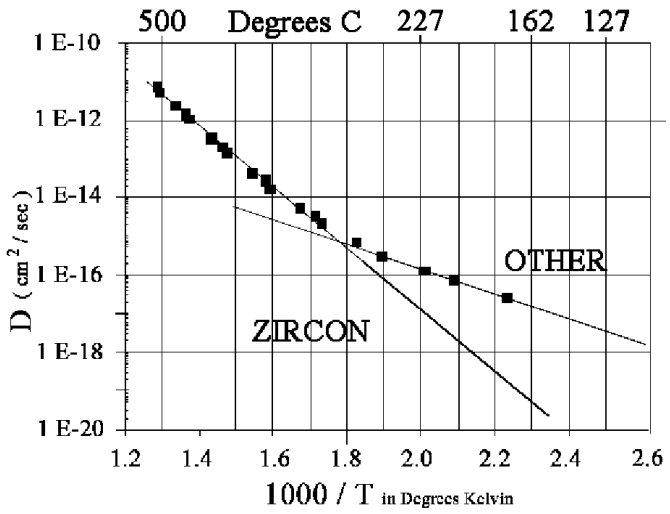
### An Odyssey of Misinterpretation

The *RATE* project obtained additional data which they offered as supporting their interpretation of recent "accelerated radioactive decay." Zircon data from 1,490 meters has been central to their claim. It will be shown in the following that the data has been misinterpreted. The data from the 1,490 meters zircon actually contradict the *RATE* conclusion.

### *RATE*'s Low Temperature Diffusion Data:

In chapter 2 of *RATE* (volume II) Humphreys attempts to analyze the results of *RATE's* helium diffusion experiments. The interpretation at issue is the diffusion of helium from the samples at temperatures below the temperature at which significant helium diffusion loss takes place in zircon.

The interpretation reveals a fundamental lack of consideration of the sequence of events in a step heating experiment and the collateral consequences that result in helium diffusion at low temperatures from sources other than the zircon. The following explanation will discuss *RATES*'s data, inform about the sequence of events in a step heating experiment and some of the consequences of those events, and identify the material which is the major source of the helium diffusion below 200 °C. A plot of the data in question is shown below to facilitate understanding the issues. Two lines are shown. One is the usual line drawn through higher temperature diffusion data. This higher temperature data is that typically taken for zircon. Diffusion values at lower temperatures are usually taken from the extrapolated line.

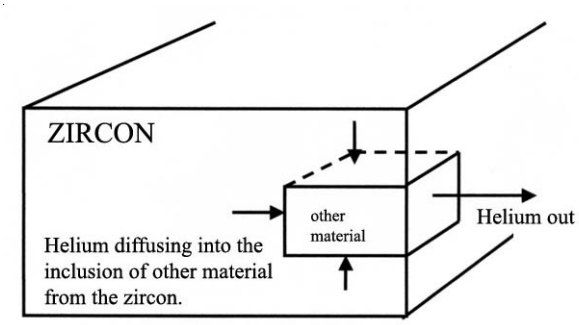



A second line is drawn through the bottom four data points and represents a deviation from the higher temperature zircon line starting at about 255 °C. The *presumption* of the *RATE* group was that the helium diffusion observed below 255 °C was diffusion of helium from the zircon. *RATE* based their conclusions on that *assumption*. The documented physical nature of zircon from the GT-2 bore, and information provided by *RATE*, lead to a different conclusion.

The above *RATE* step heating experiment started by heating the zircon sample to successively higher temperatures and measuring the helium exiting the sample during a specified time interval at each temperature step. Most of the step increments were 50 °C, with the temperature being held constant for about one hour at each of the step temperatures. During each hour the total amount of helium exiting the sample was measured. The data is basically the amount of helium measured during each hour, the temperature of the step, the total amount of helium exiting from the sample during each of the steps, and the helium that was emitted when the sample was heated to 1000 °C to diffuse all the remaining helium out of the sample.

Zircons from the GT-2 bore admittedly had material "stuck" to the zircons. Other reports on zircon from the depths in question at the Fenton Hill bore GT-2, indicate that typically more than 40% had partial overgrowths of material which was not zircon.[9] This indicates that the zircon sample can be expected to have a number of different helium diffusion sources.The helium diffusion in the step heating results at

temperatures below 255 °C can be understood as helium diffusing out from inclusions and overgrowths of another material, not from the zircon. The initial part of the step heating experiment will have added helium to the material of the inclusions and adherents (overgrowths). To explain how this comes about first consider the simplified model of a small "box-like" inclusion illustrated below. The "other material" is surrounded on three sides by zircon and open to the vacuum on another face.




First helium diffuses into the inclusion of the other material. For simplicity, the other material is presumed to not contain any substantial amount of helium from internal sources. Then the helium which has entered the other material exits to the vacuum some time later. The time delay depends on the diffusion coefficient for that material (D ), the depth of the inclusion into the zircon, the surface area exposed to the vacuum, and the temperature. The step heating experiment started by raising the zircon temperature in steps to 500 °C thereby adding helium to the other material. The two highest points on the data plot are at 500 °C and 505 °C. The lowest data points were measured after the initial heating to 500°C. The rate of helium diffusion at 500 °C is about 100,000 times the rate at 200 °C so a considerable amount of helium can be added to the inclusion in a short time.

*RATE (*volume II) shows a scanning electron microscope image of a zircon showing pits and cavities where less etch-resistant material was removed by a cold hydrofluoric acid treatment. Previously published images had also shown pits, cavities, and adherents.[10] The cold hydrofluoric acid treatment had been done by the *RATE*'s "experimenter" to remove biotite clinging to the zircon that had been provided by RATE for diffusion measurement. The step heating diffusion data indicates that helium continues to diffuse and exit into the vacuum at temperatures below 225 °C. However, below 225 °C the zircon diffusion curve extrapolated from higher temperatures indicates that the zircon no longer emits a significant amount of helium into the vacuum or into the inclusion. The inclusion material, which has a higher diffusion rate at the lower temperatures, accounts for the helium that is measured at the lower temperatures. Consequently, most of the helium measured at the lower temperatures does **not** come from the zircon and does **not** represent helium leakage from the zircon. It is a delayed emission of helium that has already exited the zircon and has been temporarily stored in the other material.

**What is the other material?**

Data reported by *RATE* is sufficient to identify the material in the inclusions. The activation energy for helium diffusion from the 2003 zircon sample will be compared with the activation energy for helium diffusion in biotite. The comparison is for the same temperature range.

For the 2003 zircon sample, my analysis utilizing the four data points from 175 °C to 255 °C indicated an activation energy for diffusion of **13.9** kilo-calorie/ mole.[11]

For biotite, my analysis using the two tabulated values of $\ln_e(D/a^2)$ at 150 °C and 250 °C for biotite sample GT-2 yielded an activation energy of **11.4** kilo-cal / mole °K.[12]

The closeness of these two values, and the known presence of biotite as an attached contaminate on the zircons, reveals that the **major portion** of the helium measured below 255 °C derives from **biotite**. *RATE's* plotted biotite diffusion coefficients for biotite from bore hole GT-2 reinforces and supports this identification. *RATE's* biotite plot (Fig.9, page 41) displays a change in slope at about 275 °C, and a more slow decrease in diffusion below that temperature. This is the same behavior (labeled "other") shown for the biotite contaminated zircon on the plot of this commentary.

**How Much Biotite?**

How much biotite does it take to produce the low temperature helium emission measured in the step heating experiments? The answer is "not very much." At 205 °C , helium emission in a time twice as long as used at the higher temperatures measured as 0.000001 of the total helium emission. The 0.000001 represents a very low rate of depletion of the helium. For biotite inclusions, one inclusion per zircon having a volume less than 0.002 of the zircon volume would be sufficient. "Box-like" biotite inclusions 0.0005 centimeter (0.0002 inch) on an edge would suffice. Because the helium loss rate scales as the inverse square of the effective particle radius, a biotite shape 5 micron (0.0002 inch) in diameter would lose helium about 125 times faster than a 30 micron radius shape. Even so, at temperatures of 150 °C and below, the time to remove a significant amount of the helium **that had been added** to the inclusions and adherents during the step heating experiment would be measured in years.

**Other Possible Contributions**

In addition to the biotite other adherent and inclusion materials may also be present and contribute as "other material" to the overall low temperature step heating experiment emission.

*RATES's* suggestion of defect diffusion is not supported by their experimental results and is contradicted by several published studies. All zircons containing radioactive U

and Th have radiation damage (and so dislocations). This is evidenced by the use of zircon for fission track dating, dating which *RATE* also did. Fission track dating utilizes the counting of etched damage tracks as the means of dating. The issue of helium loss due to defects has, as a consequence, been investigated and conclusions reported. One study, which included zircons so radiation damaged that fission track dating could not be done, found helium was retained except in the **most severely** damaged zircon.[13] The GT-2 bore zircon are not severely damaged.

Another recent (2007) article about helium dating concluded, ". . . However, the observation of extremely high U in most zircons with older ages raises the possibility that zircons with high radiation dosages may have more retentive He diffusion characteristics."[14] A similar conclusion has also been reported for helium retention in radiation damaged apatite.[15]

**Summary:**

1) The initial premise of a excess retention of the helium from radioactive decay at 960 meters has been found **not** supported. The data used to refute the assertion was data already contained in the source publications, but not used. Gentry's data does not sustain the premise.

2) The interpretation that helium diffuses from the zircons measured in 2003 with an enhanced rate at temperatures below 255°C has been shown **not** supported. The evidence contained in *RATE* (volume II) was sufficient to identify the source of the helium as biotite inclusions or adherents. This identification and a reasonable physical model for the inclusions was made based on data and information already included in chapter 2 authored by Humphreys.

3) The RATE study of the diffusion of helium from zircon gives **no** support to the assertion of an episode of accelerated radioactive decay. The chapter about helium diffusion from zircon presents **no** scientific evidence supporting the assertion of a 6,000 year old planet earth.

## 22,000 °K?

The ability of *RATE* to downplay the seriousness of their computed 22,400 °**K** adiabatic temperature for granite rock, and to ignore the effect of the above discussed data is perplexing. It is the opinion of this writer that the *RATE* interpretation of the first three verses of Genesis is a major factor and that the *RATE* interpretation is not consistent with the Hebrew text of the Bible. A brief booklet explaining this writer's view on the meaning and interpretation of the first verses of Genesis can be obtained or downloaded from the website www.creationingenesis.com

Rodney Whitefield, the author of the foregoing commentary, is a Phd. physicist, retired from IBM. 02/13/08

**Endnotes:**

[1] *Radioisotopes and the Age of the Earth volume II, 2005,* Institute for Creation Research, 2005, P.O. Box 2667, El Cajon, California 92021.

[2] Ibid. page 183.

[3] Ibid. page 764.

[4] *Differential Helium Retention in Zircons:Implications for Nuclear Waste Containment*, Geophysical Research Letters, Vol. 9, No. 10, Pages 1129-1130, October 1982.

[5] *Differential Lead Retention in Zircons:Implications for Nuclear Waste Containment,* Science, 16 April 1982, Vol. 216, pp. 296-298.

[6] Ratios are being used to determine approximate corrections to the already estimated ages because more accurate estimates are not needed to resolve the issue at question.

More generally, the (U-Th)/He age is computed using the equation: $^{4}He = 8\,[^{238}U]\,(e^{\lambda 238t} - 1) + 7\,[^{235}U]\,(e^{\lambda 235t} - 1) + 6\,[^{232}Th]\,(e^{\lambda 232t} - 1)$. $\lambda$ is the half life of the isotope.

The amounts of the elements He, $^{238}U$, $^{235}U$ and $^{232}Th$ are measured for the sample and the above equation solved to determine the time at which the sample temperature became less than a temperature $T_c$ termed the closure temperature. The He diffusion rate vs temperature is not involved in this age determination. The diffusion rate is a factor only because it determines closure temperature $T_c$ .

[7] The 8.5 factor has two components. The averaged U and Th content at 960 meters is 5.3 times the averaged U and Th content measured at the 2,900 meters depth. An additional factor of 1.6 enters in correcting a math error in the original computation of the total amount of helium that would have been produced by radioactive decay in the zircons at the 2,900 meters depth. The corrected amount 41 nano-cc per microgram multiplied by Gentry's stated 0.60 alpha particle retention factor yields 24.6 nano- cc per microgram. The ratio 1.6 is used as a correction multiplier. As a consequence, the total factor at 960 meters becomes 8.5 (i.e. 5.3 x 1.6 = 8.5). The 5.3 factor alone would lead to an approximate zircon cooling age of 153 million years. The U and Th concentration in zircon from the 2,900 meter depth are reported by R. E. Zartman, Los Alamos Sci. Lab. Rep. LS-7923-MS (1979).

The 1.6 factor acts to reduce the Gentry/*RATE* retention factors at all depths. This additionally impairs the *RATE* assertion of too much retained helium. Humphreys, a member of *RATE*, has conceded about Henke's corrected value of 41 nano-cc/µg that "He is in the right ball park, . . .." Discussions of the correction can be found in appendix A of *Young-Earth Creationist Helium Diffusion*

*Dates", Appendices and References*, Kevin R. Henke, March 17, 2005, www.talkorigins.org/faqs/helium/zircons.html

[8] *Rb-Sr, K-Ar, and Fission-Track Geochronological Studies of Samples From LASL Drill Holes GT-1, GT-2, AND EE-1*; D. G. Brookins, R. B. Forbes, D. L. Turner, A. W. Laughlin, and C. W. Naeser; Los Alamos Scientific Laboratory Report LA-6229-MS, June 1977. See Table 4.

[9] *Morphology of Zircons from Precambrian Rocks Penetrated by Geothermal Test Hole GT-2*, R. A. Heimlich, Los Alamos Scientific Laboratory Report LA-6433-MS, July 1976. See especially Fig.1.

[10] *Helium Retention in Deep-Core Zircons ,* Mark H. Armitage, American Laboratory, July 2004. Figure 2 of this paper shows a zircon with adhering contaminants. Figure 4 of this paper shows numerous pits and cavities in zircon examined after cold HF acid treatment to remove Biotite adhering to the zircon.

*Helium Retention in Deep-Core Zircons* is posted on the internet and can be found at the American Laboratory publishers web site www.iscpubs.com by clicking on articles and then searching the title on the article archive.

A different image, of a similarly HF treated zircon, is shown as Figure 10, on page 42 of *Radioisotopes and the Age of the Earth (volume II)*. This image shows an etched cavity about 20 micron in length and about 10 micron in depth, and other large pits.

[11] *Radioisotopes and the Age of the Earth (volume II)*. The analysis used the tabulated $\ln_e(D/a^2)$ values of Table 2 page 45 to compute three "two end point" activation energy values for lines connecting the data points. The paired data points were steps 17 and 19, steps 16 and 17, and steps 17 and 18. The three values obtained were averaged to obtain 13.9 kilo-calorie/mole. The spread of the values was +/- 20% about the mean.

*RATE* (page 61) claims an activation energy of 10.19 kilo-calorie/mole below 175 °C, but this estimate appears to use only one measured data point. The apparent description of the basis for this estimate at the bottom of page 60 reads "In figure 15, the right-hand four points, the 175 °C experimental point (solid dot) and the three points deduced from retentions and a 6,000 year age (hollow squares and star) make a fairly straight line. In that case the best linear fit (to lnD vs 1/T gives . . . " Recall: *RATE's* retentions were shown **not** consistent with Gentry's own data and so should not be accepted as suitable for RATE's activation energy calculation for 175 °C and below.

[12] *Radioisotopes and the Age of the Earth (volume II)*. The temperature range of interest relating to the interpretation of the lower temperature diffusion was 150 °C to 250 °C. Consequently, for this calculation, the values used from table B2., page 80 were:

Step 4 150 °C. { 423 °K }, $\ln_e(D/a^2)$ –23.18
Step 6 250 °C. { 523 °K }, $\ln_e(D/a^2)$ –20.59

Computation using steps 4 and 6 yielded the two point value of **11.4** kilo-calorie/mole °K for this region. The (Fig. 9) higher slope plot region indicated an activation energy of about 22.14 kilo-calorie/mole. Zircon typically exhibits an even higher activation energy of about 35 kilo-calorie/mole.

[13] *Incomplete retention of radiation damage in zircon from Sri Lanka*, Nasdala, L., Reiners, P.W., Garver, J.I., Kennedy, American Mineralogist, Volume 89, pages 219–231, 2004.

These gem quality zircons ( dated at 555 million years by ion-microprobe U-Th-Pb analysis) were so damaged that they could not be sucessfully etched for fission track dating. **but helium was retained**. The *RATE* 2003 GT-2 zircon does not have anywhere near this amount of damage. Reiners' publications are presently listed at: www.geo.arizona.edu/~reiners/pubs.htm

This paper concluded: ". . . Slightly to moderately metamict zircon has retained the radiogenic He whereas only strongly radiation-damaged zircon (calculated total fluences exceeding $\sim 3.5 \times 10^{18}$ alpha-events/g) has experienced significant He loss." Less severely radiation damaged zircons yielded helium ages of about 440 million years, indicating high helium retention for long periods of time, even though having a high level of defects.

[14] *Dating Young Basalts by (U-Th)/He on Xenolithic zircons*, Geology, v. 35, p. 17-20. Blondes, M.B., Reiners, P.W., Edwards, B.R., and Biscontini, A.E., 2007.

In this title, "young" refers to ages in the range of 157,000 to 273,000 years.

[15] *Radiation Damage Control on Apatite (U-Th)/He Dates from the Grand Canyon Region, Colorado Plateau*; Flowers, R. M., Shuster, D. L., Wernicke, B. P., Farley, K. A., Geology, Vol. 35, Issue 5, p.447, 05/2007.