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STRETCHING TIME: THE MAGIC IN EVOLUTION

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ABSTRACT

Rock layers of the world are dated by the hypothesis of fossil correlations to fit them into the hypothetical geologic column. At any location, only a fragment of the geologic record exists and rarely do sequential rock layers actually contain a fossil succession that agrees with the evolutionary scheme. Often vast-age gaps exist in the geologic record. Also, major areas exist where the layers contain fossils in the wrong order, the oldest on top. Physical signs should mark such breaks in the evolutionary record—erosion in the case of vast-age gaps and rock debris where overthrust movements supposedly produced the wrong order. More often than not these physical criteria are absent. Existing stratigraphy contradicts the evolutionary claims for vast ages.

INTRODUCTION

Eighty years of efforts have been conducted to verify and calibrate the evolutionary time scale using radioactive dating theories. A critique of the dating theories indicates they are flawed in their basic assumptions. It does not appear that even one radioactive vast-age has credibility. No valid basis exists for making scientific claims for vast ages in Earth history.

The conflicting concepts of evolution and creation are generally fought on a battlefield that acknowledges the existence of vast-ages in Earth history. When the concept of recent creation does not challenge claims of vast age, evolution is unshaken. Although evolution can be shown to be implausible in numerous ways, it cannot be vanquished as long as belief in vast ages persists.

To examine the conflicting concepts of evolution and recent creation, two criteria will be considered: 1) dating earth ages by use of fossils found in rock layers and, 2) determining earth ages by radioactive dating. Each will be considered in turn. It should be noted, verifiable ages are limited to recorded history. For prehistory, dating methods give only theoretical ages. Nothing is actually known to be 5 million years old, 50 million years old, or any other vast age.

DATING ROCK LAYERS BY FOSSILS

The concept of evolution teaches that different groups of creatures evolved and changed over long periods of time. By noting the appearance or absence of fossil types in rock layers and using the hypothesis of correlation, relative evolutionary ages are assigned to fossil-bearing rocks. For example, trilobites are regarded as important fossils for denoting Cambrian rocks. Dinosaurs label the Cretaceous Period. Evolution theory uses fossils to establish the hypothesis of time correlation for earth history.

On the other hand, the abrupt appearance of all kinds of fossils in any order in successive rock layers is a strong argument for recent creation. Furthermore, abruptly appearing fossils have no relative age significance. Fossils found together show only the nature of the environment in which they lived (1). If we consider these differences, we can determine whether fossils in strata verify long term evolution or appear abruptly in unpredictable order characteristic of creation.

Layering Problems

Layering problems exist widely in nature. One common problem leaves large gaps in the evolutionary record. For example, situations are found where Silurian layers are entirely

missing and Devonian rocks sit directly on Ordovician rocks. This produces a gap of 40 million years of evolutionary time.

A second evolutionary problem occurs when rocks containing older fossils are found lying parallel above rocks containing younger fossils. For example, Permian rock layers are found resting directly on presumably younger Cretaceous rocks. The age gap at such a contact is 220 million years and the layers are in the wrong order with the older on top of the younger. Can such evolutionary dating problems be explained?

A key for making evaluations is the nature of the contact between such layers. Two types of contacts exist: conformable and unconformable. A simple contact of parallel bedded layers is called a conformity. At a conformity no evidence of erosion, weathering or physical disturbance of the lower layer exists—no such indicators of the passage of time.

In contrast, at an unconformity, the layers form an uneven contact. The lower layer has a surface which shows erosion prior to the upper layer deposition. With these criteria we can look for the passage of time.

Gaps in the Geologic Record

A classic case of missing layers or age gaps in the geologic record exists near Nashville, Tennessee. Although all layers are conformable, the middle Devonian age Pegram limestone has large age gaps at both its upper and lower contacts (2). At the bedding plane separating the Pegram from the middle Silurian age Lego limestone below, there is a gap of 40 million years in the evolutionary fossil record. Likewise, between the parallel deposits of Pegram limestone and upper Devonian age Chattanooga shale, fossil dating shows another time lapse of 20 million years. In other words, based on the hypothesis of fossil correlation, 60 million years of evolutionary history are missing at the two contact lines of the Pegram limestone.

The Chattanooga shale provides countless gaps in the geologic record. Originally, this thin layer of shale covered 40 per cent or more of the contiguous 48 states and extended into Canada and Mexico. This upper Devonian age shale sits flat and parallel on layers of many different ages (3). For instance, in central Tennessee, Chattanooga shale sits directly and conformably on Ordovician rock. According to the geologic column, 90 million years are missing. There is no erosional relief between the layers. There is no physical evidence for the passage of 90 million years.

Grand Canyon Age Gaps

The same evolutionary problems are exposed on a larger scale at the Grand Canyon. Mississippi age Redwall limestone, forming cliffs more than 600 feet high, is one of the most prominent structures in the Grand Canyon. Fossil dating shows major time gaps at the top and bottom of the Redwall. Missing fossils create an age gap of 20 million years between the top of the Redwall and the layer of Supai sitting on it (4). The parallel uneroded contact is visible for long distances and covers a vast area. This simple bedding plane and 20 million missing years are self-contradictory.

At the base of the Redwall, a much larger gap of time is missing. The Redwall sits directly on the Cambrian Muav limestone. The Ordovician, Silurian, and essentially all of the Devonian are missing from the interface. Devonian rock occurs in a few, rare channel-shaped outcrops in the Canyon (5). All told, 180 million fossil years are missing. The bedding plane is simple, shows no erosion, and extends for hundreds of miles. The Redwall-Muav contact line and millions of years of erosion are self-contradicting.

An additional indicator that shows the real age of the Redwall-Muav contact occurs on the North Kaibab Trail. There the Muav and Redwall are interbedded. The interbedded sequence starting at the lower contact is Muav/Redwall/Muav/Redwall. Although the hypothesis of time correlation by fossils makes the Muav 180 million years older than the Redwall, the interbedding indicates the two layers are the same age.

Wrong Order Layers

Layers in the wrong order are the second type of exception to the evolutionary fossil sequence. The Alps have various major problems. In Switzerland near Glarus, a wrong order arrangement exists. The oldest rock is found on top and the youngest layer is at the bottom. To get this arrangement, some geologists have speculated that rock sheet sliding occurred.

When sliding, also called overthrusting, occurs, interlocking surface rock breaks off, producing fragments and grindings. One evidence of movement is a layer of ground up rock called gouge between the two hard rock surfaces. A second evidence is when a layer of pulverized and fractured rock is found. This fragmented rock material is called breccia. A third evidence is scraped and grooved surfaces caused by the sliding rock sheet, an effect called slickensides.

Returning to the Glarus exposure, it has been proposed that the upper layers slid 21 miles before forming the visible contacts (6). The layers are bedded evenly together, with gouge, breccia and scraped surfaces missing. There is no evidence of movement, no 21 mile overthrust.

The Empire Mountains in Arizona have layers arranged in the wrong order (7). Upper Permian formations are found on top of middle Cretaceous age rocks. By evolutionary fossil dating, the Permian rock is 150 million years older than the Cretaceous rock below it. The bedding layers form a wavy interlocking contact. Gouge, breccia and scraping on contacting rock surfaces do not exist. When interpretations do not use the evolutionary fossil dating hypothesis, there is no 150 million year wrong-order age problem. The Permian fossils in the upper layer are simply younger than the Cretaceous fossils below.

Wrong-Order Strata at Glacier Park

Glacier National Park is another location to test the evolutionary hypothesis of fossil correlation. All the high rocks are classified as Precambrian age. They are said to be a billion years old. Below them, Cretaceous age fossils are 900 million years younger than the Precambrian mountains above them.

To account for this fossil mix-up, some geologists postulate that the upper Precambrian layers slid over the lower Cretaceous layer, forming the huge Lewis Overthrust. The overriding strata sheet would have been at least 3 miles high. Moreover, it has to slide 50 miles. Superb evidence of sliding should be found at the contact zone, but evidence of sliding does not exist.

In Canada, near Crowsnest Mountain, an exposure of the Precambrian/Cretaceous contact is found. The contact is a simple bedding plane with Precambrian rock resting directly on Cretaceous limestone. There is no gouge, no breccia, no scraped surfaces. Rock sliding is entirely absent. There is no evidence for 900 million years.

Just inside Glacier Park, another view of the contact is found. Chief Mountain is Precambrian rock resting directly on Cretaceous shale. There is an undisturbed bedding plane between the gray limestone and the black Cretaceous shale. Further south, along Dry Fork Creek in Glacier Park, white Precambrian limestone sits directly on black Cretaceous shale. The contact is a sharp separation line. There is no indication here that a three mile high rock sheet slid across the black shale surface for many miles. The rocks show no crumbling or fragmentation.

Forces greatly exceeding rock strength would result from a sliding rock sheet. A moving rock sheet the size of the Lewis Overthrust would cause shear forces of 16,500 pounds per square inch at the contact line (8). The laminar structure of the shale has very low shear strength and the limestone is not that much greater. Moreover, the compressive force on the rocks pushing such a huge sheet greatly exceeds their compressive strength. The thrust sheet should break into large blocks which would subsequently rotate as the sheet moved (9). Such physical evidence is entirely absent.

At Marias Pass, Precambrian limestone forms a continuous cliff above the sloping shale. Once again, the limestone is found sitting directly on Cretaceous shale. This wrong-order strata covers more than 12,000 square miles. Evolutionary explanations for this wrong order originated at the start of this century. All efforts to explain the mechanical paradox have failed.

An obvious interpretation is that Precambrian rocks are in the correct order above Cretaceous fossils and the evolutionary hypothesis of dating rocks by fossils has failed. This makes meaningless all the vast-age claims based on fossil correlations.

RADIOACTIVE DATING THEORIES

Out of a vast number of radioactive determinations, now reaching about 15,000 each year, 269 dates are considered useful in supporting presumed fossil age transitions (10). To support evolution, ages calculated from radioactive element ratios must have good agreement with ages suggested by fossil correlations. On the other hand, if the calculated ages

with ages suggested by fossil correlations. On the other hand, if the calculated ages yield numerous discordances with evolutionary expectations, it could be concluded they agree with creationist predictions. By considering radioactive dating results, we can determine whether they support either evolution or creation. To evaluate radioactive dating, it is necessary to consider the three principal theories used; namely Uranium-Thorium-Lead, Rubidium-Strontium and Potassium-Argon.

URANIUM-THORIUM-LEAD DATING THEORY

There are large quantities of lead ore; millions of tons of lead are produced yearly. Uranium, on the other hand, is comparatively rare. Lead ores cannot be a by-product of uranium decay. Even over vast spans of time, available uranium could have produced only a small amount of the existing lead.

Most radioactive dating for the Uranium-Thorium-Lead dating theory is done by analyzing leads, uranums, and other elements that occur in crystalline rocks, mostly as contamination. Four separate age checks can be made on a single rock specimen; two calculations for uranium, one for thorium and one for a lead-lead ratio. Since there is a fixed time or starting point when crystalline rock forms, all four age measurements for the same crystal should be concordant; that is, they should agree. Many radioactive dating checks have been made. Concordance almost never exists. Gross age discordances within the same rock specimens are commonplace (11).

Lava

Lava flows have been considered good candidates for radioactive dating. Scientists once thought that dating lava would establish the time of eruption. Startling discordances have resulted from uranium-thorium-lead dating of recent lava flows. For example, dating a 1944 lava flow at Mount Vesuvius yielded the following results: a 5-billion-year lead-lead "age," a 6-billion-year uranium-lead "age," and a 12-billion-year thorium-lead "age," all for lava rock not even 50 years old (12).

A typical sample of Andean lava from Southern Peru gave a lead-lead "age" of 4.9 billion years, a Uranium-238 "age" of 11.7 billion years and a Thorium-lead "age" of 2 billion years. All this for a lava flow that is considered to be not very old (13). All values have been calculated using most recently published decay constants.

Molten Rock Mixing

As lavas and magmas move, the molten rock mixes. The radioactive isotopes and leads in the molten rock blend together in unpredictable quantities. This mixing violates a basic assumption of radioactive dating theory. The theory assumes that originally only radioactive parent isotopes were in the mineral. This assumption appears inaccurate.

Consider two samples being mixed together—one containing only parent isotope and the second only daughter isotope. Based on quantities of materials known to be present, the isotope mix will indicate a great age, perhaps many billions of years. But since the sample was just mixed, a vast age is obviously a false conclusion. The illustration is simple, but it simulates mixing that occurs widely in nature.

Mixing has been studied by comparing typical discordant samples with an equal age curve obtained by plotting isotopic ratios for the two uranium-lead dating methods against each other. The discordant samples often plot as a straight line. It has been shown that mixing produces all points on the straight line (14). Numerous results that give straight lines indicate the isotopes are the result of mixing and have nothing to do with any radioactive "age" for rocks.

Uranium Ores

Uraninite, once thought to give the best dating results, has recently proven to be extremely discordant. Examination of uraninite ores and minerals from Wyoming, Utah, and Washington yielded ratio-ages ranging incredibly from minus (-) 50 billion years for a pyrite sample from the Midnight Mine to a plus (+) 11 billion year age for a pyrite sample from Gas Hills district. Numerous other lead-207/lead-206 ratios also give negative ages. (A negative age means that an event is yet to happen. In other words, the sample you have in your hand doesn't exist)(15).

Not only is age dating theory meaningless for uranium ores, similar problems exist for crystalline rocks. Daughter leads produced by decay should exist with parent isotopes. However, leads in a rock can be isolated from their supposed parents. This suggests isotopes are nothing more than contamination trapped when the rock crystallized.

Lunar Rocks

Historically, it was thought lunar material would solve many dating discordances. But this did not happen. Much discordance exists in lunar rocks. More importantly, a troubling new problem arose for uranium-lead dating theory. Excess thorium-230 was found in a number of lunar rocks (16). Excess thorium-230 (half-life 80,000 years) has the effect of negating key parent elements of the uranium-238 decay series since it cannot possibly have resulted from them. This shows the decay series is out of balance.

Moreover, the alpha spectrometer on Apollos 15 and 16 discovered elsewhere on the moon local excesses of radon-222 and polonium-210, which are decay products of thorium-230. This suggests there is considerable excess thorium-230 in lunar rocks. Lunar rocks containing thorium-230 cannot be old because the excess thorium-230 should decay to near equilibrium levels in a few half-lives. An out-of-balance decay series violates an essential dating theory assumption. Uranium-lead dating is meaningless when a key assumption fails.

Uranium-thorium-lead is now seldom used in fossil dating. Eighty years of investigation indicates there is no assurance that even one uranium-thorium-lead isotope age has credibility.

Rubidium-Strontium Dating Theory

Rubidium-strontium dating is another highly regarded theory. Quantities of rubidium and strontium, determined for various minerals in a rock, frequently form a straight line when graphed. Rubidium-strontium straight lines can also be accounted for by mixing of molten source rocks. There is no compelling scientific reason to credit rubidium-strontium ratios with age dating significance (17).

Potassium-Argon Dating Theory

Radioactive ages for fossil dating of the geologic column are primarily based on the potassium-argon theory. Potassium-argon dating gives mostly discordant data. Minerals taken from the same rock source usually give conflicting, discordant ages (18). Discordant, conflicting and absurd results have been curtailed by restricting dating to a few selected minerals containing higher percentages of potassium (19). Increased potassium content usually prevents potassium-argon ratios from giving preposterously high ages. Biotite, a potassium mica, is the mineral most highly regarded in potassium-argon dating theory. Many investigators consider that biotite gives the most desirable results from among the discordant minerals.

A vital assumption in potassium-argon dating theory is that at time "zero" no argon is in the rock. This requires that primary or pre-existing argon bound in the crystalline rock structure be driven out. Presumably, this occurs for volcanic rocks during their molten phase. The fountaining of fluid lavas is caused by volatiles, mostly water, escaping from the molten rock.

Volcanic Rocks

Various examples show that all primary argon is not necessarily driven out of the rock during the molten phase. On the Big Island of Hawaii, the last active flow of Hualalai volcano known as the Kaupulehu flow, took place in 1800-1801. Thousands of tons of angular and subangular dunite and gabbro xenoliths are found in the lava (20). Although the lava flow is less than 200 years old, the xenoliths have potassium-argon ages reaching 3 billion years (21).

Salt Lake Crater in Honolulu was an active volcano in the not too distant past. Various volcanic minerals from the crater have yielded discordant potassium-argon ages as old as 3.3 billion years (21). This makes the mineral ages billions of years older than the ages assigned to the volcanic crater and the island itself.

Potassium-argon dating done on lavas at other volcanoes using preferred minerals has given radioactive ages far older than the source volcano itself (22). There is no way to know with any certainty that any unrecorded, prehistoric eruption meets the assumption that all the primary argon was driven out. Moreover, scientists recognize that molten rock which does not surface can contain most of the argon that pre-existed in it (23). Potassium-argon dating of igneous rock has doubtful merit.

Volcanic Ash and Tuff

A popular material for radioactive dating is consolidated volcanic ash, called tuff. Layers of tuff are often closely associated with fossils. Although tuff can be dated by the potassium-argon method, the results are highly unreliable.

Volcanic ash and tuff result from volcanic explosions. Mount St. Helens is a case study for the formation of volcanic ash and tuff. About one cubic mile of rock was blown off the top of Mount St. Helens. This rock never reached a temperature that would drive out argon. While the rock is fragmented and scattered widely, tests have shown that very tiny particles still retain considerable entrapped argon gas (24). Consequently, there is no assurance that the potassium-argon "clock" has been reset to zero in any volcanic rocks or ash.

For example, typical results for potassium-argon dating of volcanic ash layers are reported for three age-equivalent Nevada locations (25). Samples were collected from volcanic ash layers and 14 potassium-argon age determinations were made. All ages were glaringly discordant, varying from 6 to 141 million years. Contemporaneous layers a few feet apart had grossly discordant ages. Different minerals from the same layer had grossly discordant ages. Compounding the problems are the lack of mechanisms to explain the discordances. The potassium-argon dating theory is not convincing with typical volcanic rock samples.

Glaucanite

Fossils are found directly in one other mineral that is used for potassium-argon dating. The mineral is glauconite, a type of mica found in sedimentary layers. The use of glauconite for potassium-argon dating is controversial because of its inconsistent results. The controversy can be easily understood by considering potassium-argon dating of recent age glauconite. Samples collected from five global locations all had discordantly high age. Glaucanites, all considered younger than 100,000 years, had potassium-argon age discordances even exceeding 500 million years (26). Recent age micas should contain almost no argon. Why they contain large amounts of argon cannot be explained. It is not possible to date fossils convincingly using a mineral which has such great and obvious problems.

CONCLUSION

What is clear is that discordance and uncertainties make radioactive dating inexact. However, in spite of countless glaring discrepancies, often a preferred age is picked out of the scattered data. Preferred ages appear to be ages that best fit the investigator's preconceived notions. This "chronology by scatter" is dubious science. Most likely, isotope ratios have no relation to rock ages at all. Potassium-4, argon-40 and other isotopes appear to be included in rocks by various natural processes. No way exists to validate that any sample has an isotope ratio that gives a meaningful age apart from correlation with recorded historical events.

Likewise, in using fossils for dating rock layers, countless exceptions outnumber verifications of the theoretical evolutionary sequence. Moreover, verifications often are sketchy, based on only one or a few "index" fossils. Furthermore, physical signs to validate both the vast age gaps in the geologic record and wrong-order layers are commonly missing. While it is very popular to publish vast age interpretations, the geologic and radioactive dating results appear to contradict rather than confirm such claims.

REFERENCES

1. This interpretation was first proposed by T. H. Huxley, Geol. Society London, Quart. Journal, Pr., Vol. 18, xl-liv, 1862, Huxley coined the term "homotaxis."
2. C. O. Dunbar and J. Roger, Principles of Stratigraphy, 1957. The Lego limestone is middle Silurian age, the Pegram limestone is lower middle Devonian and the Chattanooga shale is upper Devonian age. Also see geologic map of the Kingston Springs Quadrangle, Tenn., The Pegram is about five feet thick.
3. T. H. Clark and C. W. Stearn, Geologic Evolution of North America, 168, 1968.
4. Geological Survey Professional Paper, 669, 49, 1969. Geologists have observed that 20 million years of exposure is hardly noticeable along the top of the Redwall.

5. A typical exposure of a small Devonian channel can be seen in Geological Survey Professional Paper 669, page 38, Figure 14B. Between the few small outcrops of Devonian rock, miles of parallel bedding between the Redwall and Muav exist.
6. K. J. Hsu, Ecologiae Geologicae Helvetiae 62, 143, 1969.
7. F. W. Gailbraith, So. Arizona Guide Book, No. 2, Arizona Geological Society, 21f, 1959; also C. L. Burdick and H. Slusher, C.R.S. Annual, 49, June 1969.
8. Values for friction were taken from J. Byerlee, Pure and Applied Geophysics, 116, Part 4, 614, 1978. Calculations for the normal force are based on a density of 2.85 for the limestone (dolomite). The normal force for the Lewis Overthrust strata is 1345 bars.
9. See Report on thrust sheet fracture and block rotation by H. Drewes, Geological Survey Professional Paper, 413, 1963.
10. W. B. Harland et al, A Geologic Time Scale, p. 61 (1982).
11. D. Gebauer and M. Grunefelder in Lectures in Isotope Geology, p. 105 (1979). Ed. by E. Jager and J. C. Hunziker. Also see discordances cited in Encyclopaedia Britannica, 5, 505 (1976).
12. V. M. Oversby & P. W. Gast, Earth and Planetary Science Letters 5, 199 (1968) gives data for Mt. Vesuvius and other recent volcanic flows.
13. G. R. Tilton and B. A. Barreiro, Science 210, 1245 (1980). Calculations made on Sample No. PE 49.
14. R. Arndts et al, Radiometric Dating, Isochrons and the Mixing Model (1983).
15. K. R. Ludwig et al, Economic Geology 76, p. 105 (1981); K. R. Ludwig, Economic Geology 74, 1661 (1979).
16. J. N. Rosholt and M. Tatsumoto, Lunar Science IV, 634 (1973).
17. The meaningless age significance of straight line "isochrons" can be seen in the "psuedo-isochrons" reported for the lavas in Southern Peru and northern Chile. See D. E. James et al, Geol. Soc. Am. Bull. 87, 592 (1976); J. Klerk et al, Volcanoe Geotherm. Res. 2, 49 (1977) and A. H. Clark et al, Earth and Planet. Sci. Lett. 27, 305 (1975).
18. P. E. Damon in Radiometric Dating for Geologists (ed. by E. I. Hamilton and R. M. Farquhar), Table 5, p. 14 (1968).
19. Suitable minerals for dating are restricted to those listed in Table 10-1, page 166 of Potassium-Argon Dating, G. B. Dalrymple and M. A. Lamphere (1969).
20. H. T. Stearns, Geology of the Hawaiian Islands, p. 38, 1967.
21. J. G. Funkhouse and J. J. Naughton, Journal of Geophysical Research 73, 4601 (1968). The 1801 Kaupulchu flow has a pyroxene "age" of 2.96 billion years while a garnet periodotite from Salt Lake Crater reaches an "age" of 3.3 billion years.
22. Cited by G. A. MacDonald et al, Volcanoes in the Sea, 302 (1983).
23. P. E. Damon, loc., cit., p. 17. Also R. L. Armstrong, Potassium-Argon Dating, ed. by O. A. Schaeffer and J. Zahringer, 120 (1966).
24. P. E. Damon, loc., cit., p. 18, reports that grinding rock down to 5 to 10 micron size has resulted in argon gas loss from the rock of no more than 30 to 50 percent.
25. L. A. Metcalf, Tephrostratigraphy and Potassium-Argon Age Determinations of Seven Volcanic Ash Layers in the Muddy Creek Formation of Southern Nevada (1982).
26. G. S. Odin and M. H. Dodson, Numerical Dating in Stratigraphy, ed. by G. S. Odin, 285ff (1982).