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METEORITES AND A YOUNG EARTH

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KEYWORDS

Meteorites, Radioisotope Age, Cosmogenic Isotopes, Cosmic-Ray Exposure Age, Solar System Age

ABSTRACT

Major advance in relating a young-earth creationist viewpoint to scientific data has come from recognition that radioisotope age may be a significant characteristic of an object and yet not have direct real-time significance in the history of that object. Igneous and sedimentary material may have a radioisotope age that is an inherited characteristic and not related to its present placement. It is more difficult to accommodate a young-earth perspective to extra-terrestrial objects. High energy atomic nuclei from outer space — cosmic rays — produce cosmogenic nuclides in meteorites and on the surface of the Moon. The accumulation of identifiable cosmogenic nuclides may be related to cosmic-ray intensity to obtain a cosmic-ray exposure age. Cosmic-ray exposure ages that have been determined range from about 900 thousand to about 2.4 billion years. This range has been interpreted to suggest continuing impact of meteoroids on the surface of the Moon, and continuing breakup of large meteoroids into smaller objects. The concepts of cosmic-ray exposure and radioisotope age are particularly well illustrated by the meteorite Asuka-881757, which has been classified as having originated from a meteoroid impact on the Moon. Six independent radioisotope age determinations for Asuka-881757 average 3843 ±56 (2σ) million years. Its cosmic-ray exposure age is ~900 thousand years. Five proposals for accommodating these data are considered. At one extreme Asuka-881757 may be classified as an object from outside the Solar System, from a region in the Milky Way galaxy for which 3.9 billion years has the same significance as 4.6 billion years has for radioisotope ages within the Solar System. At the other extreme of the five proposals all radioisotope ages and cosmic-ray exposure ages greater than ~10,000 years are considered to represent initial characteristics that God placed within minerals at their creation.

INTRODUCTION

A major challenge for Biblical creationists has been the need for an understanding of radiogenic and cosmogenic isotopes that is compatible with the chronological specifications recorded by Bible writers. Radiogenic isotopes may be designated as the daughter products of radioactive (unstable) parents that remain from the initial creation of elementary matter. Cosmogenic isotopes are produced by the interaction of primary cosmic radiation (principally hydrogen nuclei from outer space moving at speeds near the speed of light) with target material. Uranium-234 and lead-206 produced by the radioactive decay of parent uranium-238 are examples of radiogenic isotopes. Carbon-14 produced by the interaction of cosmic rays with Earth's atmosphere is a cosmogenic isotope.

There has been major progress in relating radiogenic isotope features to a Biblical young-earth viewpoint. Steven Austin has recently determined that the 1986 flow from the new lava dome of Mount St. Helens in Washington State has potassium-argon (K-Ar) ages ranging from 0.35 to 2.8 million years [1]. In this case the K-Ar age is unquestionably a physical characteristic of the magma, and has no relationship to the time at which the magma was ejected from the volcano. Dr. Austin's work undergirds similar conclusions from other data that have been published in the professional literature. Drill-hole cuttings from the 5,190-foot level of an oil well in the state of Louisiana had K-Ar ages in the range 164-373 million years. The conventional geologic age for the formation at this level is 10-25 million years (Miocene) [16]. It is significant that the conventional geologic age assignment was based on K-Ar data! About 85% of the radioisotope age selections on which the modern conventional geologic time scale was initially based in 1964 were K-Ar determinations [25]. We have right to question whether those K-Ar dates were any better indicators of real time than the K-Ar ages Steve Austin obtained for Mount St. Helens. Since 1964 many additional radioisotope age determinations have been utilized to "fine tune" the age assignments for the geological periods [6], but the adjustments have been minor.

We are not left to speculation as to whether other radioisotope dating systems have the uncertain relationship with real time that has been established for K-Ar dating. Sediment being formed at the present time on the floor of the Ross Sea in Antarctica has a rubidium-strontium (Rb-Sr) age of 250 million years [14], indicating that the Rb-Sr age of a sedimentary rock may have no relationship with the time at which the sediment was formed. An additional example is provided by basalt from the Benue Trough in Nigeria [5]. Stratigraphy places a dated sample of this basalt in the late Tertiary (<10 million years conventional age); yet the sample has a fission-track (FT) age of <30 My, a K-Ar age of 95 My, and a U-He age of 750 My. One can assume that the FT age is correct, in accord with the stratigraphic assignment, and the K-Ar and U-He ages are merely physical characteristics, inherited ages from the history of the magma from which the basalt was derived; that the K-Ar age is correct, fission tracks have been partially destroyed by annealing, and the U-He age is merely an inherited physical characteristic; or that the U-He age is correct, there has been partial loss of fission tracks, and also partial loss of argon by diffusion.

An illustration of the general principle represented by these examples may be obtained from a cemetery. Dates of interment therein are not determined by isotope analysis of rocks and soil. Burial dates are obtained from engraving on headstones and official records. A young-earth creationist has a sound scientific basis for using the chronologic data in the Bible as a guide for determining limits on the time of emplacement for Phanerozoic igneous and sedimentary features.

The full range of isotope age considerations is covered by meteorites. This range is illustrated by the meteorite Asuka-881757 better than by any other meteorite I know of. The cosmogenic and radiogenic features of Asuka-881757 are the principle considerations of this manuscript.

PHYSICAL FEATURES AND COMPOSITION OF METEORITE ASUKA-881757

The meteorite Asuka-881757 (preliminarily designated as Asuka-31) was found December 20, 1989, on the Nansen Ice Field of Antarctica, one of over 2000 meteorites collected there by a Japanese team led by K. Yanai during 1987-1989. It weighed 442.12 grams and had a volume of 130.8 cm^3 (density 3.38 g/cm^3) [23]. As seen in Fig. 1, Asuka-881757 has a broken surface and a smooth rounded surface that is covered by a shiny black fusion crust. It appears to be about half of an original stone. It is an unbrecciated, coarse-grained gabbro.

The mineral composition of A-881757 is 59% pyroxene, 30% plagioclase, and 6% ilmenite, with the remaining 5% including small amounts of troilite, olivine, ulvöspinel, Fe-Ni metal, apatite, and silica [13]. In addition to the elements contained in these minerals, there are sufficient traces of uranium, thorium, lead, samarium, rubidium, potassium, and argon to provide six significant independent basic radioisotope age determinations.

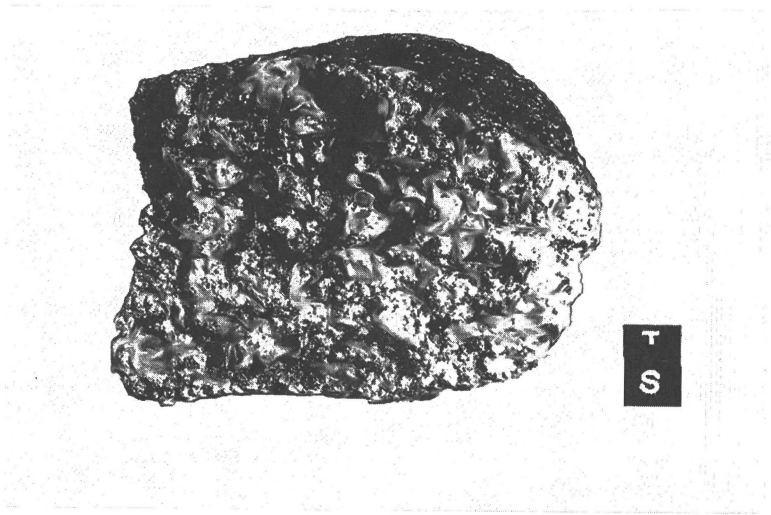

FIGURE 1. The Meteorite Asuka-881757. The 1 cm cube at the lower right provides scale. Photograph by Keizo Yanai [23].

LUNAR CLASSIFICATION OF ASUKA-881757

Asuka-881757 has been classified as a Lunar meteorite, i.e., a rock that has been ejected from the Moon. The presumed scenario is a meteoroid or comet impact that blasted some lunar surface material with sufficient velocity to escape the Moon's gravitation. Some of this ejected material was placed in an orbit that eventually intercepted planet Earth and became a meteorite. The postulate of a lunar source is supported by the similarity of mineral composition to that of mare basalts that were returned to Earth by the Apollo missions. However, the significant differences between the composition of A-881757 and the composition of each available Lunar specimen provide a basis for questioning the assignment of A-881757 to the lunar category. Major support for the lunar category assignment is provided by the oxygen isotope profile of the mineral fractions. For each mineral fraction this profile is in exact agreement with previous analyses of lunar rocks, and not similar to any other nonlunar meteorite types [23].

Another basis for considering A-881757 to have originated from the Moon is its cosmic-ray exposure age [24].

COSMIC-RAY EXPOSURE AGE

Primary cosmic rays are atomic nuclei that come from outer space and have acquired speeds sufficiently near the speed of light to have kinetic energy greater than 100 million electron-volts per particle. These particles are about 90% protons (nuclei of hydrogen atoms), about 10% alpha particles (nuclei of helium atoms), and an approximate total of 1% from the nuclei of atoms in the range from helium to nickel [8]. Secondary cosmic rays are particles and photons produced by the collision of primary cosmic rays with atoms.

When a primary cosmic ray particle such as a proton (H-1) strikes an atom it may shatter the nucleus into smaller components and also release neutrons in the process. This breakup process is called spallation. A typical spallation reaction is (spallation products in brackets):

$$\text{H-1} + \text{Fe-56} \Rightarrow \text{Cl-36} + [\text{H-3} + 2(\text{He-4}) + \text{He-3} + 3(\text{H-1}) + 4n].$$

The components produced by spallation may be either stable or unstable. Unstable is equivalent to being radioactive. Cl-36 is unstable, and has a 301 thousand year half-life. Neutrons released in a spallation will interact with nearby atoms and produce atomic transmutations. An example is the production of Carbon-14 in the upper atmosphere by interaction of spallation neutrons with nitrogen atoms. In addition to cosmogenic nuclides produced directly by spallation and indirectly by neutron capture, a cosmic ray particle passing through a crystal may disrupt the lattice structure, leaving a track that may be seen with a microscope. Figure 2 is an example of cosmic-ray tracks [17].

When an object is in outer space it will be exposed to primary cosmic rays. During the time of exposure there will be an accumulation of cosmogenic isotopes, and there will also be an accumulation of cosmic-ray tracks in any transparent crystals the object may contain. The accumulation of stable cosmogenic isotopes is not limited, but the concentration of unstable (radioactive) cosmogenic isotopes will increase only until the rate of decay equals the accumulation rate. This relationship for two cosmogenic isotopes of argon is shown in Figure 3. The argon concentration units in Figure 3 are 10^{-13} cm^3 /gram for a typical chondrite chemical composition. Argon in material that has not had extended exposure to cosmic rays is 0.0632% Argon-38. The half-life of Argon-39 is 269 years [21]. Beginning from an initial concentration of zero, production over about four half-lives (1100 years for Argon-39) is required before the bulk decay and formation rates are essentially equal.

Instruments carried by space vehicles can measure the present intensity of the primary cosmic radiation. From these measurements, and a weighted summation of laboratory determinations of nuclear reaction probabilities (cross-sections) for each kind of atom in a specimen, the present production rates of cosmogenic nuclides can be estimated. After an exhaustive study of cosmogenic nuclides in samples obtained from the Moon by the Apollo 14 and 16 missions, Hohenberg, et al., concluded that "agreement between observation and theoretical production is better than might perhaps have been expected. The agreement is, in nearly all cases, better than a factor of two, and in many cases is good to the 10% or 20% level, approaching experimental uncertainties" [10]. Table I gives a summary of their determinations of the ratio of measured concentration to predicted concentration for the stable cosmogenic nuclides Neon-21, Argon-38 and Xenon-126. The cosmic-ray exposure ages for these samples, as determined by the Krypton-83/Krypton-81 ratio, are closely grouped around 2, 25, and 50 million years.

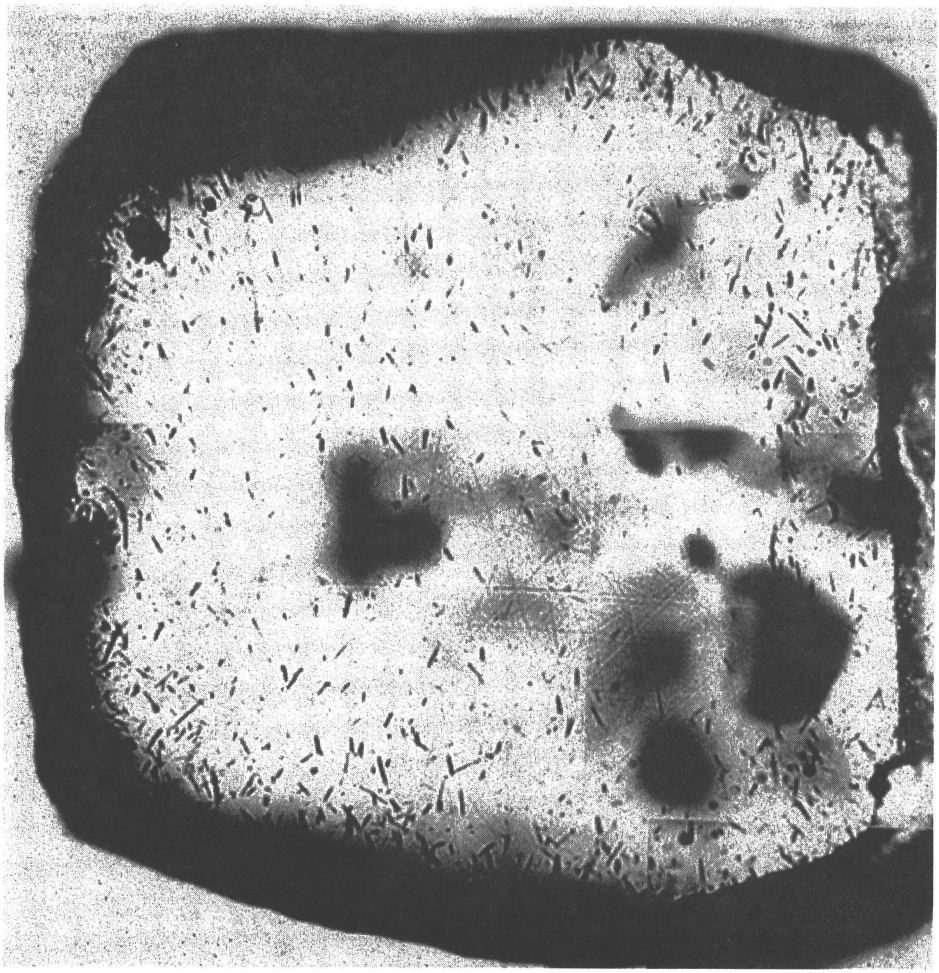

FIGURE 2. Cosmic-ray tracks from the Murchison chondrite. Magnification of a 150 micron olivine crystal. From Fig. 1 of P.B. Price, et al., (1975) [17].

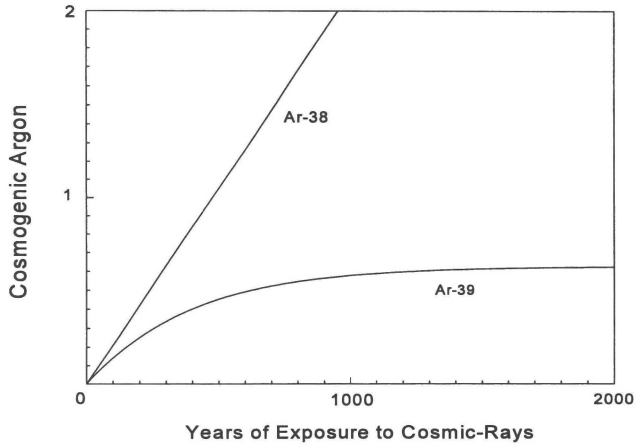

FIGURE 3. Cosmogenic argon isotope concentration growth with exposure time. Fig. 4-4 from Wood [22], p. 65. Argon units are 10^{-13} cm^3/gram.

TABLE I. MEASURED/PREDICTED COSMOGENIC STABLE NUCLIDE CONCENTRATIONS FOR APOLLO 14 AND 16 SAMPLES

Nuclide	Exposure Age Groups Represented (million years)	Number of Determinations	Mean Ratio of Measured/Predicted ±2σ
Neon-21	2,25	4	0.97 ± 0.35
Argon-38	2,25,50	12	1.24 ± 0.76
Xenon-126	25,50	22	0.82 ± 0.71
	Grand Mean	38	0.97 ± 0.48

Exposure age determined from cosmogenic Kr-83/Kr-81 ratio. Predicted concentration determined from cosmic-ray intensity and laboratory measurement of reaction probabilities.

Table II lists comparison of measured cosmogenic radioactive nuclide concentrations with predicted saturation levels (exposure for at least four half-lives) for four rock samples and three soil samples from the Moon [20]. The data in Tables I and II indicate that the concentration of a radioactive cosmogenic nuclide can be used as an indication of the primary cosmic-ray intensity. Comparison with the associated concentration of a stable cosmogenic nuclide may then be used to determine an exposure time.

Exposure ages determined by five investigators using four different cosmogenic isotope pairs for five meteorites are shown in Figure 4 [9]. The half-lives of the cosmogenic nuclides designated in Figure 4 are specified in Table III. Ar-38, Ar-36, Ne-21, and K-41 are stable. The disagreement in Figure 4 of age determinations based on the K-41/K-40 ratio suggests inadequate length of exposure to bring the 1.277 billion year half-life K-40 concentration into equilibrium with its formation rate (less than five billion years of exposure, as indicated by the other three determinations).

TABLE II. COSMOGENIC RADIOISOTOPE ACTIVITY OF MOON SURFACE SAMPLES

	Isotope	Half-Life	dpm/kg Calc.	dpm/kg Meas.
Apollo 11, rock 10017	Na-22	2.60 y	28	30 ± 5
	Al-26	7.4×10^5 y	45	50 ± 7
Apollo 12, rock 12002	Na-22	2.60 y	34	39 ± 6
	Be-10	1.51×10^6 y	11	11.5 ± 1.4
	Al-26	7.4×10^5 y	50	64 ± 6
Apollo 12, fines 12025	Na-22	2.60 y	38	34 ± 7
	Al-26	7.4×10^5 y	55	62 ± 8
Apollo 12, rock 12053	H-3	12.33 y	250	266 ± 35
Apollo 14, rock 14327	Na-22	2.60 y	43	39 ± 5
	Be-10	1.51×10^6 y	13	13.8 ± 2
	Al-26	7.4×10^5 y	82	57 ± 7
Apollo 15, fines 15031	Na-22	2.60 y	40	33 ± 3
	Al-26	7.4×10^5 y	76	49 ± 3
Apollo 15, fines 15261	H-3	12.33 y	240	240 ± 15

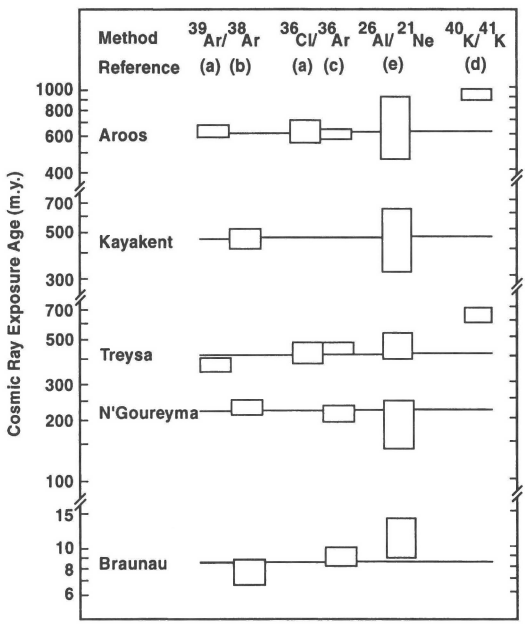

FIGURE 4. Comparative determinations of cosmic-ray exposure age for five meteorites. Five independent studies (a-e), using four isotope pairs. Vertical height of bars indicate 68% confidence range. Modified from Fig. 3 of Hampel and Schaeffer [9], p. 355.

TABLE III. HALF-LIVES OF COSMOGENIC NUCLIDES DESIGNATED IN FIGURE 4

Nuclide:	Ar-39	Cl-36	Al-26	K-40
Half-life:	269 y	3.01×10^5 y	7.4×10^5 y	1.277×10^9 y

The greatest cosmic-ray exposure age that I know of is 2.4 billion years for micro breccias collected on the Moon by the Apollo 11 mission [18]. The cosmic-ray exposure age of most meteorites is less than 100 million years [12]. A summary of chondrite (~93 % of "stones", the most common type of meteorites) cosmic-ray exposure ages that was published in 1992 is shown in Figure 5. Less than 10% of meteorites are "irons", the type most commonly seen in museums. The cosmic-ray exposure ages of "irons" cluster in the 200 million to 1.1 billion year range. The wide range over which cosmic-ray exposure ages of meteorites and samples from the Moon are distributed is taken to indicate a continuing process of meteoroid impact on the Moon, and of large meteoroid breakup into smaller objects.

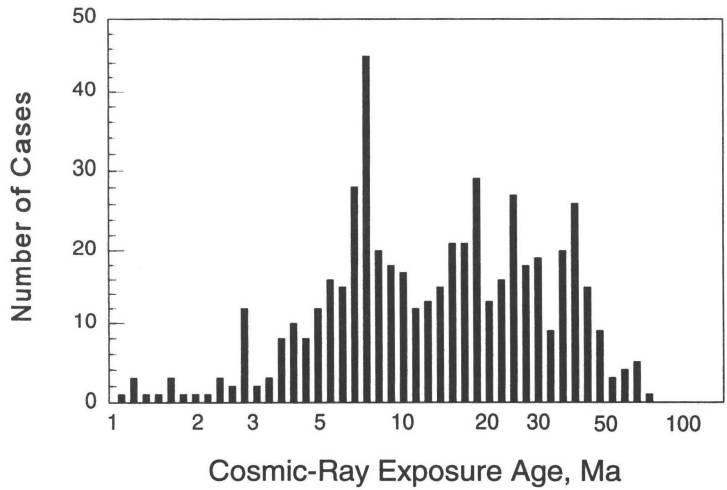

FIGURE 5. Chondrite exposure ages. Number of Cases is the sum of the numbers for subclassifications as given in Figures 4, 5, and 6 of Marti and Graf [12].

The cosmic-ray exposure age of A-881757 is only 0.9 ±0.1 million years, an exceptionally low value for a meteorite [15]. This is one consideration for classifying it as a lunar meteorite. To have an exposure age this low, any material from the Moon would have had to have been buried about two or more meters below the surface to be shielded from primary cosmic-ray exposure prior to leaving the Moon. If correct, the scenario for lunar origin begins with an impact that excavated a crater at least several meters deep.

RADIOISOTOPE AGE OF ASUKA-881757

For radioisotope dating of Asuka-881757 a 1.605 gram portion was crushed and made into nine test samples: whole rock; glass fragments; magnetic separates; pyroxene from magnetic separates and from handpicking; plagioclase from magnetic separates, from handpicking, and heavy liquid separation; and ilmenite. The concentrations of radioisotopes and their daughter isotopes in each of these samples were determined by mass spectrometry. Isochron plots were made of these determinations, and the radioisotope ages determined from those plots. For potassium-argon age determination a plagioclase crystal from the meteorite and a glass sample handpicked from the

crushed portion were subject to neutron irradiation in a reactor and analyzed by the Ar-40/Ar-39 technique for radioisotope age determination [13]. The radioisotope ages obtained from these procedures are listed in Table IV, and plotted in Figure 6. A 3940 million-year U-Pb concordia determination has been omitted, because it is derived from a 4.56 billion-year presumed primordial age for lunar material, and I want to keep this discussion free from a predetermined concept of lunar origin. The cross-hatched upper portion of each bar in Figure 6 represents the range of uncertainty within which an individual determination may be expected with 95% confidence.

TABLE IV. RADIOISOTOPE AGES OF ASUKA-881757

Isotope Type	Age in Millions of Years, ±2σ
Pb-Pb	3940 ± 28
U-Pb	3850 ± 150
Th-Pb	3820 ± 290
Sm-Nd	3871 ± 57
Rb-Sr	3840 ± 32
$^{40}Ar/^{39}Ar$ (K-Ar)	3798 ± 32
MEAN	3853 ± 136
WEIGHTED MEAN	3843 ± 56

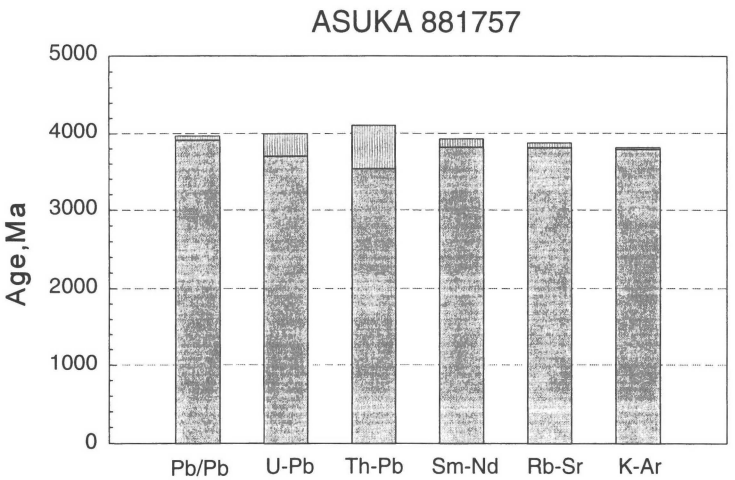

FIGURE 6. Asuka-881757 radioisotope age histogram. Upper bars indicate the range of uncertainty within which 95% of individual determinations may be expected. Age in millions of years. Data from Keiji Misawa, et al. [13].

The 95% confidence range about the weighted mean is ±1.46%. Each of the radioisotope age determinations falls within this range, excepting the Pb-Pb determination which is 2.52% higher than the weighted mean. The lowest determination (K-Ar) is 1.17% below the weighted mean. Since argon is an inert gas, and lead isotope ratios are highly unlikely to be influenced by chemical activity or heat, the 3.6% difference between Pb-Pb age and K-Ar age probably indicates loss of argon in an episode of high temperature during the history of Asuka-881757.

The heating episode could have occurred during passage through the atmosphere of Earth and/or when Asuka-881757 was ejected if it came from the Moon. During the heating episode(s) the U-Pb,

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The heating episode could have occurred during passage through the atmosphere of Earth and/or when Asuka-881757 was ejected if it came from the Moon. During the heating episode(s) the U-Pb, Th-Pb, Sm-Nd, and Rb-Sr isotope systems also appear to have been reset, but to a lesser extent than the K-Ar system.

The close agreement of six independent radioisotope age determiners involving nine chemically and physically diverse elements is remarkable, particularly so since the 3.84 billion year age characteristic indicated by the weighted mean is 0.72 billion years less than the 4.56 billion years usually indicated as the upper-limit age of meteorites and Moon rocks [4].

POSSIBLE EXPLANATIONS FOR THE ASUKA-881757 RADIOISOTOPE AGE

Using the 4.56 billion years determination as a Solar System Reference radioisotope characteristic, without encumbrance by real-time associations that may be attached to it, and 3.94 billion years as the Asuka-881757 Reference radioisotope characteristic (Pb-Pb), we may consider five options for explanation of the Asuka-881757 radioisotope age determinations.

1. 620 million years after the Solar System Reference Event, Asuka-881757, or its parent body, experienced a violent metamorphism that selectively removed all radioisotope daughter products, and required 3.94 billion years of succeeding daughter buildup to develop its present 3.94 billion year Pb-Pb characteristic.

2. 620 million years BP (before present) Asuka-881757, or its parent body, experienced a violent metamorphism that selectively removed all radioisotope parents, leaving a 3.94 billion year characteristic that remains indefinitely unchanged.

3. Asuka-881757 came from outside the Solar System, from a region in the Milky Way galaxy for which 3.9 billion years has the same significance as 4.6 billion years has for radioisotope ages in the Solar System.

4. Radioisotope age determinations, as well as cosmic-ray exposure age determinations, are based on incorrect assumptions, and do not have a time-related significance.

5. Radioisotope age features represent initial characteristics that God placed within minerals at their creation. The reasons for their placement, selection, and non-significance with respect to real time are inscrutable to human intelligence, at least for the present.

Associated with Options #1, #2, and #3 is a 142 million year drop in K-Ar age (difference between the Pb-Pb and $^{40}Ar/^{39}Ar$ ages listed in Table IV) due to loss of argon from heating during passage through Earth atmosphere and/or ejection from the parent body.

Option #1, with radioisotope age considered to represent real-time age, is essentially the conventional scientific view. It can be elaborated to include several metamorphic events, or periods of metamorphism, that have the ultimate effect of removing 620 million years of daughter product accumulation from each of the radioisotope sequences. For undirected natural processes to modify two radioisotope pairs to within less than 2% of the same age indication is possible, but highly unlikely. For three to be modified in the same amount is extremely unlikely. The chemical and physical characteristics of Pb, U, Th, Sm, Nd, Rb, Sr, K, and Ar, and the minerals in which they may be chemically bound, are so diverse that six radioisotope age characteristics of their isotopes would be changed in approximately the same amount by a natural process is incomprehensible. Therefore Option #1 is unacceptable in my consideration.

If the isotope data that are represented in Table IV and Figure 6 are coordinated with mixing lines, rather than isochrons [2], the similarity of six mixing lines within a 4% range (±2%) for a hand-sized rock specimen is equally incomprehensible. An arbitrary mixture of eleven minerals is extremely unlikely to produce six similar sets of binary combinations.

Option #2 is reasonable for the Pb-Pb age determination; but it is nonsense for the other five determinations that require residual radioactivity of the parent.

Option #3 is supported by the considerations for rejecting Option #1, and by recognition that although the mineral and chemical composition of Asuka-881757 is similar to that of basaltic samples that have been collected on the Moon, it is also notably different from specimens that have been collected there. Misawa, et al. [13], specifically state that "The petrology and chemistry...are not the same as those of the Apollo and Luna samples". In the opinion of K. Yanai [23], Asuka-881757 "is different from other known lunar meteorites in that it retained its original texture after it consolidated as gabbro...[it] appears to be a previously unknown type of rock from the Moon". The U-238/Pb-204 ratio is extremely low in comparison with rocks that have been obtained from the Moon (10, as indicated by U-Pb concordia, compared with values from 12 to over 500 – Fig. 2 of Misawa, et al. [13]). Whether the similarities between the composition of Asuka-881757 and material that has been returned from the Moon are considered to indicate a lunar origin, or the dissimilarities are considered as support for the concept of origin outside the Solar System, the limited amount of data available make choice a subjective conclusion which is outside the primary focus of this paper. My concern is for a treatment of radioisotope age and cosmic-ray exposure data that is compatible with a young-earth concept based on sound grammatical-historical exegesis of the Bible. Option #3 does not necessarily involve a presumption that the characteristic 3.9 billion years and 4.6 billion years radioisotope age features represent real time from a planet Earth perspective.

Option #4 is a faith statement that arises from an apparent conflict between an interpretation of historical and chronological specifications in the Bible and an interpretation of scientific evidence with due consideration of open system (migration of parent or daughter atoms) and inherited age possibilities. Effort to give scientific credibility to this option has involved speculation concerning time dilation and relativity [11], and also orders-of-magnitude change throughout the history of the universe in the basic forces that determine atomic structure [14]. Option #4, as stated, is intended to deal with radioisotope age determinations greater than ~10,000 years. In some cases Carbon-14 and other isotopes with half-lives less than ~200,000 years do provide data that may relate unquestionably to a real time sequence, and may with suitable calibration designate a specific real-time date within a range less than 6000 years.

Option #5 is undebatable as a possibility. It must be evaluated subjectively on the basis of its effectiveness in forming a personally satisfactory view of the physical universe, in sustaining essential religious commitment, and in witness for the testimony of the Bible. The intention of Option #5 is the same as that of Option #4; hence the qualifier *represents* is used to allow for open system modification in the history of a mineral since its creation.

EPILOG

Some readers may be able to contribute an additional option for interpreting radioisotope and cosmic-ray exposure data for Asuka-881757, and meteorites in general. It has been the intent of the author to identify a class of data that must be addressed by young-earth modeling to which this Conference is committed, and to explore the range of options for interpreting these data. For a balanced investigation there should be a comparable exploration of the options for interpreting the specifications in the Bible concerning natural history and chronology.

A cosmology that limits the existence of the matter that makes up meteorites to a duration period of only several thousand years should offer plausible reasons for the creation of meteorites *de novo* with the cosmogenic isotope and radioisotope features that characterize them. A cosmology that allows the most obvious naturalistic explanations for meteorite isotope data should be supported by Biblical testimony that the creative activity specified for the Genesis Creation Week was principally confined to planet Earth. One option for such support is consideration of Genesis 1:1 as a brief reference to primordial creation of the physical universe, verses three and following as a more detailed specification concerning a subsequent creation epoch that fitted planet Earth with its initial organic life, and verse two as a transition statement concerning the state of planet Earth immediately before it was fitted with organic life [7]. Another option is exegesis of the Creation Account from Genesis 1:1 to 2:4a strictly on the basis of the definitions given in verses 8-10 [3].

The widely different religious backgrounds, and the widely different scientific backgrounds of individuals who address these considerations make it unrealistic to anticipate a unanimity of opinion, even among those who have a high view of the authority of the canonical Hebrew-Christian Scriptures, and are committed to strict historical-grammatical exegesis. We can seek Christian unity on the essentials, with mutual respect where there are differences that do not compromise our basic witness.

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REFERENCES

[1] Austin, Steven A., **Excess Argon within Mineral Concentrates from the New Dacite Lava Dome at Mount St Helens Volcano**, CEN Tech. J., 10:3(1996) pp. 335-343.

[2] Brown, Robert H., **MIXING LINES–Considerations Regarding their Use in Creationist Interpretation of Radioisotope Age Data**, Proceedings of the International Conference on Creationism, R.E. Walsh, et al., Editors, 1994, Creation Science Fellowship, Inc., Pittsburgh, PA, pp. 123-130.

[3] Brown, Robert H., **Too Much Creation?**, unpublished manuscript available from the author, 12420 Birch St., Yucaipa, CA 92399-4218.
Also accessible on the Internet: http://www.tagnet.org/gri/w/rbrown/too_much.htm

[4] Dalrymple, G Brent, The Age of the Earth, (1991), Stanford University Press, Stanford, California, Chapter 6.

[5] Fisher, David E., **Excess Rare Gases in a Subaerial Basalt from Nigeria**, Nature, Physical Science, 232:29(1971), pp. 60-61.
Perry, E.A., Jr., **Diagenesis and the K-Ar Dating of Shales and Clay Minerals**, Geological Society of America Bulletin, 80(1974), pp. 827-830.

[6] Gradstein, F.M., and Ogg, J., **A Phanerozoic Time Scale**, Episodes, 19:1,2(1996), pp. 3-5.

[7] Gray, Gorman, The Age of the Universe: What are the Biblical Limits?, 1997, Morningstar Publications, Washougal, WA 98671-1209.

[8] Gregory, A. and Clay, R.W., **Cosmic Radiation**, (in) Lide, David R., Editor, CRC Handbook of Chemistry and Physics, 75th Edition (1994), CRC Press, Boca Raton, Florida, pp. **11**:155-159.

[9] Hampel, W., and Schaeffer, O.A., **^{26}Al in Iron Meteorites and the Constancy of Cosmic Ray Intensity in the Past**, Earth and Planetary Science Letters, 42(1979), pp. 348-358.

[10] Hohenberg, C.M., Marti, K., Podosek, F.A., Reedy, R.C., and Shirck, J.R., **Comparisons Between Observed and Predicted Cosmogenic Noble Gases in Lunar Samples**, Proceedings of the Lunar and Planetary Science Conference 9th, (1978), pp. 2311-2344.

[11] Humphreys, D. Russell, **A Biblical Basis for a Creationist Cosmology**, and **Progress Toward a Young-Earth Relativistic Cosmology**, Proceedings of the International Conference on Creationism, R.E. Walsh, et al., Editors, 1994, Creation Science Fellowship, Pittsburgh, PA, pp. 255-286. For a critique of Humphreys' treatment see Byl, John, **On Time Dilation in Cosmology**, Creation Research Society Quarterly, 34(1), (1997), pp. 26-32; and Humphreys' rejoinder on the following pp. 32-34.

[12] Marti, K., and Graf, T., **Cosmic-Ray Exposure History of Ordinary Chondrites**, Annual Review of Earth and Planetary Sciences, 20(1992), pp. 221-243.

[13] Misawa, Keiji, Tatsumoto, Mitsunobu, Dalrymple, G. Brent, and Yanai, Keizo, **An Extremely Low U/Pb source in the Moon: U-Th-Pb, Sm-Nd, Rb-Sr, and $^{40}Ar/^{39}Ar$ Isotopic Systematics and Age of Lunar Meteorite Asuka 881757**, Geochimica et Cosmochimica Acta, 57(1993), pp. 4687-4702.

[14] Morton, Glenn R., **Changing Constants and the Cosmos**, Creation Research Society Quarterly, 27(2), (1990), pp. 60-67.

[15] Nishiizumi, K, Arnold, J.R., Caffee, M.W., Finkel, R.C., and Reedy, R. C., **Cosmic Ray Exposure Histories of Lunar Meteorites Asuka 881757, Yamoto 793169, and Calcalong Creek**, Papers Presented to the Seventeenth Symposium on Antarctic Meteorites, August 19-21, 1992, Tokyo, Japan, pp. 129-132.

[16] Perry, E.A.,Jr., **Diagenesis and the K-Ar Dating of Shales and Clay Minerals,** Geological Society of America Bulletin, 80(1974), pp. 827-830.

[17] Price, P.B., Hutcheon, L.D., and Braddy, D., **Track Studies Bearing on Solar-system Regoliths**, Proceedings of the Lunar Science Conference 6th, (1975). pp. 3449-3469, particularly p. 3452.

[18] Rancitelli, L.A., **Extraterrestrial Materials**, Geotimes, (June 1979), pp. 30-31.

[19] Shaffer, Nelson R., and Faure, Gunter, **Regional Variation of $^{87}Sr/^{86}Sr$ Ratios and Mineral Compositions of Sediment from the Ross Sea, Antarctica**, Geological Society of America Bulletin, 87(1976), pp. 1491-1500.

[20] Trivedi, B.M.P., and Goel, P.S., **Nuclide Production Rates in Stone Meteorites and Lunar Samples by Cosmic Radiation**, Journal of Geophysical Research, 78:23(1973), pp. 4885-4900.

[21] Tuli, Jagdish K., Nuclear Wallet Cards, Fifth edition, (1995), Brookhaven National Laboratory, Upton, New York 11973.

[22] Wood, John R., Meteorites and the Origin of Planets, (1968), McGraw-Hill, New York, p. 65.

[23] Yanai, K., **Gabbroic Meteorite Asuka-31: Preliminary Examination of a New Type of Lunar Meteorite in the Japanese Collection of Antarctic Meteorites**, Proceedings of Lunar and Planetary Science, 21(1991), pp. 317-324.

[24] Yanai, Keizo, et al., **Consortium Reports on Lunar Meteorites Yamato 793169 and Asuka 881757, a New Type of Mare Basalt**, Lunar and Planetary Science Conference XXIV, 24(1993), pp. 1555-1556.

[25] York, Derek, and Farquhar, Ronald M., The Earth's Age and Geochronology, 1972, Pergamon Press, Oxford, pp. 109-115.