EDITORIAL

BUT IS IT AS MUCH FUN?

It is to be expected that where there is a diversity of opinion between groups, a misunderstanding of the other's position will inevitably result. Because of limits in resources and time it is natural to concentrate one's efforts in areas which one believes to be correct and gain only glimpses of what the other side believes to be true. The discourses between proponents of creationistic and evolutionary thought provide a good example. With their minority position and a certain defensiveness, a case could be made, however, for a claim that creationists better understand the basis from which evolutionary thought arises, than the converse. If one uses information taken from recent publications, as well as from letters to editors in journals such as *Nature* and *Science*, one is impressed at how poorly the creationist stance is understood by those of an evolutionary mind.

The presumption that the presence of God in a scientific discipline somehow makes science unpredictable, unusable and not even much fun is a recurring and very troubling theme. If the basis of science rests on reproducibility, experimentation and model testing, the entrance and action of God into this scheme is considered to mess things up because one does not then know whether the results one sees are from natural events or the finger of God.

Man is a creature who looks for cause and effect and is driven to place the Universe in some intellectual order. With this order comes assurance that life can be lived with only a limited number of surprises. An existence where nothing is the same from moment to moment would be most troubling. Some psychiatrists suspect that certain emotional disturbances are rooted in one's inability to see form and pattern in one's surroundings, thus leading one so affected to withdraw into some inner space, or to become wildly erratic. Thus the evolutionists' charge that the entrance of God into the natural world destroys the rational mind's ability to cope is indeed important and needs to be considered seriously.

Let us therefore see if the charge has any validity. If one examines the number of supernatural events attributed to God or His human associates, one quickly realizes how very infrequently God has indeed put His finger unpredictably into the world about us. Using a time span of thousands of years from creation to the present, the number of observed events considered by more than a few individuals to be miraculous departures from generally observed laws of nature would probably not average more than one or two per century. This is a number far less than the numerous unique events thought by scientists to have occurred for which no solid explanation exists but which are inferred from fragmentary data.

Even with those infrequent events of Divine origin there is a significant difference. With the exception of the creation account, the majority, if not all, of God's entrances into the human sphere have been preceded by a statement of what was going to take place. It is almost as if God realizes the importance for humankind to recognize order in his surroundings, and thus protects him from falling into a confused state by saying that He will enter the human domain and will do the following acts. Rather than providing surprises, God notifies humankind of an event so that the process can be watched and understood.

This last consideration brings me to a final thought. Only sometimes stated but often implied is the idea that science in the presence of God is just not much fun. Part of this feeling may arise from the fact that science, in its race into the unknown, rewards the first one there with such honors as fame, position, and research grants. The Ph.D. system of education demands that the student discover something new. If it is learned that the research had been done already by another, the subsequent work is not considered sufficient to fulfill the requirements. Thus to say that what I am learning is already known by God (even though He may keep it a secret) can put a damper on the excitement of discovering the new. But this attitude should be viewed as an emotional and maturation problem rather than a scientific one.

I should like to propose that rather than taking away from the pleasure of doing science, a knowledge of the actions of God could increase its pleasure. Subtle hints of forces and conditions in areas about which our knowledge is very limited are given when God is described as entering our world. Why could not these be used as a basis for thought and experiment?

If science is the pursuit of knowledge, would it not be wise to use all sources of information available as a starting point? Would not the rate at which new knowledge is acquired increase, rather than decrease, as is often thought? It seems to me that instead of inhibiting the cause of science, the entry of God into the human realm could be a way to make more new and exciting discoveries of the world around us. One could only wish He did it more often.

Richard D. Tkachuck

ARTICLES

PRECAMBRIAN POLLEN IN THE GRAND CANYON — A REEXAMINATION

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WHAT THIS ARTICLE IS ABOUT

Primary in evolutionary thought is the concept that the geologic column has great validity. As geologists observe the rock strata around the globe, most would insist that its fossil record represents a description of life in the past. Implicit in this argument is the assumption that there is an orderly appearing of organisms from the more simple in the lower strata to the complex in the upper layers. This claim for orderliness in the fossil record has been challenged by creationists with claims of finding in the very lowest layers fossil remains of organisms that should have evolved hundreds of millions of years later. If such observations were indeed true, they would be a serious blow to the evolutionary concept. In the early sixties, Clifford Burdick claimed to have discovered pollen of modern plants in Precambrian rocks — rocks that were reportedly older than almost all known forms of life. Dr. Chadwick reexamines this claim. He has not been able to confirm Burdick's findings. However, Chadwick does point out that this type of irregularity in the fossil record has been reported by several traditional geologists and that these findings pose a challenge to one of evolution's fundamental tenets.

In 1966 C. L. Burdick published the remarkable claim that evidence exists for the presence of flowering plants in the lowest layers of Precambrian sedimentary rocks of the Grand Canyon. The magnitude of this claim can be more clearly understood by considering that the remains of vascular plants are almost unknown as fossils in the lower third of the Phanerozoic rock record, and that flowering plants are usually considered to be restricted to the Cretaceous and above. Burdick's evidence for the existence of these plants in the Hakatai Formation (Precambrian) was obtained from rocks lower in the geologic record than the remains of any previously reported vascular plant. During recent years, this paper has been cited on numerous occasions as a landmark for creationists (e.g., *Bible-Science Newsletter*, June 1981). Evolutionists on the other hand have by and large considered such results as an impossibility and have concluded, without seriously scrutinizing the data or reinvestigating, that his data resulted from contamination. Clearly such a discovery demanded both careful scrutiny and independent reinvestigation and, if authentic, deserved wide publicity. However, no such detailed account has yet been reported. Thus a careful reevaluation is in order and is long overdue.

In 1971 I obtained a collecting permit from the National Park Service and accompanied C. L. Burdick to the Grand Canyon. His previous sample localities were relocated and new samples were collected, returned to my

laboratory at Loma Linda University and processed by C. L. Burdick using techniques similar to those he had employed in his earlier work at the University of Arizona. On the basis of results from these samples, Burdick (1972) published a second paper claiming substantiation of his earlier paper. It is unfortunate that Burdick chose to publish the results of this work without waiting for independent confirmation. In this second article, as in the first, he figures several objects which are not identifiable and several pollen grains which are either modern or of modern affinities. However, he made the claim [challenged in a subsequent cautiously worded report (Chadwick, DeBord & Fisk 1973)] that these data supported his previous findings. In a sense they do, in that both papers figure grains which are clearly modern in aspect and indistinguishable from grains abundant in the present pollen spectrum of the Grand Canyon region. However, the conclusion that these findings support the concept of Precambrian higher plants is a *non sequitur* until all cause for concern regarding modern contamination has been eliminated. It was with this goal in mind that the work reported herein was undertaken.

MATERIALS AND METHODS

A second trip was made to the Grand Canyon in 1972. The collection sites described by Burdick were relocated and samples taken. Two subsequent trips were made to obtain additional samples. Particular attention was paid to the collecting and storing of materials so as to prevent field contamination. In the laboratory the samples were thoroughly washed using filtered water and soap, then all external surfaces were removed using a trim saw with non-recirculating coolant. The entire external surface of the freshly exposed rock was scrutinized to eliminate samples with microfractures or other flaws. Processing was by standard techniques (e.g., Doher 1980), except that unusual precautions were taken to prevent contamination. All solutions were filtered, the room was maintained under positive pressure with a filtered air supply, and all glassware was scrupulously cleaned using filtered water and soap. Special recovery techniques were employed to prevent accidental loss of material during processing (Chadwick 1980).

Slides were scanned in their entirety with overlapping scans at a magnification of approximately 200 and 500×. Records were made of any material of biologic or suspected biologic origin.

RESULTS

A total of fifty samples from the same strata which Burdick had studied were processed. All slides were completely scanned. No single example of an authentic pollen grain was obtained from any of these samples. In fact, the slides produced from the Hakatai Formation were in most cases completely free from any material of biologic origin, modern or fossil.

DISCUSSION

Before considering the implications of the above findings in relation to the data presented by Burdick, let us briefly review a little of the sedimentary history of the Grand Canyon.

The walls of the Grand Canyon expose rocks ranging from Permian at the top to Precambrian at the base. Below the Cambrian Tapeats Sandstone, the first layer containing the authentic remains of metazoan fossils, lie 12,000 feet of sediments which in nearly every detail but one are similar to various sediments found higher up in the rock strata. That one detail is the absence of the indisputable remains of metazoan life forms in the Precambrian rocks.

The Hakatai Formation from which Burdick obtained his samples occurs in the lower portion of this section. Almost 10,000 feet of Precambrian sediments separate this deposit from the first rocks (Tapeats Sandstone) containing the undisputed remains of metazoan life. Prior to the deposition of the Tapeats, these Precambrian sediments were lithified, tilted and eroded away to a depth of over two miles in places. The evidence that these Precambrian sediments were already hardened into stone before their uplift and erosion is clear: large angular fragments of indurated and fused quartz sand from the Precambrian Shinumo Formation (which overlies the Hakatai Formation) were incorporated into the Tapeats Sandstone.

The scenario required by Burdick's data, if correct, is as follows. First, Hakatai mud accumulates. As it does so, grains of pollen from conifers, ephedra, composites and other plants similar to those found presently at the Grand Canyon fall into the mud and are buried. Subsequently nearly 10,000 feet of sediment accumulate on top. These layers become subjected to diagenetic alteration and are converted into hard rock. The layers are uplifted and tilted, and two miles of solid rock and sediment are eroded away over large portions of the Colorado Plateau. Then the influx of sediment begins again as the Cambrian sediments accumulate, and this time abundant remains of living organisms are preserved.

The simplest hypothesis to explain Burdick's data is that the pollen grains he reported in 1966 and in 1972 were modern contamination picked up either during collection and transportation or infiltrated into the sample itself prior to collection. Palynologists are well aware of the constant danger of contamination at all stages in sample collection and preparation. The kind of questions one asks when faced with this possibility are as follows:

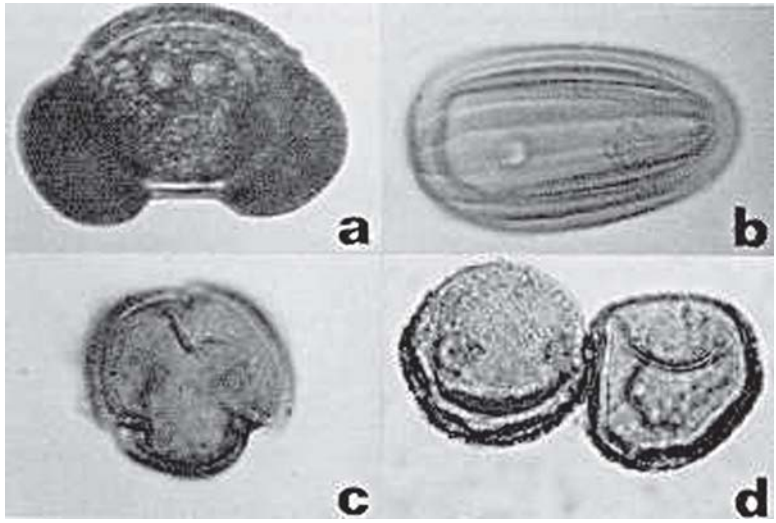
1. do the pollen and spores found in the sample match grains from modern plants in the area?
2. does the preservation of the grains accord with the level of preservation of other organic material in the sediments?

3. do the grains make good sense in the stratigraphic setting in which they were found?

With respect to these questions we can draw the following conclusions from Burdick's papers.

1. No rigorous attempt was apparently made by Burdick to evaluate personally the modern pollen rain in the Grand Canyon. A single sample of soil from near one of the collecting sites could have completely satisfied Burdick as to the source of most of the grains he has reported. A typical analysis of a site near where Burdick collected his Hakatai samples yielded the following profile: bisaccate pollen (conifers) 30%; juniper 12%; ephedra 16%; various species of angiosperms (42%) (Sigels 1971). Although the poor quality of the photographs in the plates of Burdick's first paper makes definite assignments impossible, one can approximate the composition of the flora he reports. Of the grains identifiable as pollen or spores in the two papers by Burdick (n=18), 7 or 37% are bisaccates, 2 or 11% are possibly juniper. Ephedra pollen constitute 11% and angiosperms and unassignable grains 34%. Thus even with this small sample

FIGURE 1(a-d). Some typical modern pollen types from tree species presently growing in the Grand Canyon region. (a) Pinus sp., cf. Burdick 1972, figure 3; (b) Ephedra nevadensis, cf. Burdick 1972, figure 5, also Plate I, figure 3, probably Ephedra torreyana, the other Ephedra species in the Grand Canyon; (c) Quercus sp., cf. Burdick 1966, Plate IV, figure 4; (d) Juniperus scopularum, cf. Burdick 1966, Plate II, figure 4.



size, Burdick's grains approximate the modern pollen rain found in surface samples *in the area of the Grand Canyon where he collected his samples*.

2. The preservation of the grains which Burdick figures in his first paper is difficult to estimate because of the poor quality of the photos. In the second paper the grains appear nearly fresh. The complete absence of organic material other than the pollen and spores cited by Burdick makes comparisons difficult, but many analyses from other Precambrian rocks where organic remains are thought to occur reveal little more than carbon films. Considering the deep burial, lithification, and oxidized condition of the Hakatai shales, the state of preservation of these grains suggests that they were not a part of these sediments during their diagenesis. Incidentally, the red color of the grains, cited by Burdick as an indication of their antiquity, if not due to laboratory staining procedures commonly employed, is in any case not necessarily an indication of antiquity since the ferruginous stain in the rocks can be readily acquired (as any Grand Canyon hiker will testify).
3. While one may tend to consider the third point as introducing bias, only a tyro of earth history would lay aside the general orderliness of the stratigraphic record as meaningless. Clearly the general absence of the remains of higher land plants from the Precambrian and lower Phanerozoic rock record does have meaning. It does not however indicate that the plants were not on the earth somewhere contemporaneously, since it is also possible that they were not often preserved or incorporated into the rocks. More difficulties are created than are solved by Burdick's report since it would require the explanation of the accumulation of all the Upper Precambrian sediments (10,000 ft.), their lithification and subsequent erosion before the first additional fossil forms were buried. Add to this picture the many thousands of macerations of lower Paleozoic and Precambrian rocks which have been carried out in scores of palynology laboratories around the world which have not supported Burdick's claims. There is a general absence of evidence for flowering plants below the middle Cretaceous. It is a responsibility and challenge to creationists to develop a model of earth history which explains this absence.

Unfortunately it is not an easy task to correct a positive report such as Burdick's with negative data. In our hands, application of the cardinal principle of the scientific method — reproducibility — has failed to authenticate his record. Thus the hypothesis that the grains are authentic

examples of Precambrian pollen can only be treated with incredulity at present, even among creationists.

ONE POSITIVE NOTE

Although there may not be evidence for Precambrian pollen in the Grand Canyon, there is one thoroughly documented report of the occurrence of pollen and vascular tissue of higher plants which does support the existence of angiosperms earlier in the fossil record. The story surrounding the discovery of authentic higher plant remains in the Saline series of the Salt Range in Punjab, India, and its subsequent elaboration is anecdotal but nevertheless is worth investigating. Although the subject of the Salt Range beds is proscribed among Indian and many western paleontologists today, the case rests precisely where it did 30 years ago (Ghosh, Sen & Bose 1951). The fossils are modern in aspect ("Eocene" according to Sahni 1944) yet the beds containing the fossils are overlain conformably by early Cambrian sediments (Coates et al. 1945). Creationists who wish evidence for the existence of angiosperms early in the fossil record should cite this well-known case.

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ARTICLES

THE WORD "EARTH" IN GENESIS 1:1

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WHAT THIS ARTICLE IS ABOUT

Genesis 1:1 states that "in the beginning God created the heavens and the earth"; however, a serious question can be raised as to what is meant by the word "earth." Is it the physical (inorganic) material of our planet, the planet itself as part of our solar system, or the ground upon which life exists? This study presents a linguistic analysis which reveals that the usage of the word "earth" in its Near Eastern setting is as varied as its present-day usage. Among the meanings of "earth" are the concepts of the whole world (or universe), a ruler's territory, the sphere of human life, and land (or ground). In the context of Genesis 1:1, it is not possible to circumscribe the Hebrew term to fit any specific category.

A time problem is presented in Genesis 1:2, because it seems to imply preexisting material on the first day of creation. Among creationists are two major divisions of thought concerning the meaning of this verse. While one view postulates that both life and the inorganic matter of our earth was created during creation week, others interpret the verse to allow for the possibility of the existence of the inorganic matter long before creation week. With the author's observations about the Hebrew usage of the word "earth," it is possible to allow for either an entire creation event of inanimate and animate material in close succession or a long interval between the two.

The opening sentence of the Old Testament is beautiful in its simplicity, "In the beginning God created the heavens and the earth." Even a child can understand it, and yet every single word in it has been the object of interpretative disagreement.[1] The word "earth" under discussion here is no exception. The question is, does it refer a) to the physical material of the earth;[2] b) to the planet earth as a part of our solar system;[3] c) or to our earth in the sense of the land upon which life can exist?[4] We will address this question very briefly by reviewing four problems. First we will examine the meaning and usage of the word "earth" (Heb. *ʾeres*). Secondly, we will consider the word in the context of Genesis 1:1. Thirdly, we will review the problem of Genesis 1:2. Finally, we will seek to ascertain what is the biblical conception of the physical world as expressed in this verse.

THE WORD "EARTH"

The Hebrew word from which the English word "earth" is a translation in Genesis 1:1 is *ʾeres*, and it is generally rendered "ground," "earth," or the like. Can we be more specific about its meaning? In answering this question the interpreter commonly begins by looking for the root meaning by examining the word in its Near Eastern context.

The most common Egyptian word for "earth" or "land" has several meanings ranging from "earth," "dust," "dirt," and "ground" to "land," "nation,"

and "country."[5] It also occurs with the word for heaven, thereby forming a word pair indicating the larger (deified) cosmos. Unfortunately it is not possible to determine which of these meanings is original.[6]

The Accadian language of ancient Mesopotamia employed several words for earth, but one, *eresetu*, is clearly related to the Hebrew *ʾeres*.[7] It is used together with the word *šamu* (heaven) to form the familiar pair, heaven and earth, meaning the whole world, or even universe. Interestingly enough, it also refers to the underworld, the land of no return, and less frequently to the land or territory of a ruler. Finally, it means "ground," the material which can be plowed, soaked in blood, and used for burial.

Closely related to the Hebrew language are the west Semitic dialects of Canaan and Phoenesia. In Ugaritic *ʾrs* means "earth,"[8] and again stands in antithesis to heaven/clouds, thereby indicating the sphere of human life. Elsewhere it specifies the ground to which someone can fall, upon which it rains, and from which produce grows.[9] Finally the word appears in the Mesha inscription (Moabite) meaning "land" (Chemosh is angry with his land).[10]

These illustrations could be multiplied, but the emerging picture would not change much. A word "earth," related to the Hebrew *ʾeres*, was used commonly in the ancient Near East with the meanings of "earth," "ground," and "land." Only its context will indicate if reference is made to the whole world (what we call the planet), to the surface of the earth on which life is lived, or to a territory of the earth.

The Hebrew *ʾeres* (earth) occurs more than 2500 times in the Hebrew (and Aramaic) Old Testament. To examine all of these, or even a good part of them, would take us beyond the scope of this essay. Nevertheless, even a cursory look at the word will suggest that its meaning varies within the Old Testament just as is the case with its usage outside the Old Testament, and it includes the idea of planet earth, earth surface, and land.

Thus, *ʾeres* refers to the whole earth (or planet, as we say); for example in expressions such as "the God of heaven and of the earth" (Gen 24:3), "creator of heaven and earth" (Gen 14:19, 22), and "Heaven is my throne and the earth is my footstool" (Isa 66:1). This does not mean that the earth was always perceived as a sphere then as now. Thus, it is described (poetically) as having four corners (Isa 11:12) and ends (Isa 40:28). It is also said to have a center; literally, a navel (Ezek 38:12), and it could tremble and quake (Ps 18:7) and stagger like a drunkard (Isa 24:19f).

Secondly, in addition to the two-part division of the world into heaven and earth (planet), a three-part division also appears in the Bible. Heaven is above, the water beneath, and the earth is the dry land in between (Exod 20:4; Ps 135:6). In these cases *ʾeres* (earth) refers to only the dry surface, or the land of the living (Ps 52:5; Isa 38:11). Of course, it also provides the dead with their graves (Isa 26:19; Ezek 31:14). Moreover, the dry dust and the waste places are part of it (Deut 28:23; 32:10; Ps 107:34; Jer 2:6). Thus, not just the earth's lifegiving surface, but its specific and various materials are indicated by *ʾeres*. A person can be pinned to it (1 Sam 26:8), and blood can be spilled upon it (1 Sam 26:20).

At this point ʾ*eres* receives a meaning akin to that of ʾ*adama* (ground, soil, earth),[11] but primarily it is the ground upon which life can thrive (Gen 1:11f; 27:28; Deut 1:25).

Finally, ʾ*eres* means "land" in the sense of circumscribed territory. Thus, we find "the land of the north" (Jer 3:18); "the land of the plain" (Jer 48:21); "the land of the fathers" (Gen 31:3); "the land of their captivity" (1 Kings 8:47); "the land of the Canaanites" (Exod 13:5); "the land of Israel" (1 Sam 13:19); "the land (territory) of Benjamin" (Jer 1:1); and "land of Yahweh" (Hos 9:3).

Once again we must conclude without a clear definition of our term. Earth, dry land, ground, territory, all are suitable and common translations of the Old Testament word ʾ*eres*. Only the context can guide us in the selection of a proper translation.

EARTH IN THE CONTEXT OF GENESIS 1:1

A contextual investigation is difficult to contain in a limited space, since the context of a verse or word compares well with the ripples a stone will make when thrown into the water. The problem grows larger even as one pursues it. Consequently, we can make only summary observations.

The immediate context is verse 1, specifically the expression "the heavens and the earth."[12] It is a familiar expression[13] that is generally taken as a reference to all — the whole world, on the grounds that heaven and earth are the outer limits intended to include everything in between, i.e., the whole world.[14] Of course, one could also read the expression as a reference to God's and man's residences or realms respectively (Eccles 5:2). In this case, the heavenly vault and the earthly surface would be the meanings intended. However, in the context of divine creation there is some support in the Old Testament for understanding these terms as an inclusion (of all things) rather than as a specification of the realms (Ps 136:1-9; Isa 40:21-23; 45:11f).

The whole translation of Genesis 1:1 is difficult, as recent versions of the Bible make clear.[15] This matter cannot be taken up here, except to say that verse 1 likely is a general introduction to the whole account of creation (Gen 1:1; 2:4)[16] and should be translated "In the beginning God created the heavens and the earth." Heaven and earth, then, is everything that follows in the account, beginning with God's first act of creating the light (v 3). Subsequently, the second day witnesses the formation of heaven (v 8) and the third day tells of the making of earth (v 10), followed by the creating of their respective contents (v 11 - 2:1).

The emerging earth (v 9) *yabašša* (dry land) is named ʾ*eres* (land) as opposed to the waters that are called sea. This might lead us simply to identify ʾ*eres* as the physical hard ground (earth, rocks etc.) were it not for the fact that the word ʾ*eres* (earth) is also used already in verse 2 to describe that which had not yet been separated into dry land and sea. Consequently, some may conclude that ʾ*eres* (earth) in the opening chapter of the Bible has at least two meanings. It obviously refers to the dry land (v 10) but also to the formless and void something that preceded it (v 2).

It seems clear that the first of these meanings, "dry land," dominates the rest of the chapter (v 11, 12, 20, 22, 24, 26, 29, 30). In one instance (v 25), the earth (*ʾeres*) is specifically identified with the ground (*ʾadama*) as though to underscore that point. However, in a few places a more global understanding of *ʾeres* may be preferable. Thus verses 14-19 speak of sun, moon, stars and their relationships to the earth. They are positioned in the firmament not only to give light, but also to measure seasons (festivals), days and years. It would seem that the solar system and its movements (as understood then) is being considered here. Genesis 2:1, 4 similarly speak of heavens and earth and their hosts, indicating, we may presume, the whole system, and thus complete the account that began in verse 1.[17]

We can thus draw the following preliminary conclusions. In general the word *ʾeres* (earth) refers in Genesis 1:1 - 2:4 to the dry land, in distinction from air and sea, on which plants, animals and man can live. In other words, *ʾeres* is the earth surface. Secondly, the account also implies that this earth is part of a larger system, including sun, moon, and stars,[18] and hence has a larger meaning than mere dry ground upon which to stand. It is at least a realm as well, the sort of thing we mean by the adjective "terrestrial." As such, it includes the sea for the fish and the air for the birds, both of which are created together on the fifth day before land animals. Thirdly, in the expression "heaven and earth," *ʾeres* is part of an inclusion encompassing everything God has created from the terrestrial to the celestial realm. However, here *ʾeres* is least instructive to our query, for it is concerned neither with the material nor with the territory of the earth, but simply with the lower end of the spectrum that describes God's whole creation. When we ask, therefore, what is the heaven and the earth God created in Genesis 1:1?, we probably should answer, everything that follows in Genesis 1:2 - 2:4, but chief attention is given to the earth, the fruitful surface that can sustain and maintain life.

THE PROBLEM OF GENESIS 1:2

This leaves us with the knotty problem of Genesis 1:2, a verse that is often used to describe the condition of the very first earth. But what is meant by the term "earth" here? A globe, physical material, or ground covered with water? Can we somehow penetrate the screen that hides God's creative work and know how he really did it at first? Several proposals have been made.

1) The verse describes the existence of the earth in the interval between the original creation of matter and the creation of life. Either it should be seen as raw material waiting to be shaped into an orderly earth,[19] or, following the so-called hypothesis of restitution,[20] it describes a world fallen in Lucifer-like fashion from its pristine glory (v 1).
2) The verse describes God's first work of creation, a watery dark earth, on Day 1 of the creation week. This view may place some strain on the sequence of God's works of creation beginning with light and ending with man, and could lead to the impossible

suggestion that God's first creative act was not good.[21] However, Young has argued that this first earth, created by God, was in fact good, though not yet ready for life.[22] Here ʾ*eres* would have different meanings in verse 2 and verse 10. The latter would show a development beyond the former.

3) The verse describes a chaos that stands not so much before creation as opposite creation, expressing an ever-present threatening possibility of divine judgment.[23] Here the earth of verse 2 is the earth of verse 10 as it would be or might be without God's creative power.

4) The verse describes the earth prior to creation and characterizes it as a "nothing," that is, as no more than a condition in which creation of the earth could occur. According to this very common suggestion, ʾ*eres* (earth) in verse 2 has no special meaning at all (just like a totally empty room has no content).[24] Here verse 2 reiterates the theme of verse 1, but in a negative sense, namely that God has created everything in the beginning.

This means that ʾ*eres* (earth) in verse 2 is not very helpful in resolving our question, unless, of course, we posit a gap between verses 1 and 2 so that verse 1 becomes a temporal clause and verse 2 a description of pre-existing matter, but that goes against some careful studies of the problem.[25] Alternatively, verse 2 does not contribute to a description of the created earth, unless we follow the view of Young, but that is endowed with serious difficulties, particularly, that the suggested divine creation of the earth in verse 2 does not follow the pattern of God's other works of creation. If we thus eliminate proposals 1 and 2, we are left with 3 and 4, neither of which contribute anything to our concept of the first earth, other than that God created it.

Consequently, we are thrown back upon Genesis 1:1 which announces in summary fashion that God created the heavens and the earth, followed by a description of this event. It would appear that the earth (ʾ*eres*) is the dry land upon which life can flourish, though it is recognized that this realm is part of a larger system (sun, moon, stars) that gives light and orders its temporal seasons.

THE EARTH IN BIBLICAL THOUGHT[26]

This leaves a final question. What conclusions can we draw from the above considerations regarding the geophysical questions with which we began? Does Genesis 1:1 report the creation of the material earth, the planet earth, or the land on the surface of the earth? To answer this, we must first inquire about the meaning of the word "earth." We have found that it generally means land (certainly in Gen 1 - 2:4), although with the awareness that there is more to the earth than just its land (v 14-19). However, when we put our contemporary question to the Bible, we must also inquire about the willingness of the Bible to acknowledge our distinctions and our reasons for making them.

For example, we distinguish between earth and planet because science has given us a long chronology for the existence of the planet, whereas the

Bible has given us a short chronology for the earth. But there is no evidence that the Bible was confronted by this problem. Rather, it distinguishes between the earth as land and planet (world) because the former represents the realm of human life and its dominion, whereas the latter is God's work and charge: thus God created the heavens and the earth (the whole world), whereas the earth (dry land) was made for life and for mankind. The distinction is based upon a perspective of function, not of chronology, and consequently no explicit temporal distinction between the two can be expected, nor indeed is found.

The best we can say about the creation of the earth in Genesis 1:1 is that it concerns this world, our earth, and that it involves the ecological system within which we live. Much more may need to be said about the geophysical questions in our time, but the Bible is generally silent about them. Thus, our finding that the word *ʾeres* (earth) refers primarily to the dry surface of our planet and to its life does not allow us to conclude that Genesis 1 portrays a second stage of a two-stage creation, first the matter of the planet, then the earth, with a temporal interval in between. It does allow a distinction of perspective between our world system, heaven and earth, and the earth as dry land with its life and territories, but any temporal distinction between them we will have to introduce on our own initiative, without the help of the Bible. It is not without significance, it would seem, that the Bible and the story of creation opens with a single word, *bᵉreʾšit*, meaning "in the beginning" (and not with the word "God," as some have thought). Hereby the Bible instructs us that anyone who wishes to understand its story of creation is not invited to inquire about what may have happened prior to the beginning, for at the beginning stands only God, nothing else. We are invited by the Bible to inquire about that which happened following the beginning of God's creation, but alas, it does not answer all our questions.

ENDNOTES

1. The literature is overwhelming and varied. See for example: (a) Eichrodt W, 1962. In the beginning. In: Israel's prophetic heritage (NY), p 1-10; (b) Hasel GF. 1972. Recent translations of Genesis 1:1: a critical look. The Bible Translator 22:154-167; (c) Young EJ. 1964. Studies in Genesis one (Philadelphia); (d) Ridderbos NH. 1958. Genesis i:1 und 2. Oudtestamentische Studiën 12:214-260; (e) Schmidt WH. 1967. Die Schöpfundsgeschichte (Neukirchen); (f) Westermann C. 1967. Genesis BK1/2 (Neukirchen), p 130-141.
2. This unusual position is advanced only infrequently and is probably influenced by the words *tohu wabohu* (without form and void) in verse 2. See: (a) Calvin J. 1847. Genesis (Edinburgh), p 70; (b) Clarke's commentary. 1830. Vol. I (NY), p 30.
3. This is the most common view. It reads "the heaven and the earth" (v 1) as an expression of the whole world, the universe, or the like. (a) Gunkel H. 1922. Genesis (5th ed., Göttingen), p 102; (b) Skinner J. 1910. Genesis (NY), p 14; (c) Westermann, p 140f (Note 1f).
4. A less frequently expressed view which questions that the Old Testament has a universal perspective. Instead its perspective is limited to the vault of heaven with the land below. See: (a) Young, p 9f (Note 1c); (b) Cassuto U. 1978. A commentary on the Book of Genesis, Vol. I (Jerusalem), p 26; (c) Vawter B. 1977. On Genesis: a new reading (NY), p 38.
5. Helck W, Otto E, editors. 1975. Lexicon der Ägyptologie (Wiesbaden), p 1263f.

6. See: Morenz S. 1973. Egyptian religion (London), p 29f.
7. The Assyrian dictionary. 1958. Vol. IV (Chicago), p 311-313.
8. Ugaritic textbook 1965. (Rome), p 366f.
9. See: Botterweck GJ, Ringgren H, editors. 1978. Theological dictionary of the Old Testament, Vol. 1 (Grand Rapids, MI), p 392.
10. Gibson JCL. 1971, Textbook of Syrian Semitic inscriptions, Vol. I (Oxford), p 74.
11. Recently: Miller PD. 1978. Genesis 1-11. Journal for the Study of the Old Testament Supplement 8:37f.
12. The Hebrew word heaven (*šamayim*) is dual (rather than plural), indicating perhaps two heavenly regions. See: Stadelmann LIJ, S.J. 1970. The Hebrew conception of the world. Analecta Biblica 39:37-41 (Rome).
13. See Habel NC. 1972. Yahweh, maker of heaven and earth; a study in tradition criticisms. Journal of Biblical Literature 91:321-337.
14. See: Honeyman AM. 1952. Merismus in biblical Hebrew. Journal of Biblical Literature 71:16.
15. See the New English Bible, the New American Bible, the New Jewish Version, Anchor Bible, all of which abandon the traditional rendering "In the beginning God created the heavens and the earth."
16. See Hasel (Note 1b).
17. See Schmidt, p 76 (Note 1e).
18. The Hebrew *cocavim* (stars) are heavenly bodies other than the sun and moon. A distinction beween planets and fixed stars is possible but not necessary on the basis of the word alone. The reference to the stars here is incidental, almost parenthetical, to complete the picture. See Westermann, p 182 (Note 1f).
19. This view presupposes an early creation of the material universe and is favored by those scientists who accept a long chronology for matter and a short chronology for life on this earth.
20. Also called the "Ruin-Reconstruction Theory of Genesis 1:2." In: Lammerts WE, editor. 1971. Scientific studies in special creation (Philadelphia), p 32-40.
21. Childs B. 1962. Myth and reality in the Old Testament (NY), p. 31-43.
22. Simpson CD. 1952. Genesis, Interpreter's Bible, Vol. I (NY), p 468.
23. Young, p 32 (Note 4a).
24. Arguments supporting this interpretation are taken from ancient Near Eastern creation stories and Genesis 2:4 which uses the formula, when as yet no plant, etc., existed. See: (a) Westermann, p 141f (Note 1f); Ridderbos, p 224-227 (Note1d), et al.
25. See Note 1.
26. For a thorough assessment of this subject, see Stadelmann, p 126-154 (Note 12).

ARTICLES

GEO AND COSMIC CHRONOLOGY

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WHAT THIS ARTICLE IS ABOUT

This article represents an added feature to Origins. *The material on geo and cosmic chronology is presented in brief outline form and is supplemented by an extensive bibliography. In the narrative portion, the author discusses the various evidences for a 4.5 billion-year-old universe and lists the different methods used to develop this date. Twenty-four different methods for dating and their conclusions are briefly listed. It is hoped that the readers of* Origins *will find this format useful as a reference tool for their own research. The Editors invite your suggestions to assist us in determining other areas that should be considered.*

Scientific creationism that is neutral with respect to religious issues has no need to defend a particular viewpoint regarding time. Proceeding only on the basis of inductive logic, it is free to pursue any interpretation that may seem to be suggested by available data. The data related to chemical evolution probabilities, thermodynamic considerations, spontaneous origin of life, genetics, and paleontology lead naturally to the conclusion that life and the life support system are products of intelligent design and creative ability. But at present there are no data that independently suggest inductively either a 6-day creation week or placement of such an event within the last 8000 years.

In contrast with neutral scientific creationism, apologetic scientific creationism utilizes deductive logic in an effort to relate satisfactorily available scientific data to viewpoints derived from religious sources. Some individuals would insist that only neutral scientific creationism is truly "scientific." However, apologetic scientific creationism can be defended as truly "scientific" to the extent that it does not go beyond sound principles of logic, data collection, and data evaluation. Efforts to explain data concerning the natural world within the constraints of the first eleven chapters of Genesis, if carried out in a sound scientific manner, would be classified as apologetic scientific creationism.

In certain areas apologetic scientific creationism may have an advantage over neutral scientific creationism and non-theistic science in that it operates from a larger data base and may develop scientifically sound interpretive models that would not have been accessible by pure inductive logic. This advantage is illustrated by a comparison between a reconstruction of an event based on both the testimony of a reliable eyewitness and analysis of the consequences, and a reconstruction based on only analysis of the consequences. These two reconstructions may be

evaluated on the basis of which one provides a better account of the available after-the-event data.

On the basis of the principle that truth is consistent, irrespective of the means by which it is apprehended, one can say that when rightly understood, natural science and authentic historical or religious source material agree, each complementing and supplementing the other. Accordingly, apologetic scientific creationism can be an instrument for arriving at a more correct understanding of specifications obtained from a religious source, as well as of data obtained from investigation in the natural sciences.

It may be appropriate to digress at this point and state my conviction that in a pluralistic society such as the United States only neutral scientific creationism is appropriate for inclusion in public school science curricula. A limited amount of apologetic scientific creationism would be appropriate in a public school sociology course that aims to acquaint the student with the various streams of thought in modern culture.

Geo and cosmic chronology are major concerns of creationist literature, usually from an apologetic viewpoint. The major purpose of this essay is to provide the reader with convenient access to the principal areas of evidence that must be taken into account by any scientific treatment of geo and cosmic chronology. For each of these areas I have endeavored to provide an introduction to the pertinent literature. Limitations of time and interest have prevented me from providing an adequate bibliography for some of the areas that are included in this outline.

RADIATION COOLING OF THE EARTH (1)

Serious attempts to determine the scale of geochronology on a scientific basis began in 1862 when William Thomson, who later became Lord Kelvin, estimated that planet Earth could have cooled from a molten state to its present temperature configuration within between 400 and 20 million years (m.y.). This constraint was an irritation to Charles Darwin who sensed that it did not provide sufficient time for his model of biologic evolution. By 1897 Lord Kelvin had narrowed the range of uncertainty in his estimate to between 40 and 20 m.y. By including the contribution of heat presumed to be available from radioactive material, the geophysicist, Arthur Holmes was able in 1947 to extend this estimate of cooling time to between 2 and 4 billion years (b.y.).

MINERAL CONTENT OF SEAWATER (2)

The astronomer Edmund Halley suggested in 1715 that planet Earth might be “much older than many have hitherto imagined,” and proposed that the salinity of the ocean might provide a basis for an estimate of its minimum age. By 1898 sufficient information on the rates at which the major rivers carry salt into the ocean became available to permit John Joly to estimate that the present salinity of the ocean could be attained within

80 to 90 m.y. In the early 1940s this estimate was reexamined and extended to between 150 and 250 m.y. on the basis of processes by which salt is now known to be recycled from the sea back to the land. By postulating slower input from rivers in the ancient past, Arthur Holmes was finally able to suggest an age of the Earth between 1 and 7 b.y. on the basis of ocean salinity.

EARTH-MOON SEPARATION (3)

As the principles of celestial mechanics were developed it became evident that tidal friction causes both Earth and Moon to slow down in their rotations until they each maintain the same face toward the other (no further tidal energy dissipation). During this process the separation between them gradually increases as required to conserve angular momentum. On the basis of his study of tides throughout the world Lord Kelvin came to the conclusion that the Earth-Moon system had been in existence less than a billion years. G. H. Darwin estimated that the present Earth-Moon separation has been achieved in 57 m.y. More recent calculations indicate that, beginning with close proximity to Earth, the Moon would reach its present separation distance in between 1 and 4 b.y.

DENUDATION OF IGNEOUS ROCKS (4)

The previously mentioned early efforts to obtain an age estimate for planet Earth are significant only for their historical interest. They depend on highly uncertain initial assumptions concerning a molten state of the planet, a fresh-water ocean, and a tightly bound Earth-Moon system. Another interesting attempt to obtain an age for the Earth is based on the assumption that all sedimentary rocks have been produced by erosion of igneous rocks, at present rates. The uncertainties in these rates and in the volume of sediments involved lead to estimates in the range between approximately 400 million and 3 billion years.

COMET FREQUENCY (5)

The existence of comets has been taken to indicate that the Solar System has not been in existence longer than a few million years. This conclusion comes from recognition that because of evaporation, radiation pressure, and solar wind effects very few comets survive as many as ten trips around the Sun. Since there is only speculation concerning the manner in which the Solar System has acquired cometary material, and there is absolutely no data with respect to the inventory of this material at any time, one should not expect the frequency with which comets appear to give a reliable indication of the scale for Solar System chronology.

COSMIC DUST DENSITY (6)

There is sufficient cosmic dust in interplanetary space to produce the phenomenon known as Zodiacal Light. In the order of 10-100 thousand

tons of this dust are captured by Earth each year. Since this dust is constantly swept up by the planets, driven out of the Solar System by radiation pressure, and pulled into the Sun as a result of the Poynting-Robertson effect, its present existence has been taken as evidence that the Solar System has been in existence no longer than approximately 2 b.y. It can be shown that all particles smaller than one centimeter in diameter would be removed from the space between Earth and the Sun within 10 m.y. The credibility of maximum Solar System age estimates based on the density of cosmic dust suffers from our ignorance concerning the distribution of this material in the past, and particularly from our ignorance concerning the amount of such material that may be swept up as the Solar System moves through its galaxy.

SYNCHRONOUS ORBITS OF SATELLITES (7)

The Moon is in a synchronous orbit, i.e., it makes precisely one rotation on its axis for each revolution about the Earth, with the result that it always shows the same face toward Earth. Any elastic object orbiting in a force field that causes deformation will approach a synchronous orbit due to conversion of rotational energy into heat by internal friction. The synchronous orbit of the Moon may be taken as evidence that the Earth-Moon system has been in existence for many hundreds of millions of years, presuming the Moon was once rotating more rapidly than at present. All planetary satellites that have been adequately observed (telescopic observation of Jupiter and Saturn, space probe observation of Mars, direct observation of the Moon) are in a synchronous orbit. Most of these satellites are marked by craters from meteoroid impacts that would have changed the rotation rate of these satellites. Calculations have been made of the amount of time that would be required for the Martian satellites to reach a synchronous orbit after the last significant perturbation by meteoroid impact. The greater the orbit radius the weaker the tidal forces will be, and the longer the time required to achieve a synchronous orbit. For the outermost satellite of Mars, Deimos, the estimated minimum synchronization time is 3 m.y. if the structure is compacted sand, and 100 m.y. if it is solid basalt.

SYNCHRONOUS ORBITS OF PLANETS (8)

The planets experience tidal forces that reduce their motions to synchronous orbits with respect to the Sun. The motion of Venus is within -8% of perfect synchronism (retrograde spin with -243/225 spin/orbit periods in Earth days). Mercury has a commensurate orbit with a spin/orbit period ratio of 2/3 (58.6/88 in Earth days). A spin/orbit period coupling of 2/3 is a resonant state that is stable and is a special case of synchronous orbits. A mass distribution of Mercury and/or the Sun that does not have perfect spherical symmetry (dipole and higher terms in the gravitational

field) could prevent a transition of the spin/orbit ratio from the 2/3 state to the 1/1 state.

More amazing is the discovery that Venus is in a synchronous relationship with respect to Earth. Venus turns the same face to Earth at each inferior conjunction. The most reasonable explanation of this relationship requires gravitational coupling between Earth and Venus over a time period in the magnitude of billions of years. The lack of a synchronous relationship of Earth with respect to Venus is explainable as the consequence of the diurnal cycle necessary for the maintenance of organic life and established at the beginning of the creation week described in the first chapter of Genesis. In summary, one can say that the observed characteristics of the inner planet orbits indicate that the Solar System has been in existence for a billion years, or more.

EXTRATERRESTRIAL EROSION (9)

Rocks on the surface of the Moon are found to be highly eroded. They are pitted, have rounded edges, and are often surrounded by a sloping bank of fine material that can be described as soil, while the buried portion may have relatively smooth surfaces bounded by sharp angular edges. The factors that produce this erosion are expansion and contraction associated with rapid extreme changes in temperature, the "sandblasting" effect of micrometeoroid bombardments, and sputtering produced by the solar wind.

Fresh-looking craters with sharp edges are found superimposed on highly eroded, "old," rounded-off craters, some of which are so eroded as to be scarcely discernible. In the highland areas of the Moon craters are found in a saturation distribution (further meteoroid bombardment would not produce a major change in the crater density, obliterating previous craters as rapidly as new ones are formed). But in the mare areas the crater density is only $^{1}/_{10}$ to $^{1}/_{50}$ as great. The evident interpretation is that since the mare areas were filled in by lava flow they have been exposed to meteoroid impact for a much shorter time than have the highland areas. The impact crater density on the Moon cannot be accounted for within a 5 b.y. time span unless the meteoroid impact rate is assumed to have been much greater during the early history of the Solar System than it has been during recorded Earth history.

The totality of this evidence leads to the conclusion that the Moon has been in existence as a solid object for a time in the order of at least one billion years.

Similar features of crater distribution and erosion have been revealed in the televised pictures sent from Mercury and Mars by space probes. The erosion features seen on Mercury are probably due to the same processes that have been operating on the Moon. Mars is experiencing strong aeolean erosion at the present time. It appears to have had an

episode of severe fluid erosion under climatic conditions vastly different from those that can be accounted for under present circumstances.

LIGHT-YEAR SCALE (10)

Astronomers have good reasons for believing that they are now observing galaxies and quasars that are tens of billions of light years distant from Earth. If the current estimation of distance for these objects is correct, the universe must have been in existence for at least tens of billions of years.

GALAXY CLUSTERS (11)

Galaxies are known to be grouped in clusters. At the present state of our knowledge concerning the mass of matter contained within galaxies, the gravitational forces that can be expected to act between members of a cluster are not sufficient to hold the cluster together. With the individual galactic motions that have been observed, the known galactic clusters can be expected to dissolve within less than 100 b.y. On the basis of this argument some galactic clusters have been considered to be no more than 2-4 b.y. old.

SPIRAL GALAXY STRUCTURE (12)

The Milky Way and its neighbor, Andromeda, belong to the Spiral Galaxy classification. It is thought that the spiral arm features of these galaxies would be obliterated after between one and three full rotations of the galaxy about its center of mass, since the angular velocity of revolution increases the closer a star is to the galactic center. On the basis of the rotation rates that have been observed, the lifetime of spiral galaxies has been estimated to be in the order of 300 m.y. Accordingly, our own galaxy would not be more than 300 m.y. old. It has been suggested that spiral arm galactic structure is not due to an initial star distribution, but rather is the result of gravity waves that cause the stars to bunch together in a cyclic manner as they revolve about the galactic center of gravity.

STAR CLUSTERS (13)

Many of the stars within galaxies are themselves grouped into clusters. It is expected that perturbing gravitational influences from nearby stars and star clusters will gradually pull these clusters apart. Detailed consideration leads to the estimate that star clusters are no more than 3-6 b.y. old.

BINARY STARS (14)

Within our own Milky Way galaxy it is possible to observe that many of the stars are gravitationally coupled in pairs that revolve about a common center of mass. It can be expected that a high proportion of binary stars is to be found only in a relatively young galaxy, for the perturbing influences of nearby stars should slowly pull the binary stars apart. On the basis of the expected mean lifetime of a binary star system our galaxy has been estimated to be less than 10 b.y. old.

STELLAR DYNAMICS (15)

With the knowledge of thermonuclear reactions man has acquired since World War II, and with the aid of electronic computers, it is possible to predict the detailed history of a large mass of hydrogen gas that will experience nuclear fusion under gravitational confinement — i.e., calculate the history of a star. Astronomers can observe numerous stars that have the characteristics associated with each state but one in the theoretical life history of a star. The stage for which no definite example has yet been found is the extremely rapid transition (lifetime measured in months) to the White Dwarf stage.

If the correspondence between real stars and the theoretically determined life history of a star is not merely fortuitous, one can confidently state that an average star such as our Sun has a life of approximately 10 b.y., provided it is maintained as an isolated system without replenishment of fuel (hydrogen). According to this model, the observed distribution of star types places the age of our galaxy, as well as the age of the universe, at not less than 10 b.y.

RESIDUAL RADIOACTIVITY (16)

The accidental discovery of radioactivity by Henri Bequerel in 1896 initiated a series of developments that have provided man with his most precise and most reliable tools for investigating geo and cosmic chronology. The most crucial steps in this development were the discovery of spontaneous atomic transmutation by Madame Curie in 1898, and the discovery of isotopes by Sir J. J. Thomson in 1913. Instrumentation and laboratory techniques developed since World War II have made possible spectacular advances in geo and cosmic chronology.

An infinitely old object would not be radioactive, for any radioactive isotopes it may have contained originally would have transformed to stable daughter isotopes. The presence of uranium in minerals from Earth, the Moon, and meteorites indicates that these components of the Solar System have been in existence less than 20 b.y. The present ratio of uranium-235 to uranium-238 further indicates that Earth and the Solar System have not been in existence longer than about 5 b.y.

EXTINCT RADIOACTIVITY (17)

Uranium-235, which is the basis of the contemporary nuclear energy technology, is present as only 0.72 atom percent of relatively rare uranium. The half-life of uranium-235, 704 m.y., is the lowest among unsupported radioactive nuclides that are known to exist in significant quantity throughout the Solar System. The next lower half-life among the nuclide possibilities is 170 m.y. (within a factor of two) niobium-92. There is 90 percent confidence that niobium-92 has been observed at $(1.2 \pm 0.7) \times 10^{-10}$ percent isotopic abundance in association with stable niobium-93.

No evidence for natural occurrence of 100 m.y. samarium-146 has yet been found. Diligent search with the most sophisticated techniques has detected 83 m.y. plutonium-244 at approximately 10^{-16} weight percent in a sample of the rare earth bastnaesite. Since plutonium is chemically similar to cerium, it is most likely to be found in a high-cerium-content mineral such as bastnaesite. Search for other unsupported radioactive nuclides with half-life less than 80 m.y. has been diligent but unfruitful.

All nuclides that are stable or have half-lives greater than 80 m.y. have been found in Earth, Moon and meteorite material. In Solar System material there is both fission-track and daughter-product isotope evidence for the prior existence of extinct 100 m.y. samarium-146, 83 m.y. plutonium-244, 15.9 m.y. iodine-129, 15.4 m.y. curium-247, 6.5 m.y. palladium-107 and 740,000 year aluminum-26. The conclusion from this evidence is that at least some components of Earth and other members of the Solar System have been in existence as solid objects for no less than 300 m.y. — the time for a 90 m.y. half-life nuclide to reach 1/10 of its initial concentration. Since there is good reason for expecting that in a creation of elementary matter plutonium-244 appears in the ratio of 0.013/1 with respect to uranium-238, the data on the present availability of natural plutonium-244 indicates that the matter from which the bulk of the Solar System is constructed has been in existence in the order of 5 b.y. Similar consideration regarding niobium-92 yields the same conclusion.

COSMOGENIC RADIOACTIVITY (18)

Atomic nuclei that have been ejected from stars and acquired immense amounts of kinetic energy are known as cosmic rays. (The relatively low energy atomic particles emitted by a star are known as “solar wind”). These cosmic particles have the capability to shatter atoms which they may strike. Some of the atom fragments thus produced are unstable atoms of a simpler construction than the target atom that was shattered. (Spallation is the scientific name for this process). Unstable atoms produced in this matter are described as having cosmogenic radioactivity.

The half-lives of the principle cosmogenic radioactive products range from 5.7 day Mn^{52} to 740 thousand year Al^{25}, 1.6 m.y. Be^{10}, and 3.7 m.y. Mn^{53}. Some 1.28 b.y. K^{40} is also produced in this manner. After exposure to a constant cosmic ray flux for a time equal to about four half-lives, a cosmogenic radioactive nuclide reaches an equilibrium concentration at which the number of new atoms formed within a given period of time is equal to the number that experience radioactive decay during the same time.

The land and water surface of Earth is protected by the atmosphere from primary cosmic radiation. In meteorites and in material that has been secured from the Moon we have access to objects that contain cosmogenic radioactivity. The cosmogenic nuclides from 5.7 day Mn^{52} to 740 thousand

year Al^{26} and 3.7 m.y. Mn^{53} found in these objects are in almost all cases in equilibrium with the present cosmic ray flux. This implies that the meteoroids and the surface of the Moon have been exposed to cosmic rays for at least 15 m.y., that the intensity of cosmic rays at present is very close to the average intensity over the past 15 m.y., and that the intensity of cosmic rays probably has not varied by more than a factor of two during this time. A short burst of radiation at some time in the recent past could adjust *two* cosmogenic nuclides to be in equilibrium with the present cosmic ray intensity, but it is inconceivable that as many as eleven could be simultaneously adjusted in this way.

COSMIC RAY EXPOSURE (19)

The shattering of atoms by impact from cosmic rays produces both stable and unstable nuclides. The stable spallation products accumulate continuously as long as there is exposure to cosmic radiation. In many cases stable cosmogenic nuclides can be clearly distinguished from primordial matter. In such cases the concentration of a cosmogenic nuclide indicates the amount of exposure to cosmic radiation. The time of exposure, or cosmic ray exposure age, is readily obtained by dividing the amount of exposure by the exposure rate — the cosmic ray intensity. Within the experimental uncertainties, independent cosmic ray exposure age determinations with nuclides such as He^3, Ne^{21}, Ne^{22}, and Ar^{38} are usually in agreement.

As a primary cosmic ray particle passes through a solid it disrupts the crystalline arrangement along its track. In certain minerals it is possible with appropriate etching techniques to make these tracks visible in a microscope. The density of these cosmic ray tracks provides an independent measure of the total exposure to cosmic radiation, and the cosmic ray exposure age. If the mineral has not experienced heating or shock that erases damage patterns by realignment of crystal structure, the cosmic ray exposure age determined by track analysis may be expected to be in agreement with that determined by stable cosmogenic nuclide analysis.

Cosmic ray exposure ages for meteorite and lunar material that has been studied are scattered over a range from one million to one billion years, with strong grouping at several points over this range. The range over which these exposure ages fall has been taken to indicate that at various times portions of the lunar surface have experienced turnover due to volcanic activity and meteoroid impact; and that meteorites have been formed by the breakup of larger objects at various times in the history of the Solar System.

RADIOACTIVE DECAY SEQUENCES (20)

The possibility of using radioactive elements for determining chronology was recognized by Lord Rutherford in 1904. Substantial radiometric

dating was not achieved until many years later, after techniques had been developed for quantitative analysis of isotopes. At the present time as many as ten independent techniques may be available for determining radioisotope age of a mineral specimen.

Among the various radioisotope age determination techniques there is potential capability for indicating the time at which the matter of which a specimen is composed, experienced events such as nucleogenesis, solidification, heating, remelting, shock, mixing with other material, exposure to water, and exposure to high energy radiation. Because a given sample may have experienced two or more such events all the various radiometric age determinations that may be performed on it should not be expected to be in agreement. Disagreement between independent radiometric age determinations (discordance is the technical term) may be taken as an indication that the sample has a complex history, and may provide useful insight into the chronology of events that the sample has experienced.

The many cases in which chemically and physically independent radiometric age determinations are in agreement (concordant) within limits of precision and accuracy indicate that radiometric dating procedures may yield physically significant results, regardless of whether there may not be a one-to-one correspondence between a specific radioisotope age and real time. Discordant ages generally have a rational explanation in terms of metamorphic events that the sample may have experienced.

It is well known that a radiometric age is equivalent to the corresponding real time age if the initial conditions are specified with sufficient accuracy and precision, the associated radioactive decay constant(s) has (have) not changed essentially during the time involved, and the sample has been chemically isolated during this time. The large number of cases in which essential agreement exists between diverse radiometric age determinations can hardly be fortuitous, and indicate that samples can be obtained which meet the requirements for conversion of radiometric age into real time. All the radiometric age data that have accumulated for minerals from meteorites, the Moon and planet Earth lead to the conclusion that these portions of the Solar System have been in existence and contained solid material for 4.56 b.y. The available radiometric evidence indicates that the present crust of Earth does not contain rocks older than 3.9 b.y.

INHERITED RADIOMETRIC AGE (21)

If a radiometric age can be satisfactorily converted into real time there often still remains a problem in determining the nature of the event that initiated the time period. Radiometric dating techniques were developed in a climate that fostered a presumption concerning vast ages for the evolutionary development of living organisms, and that stimulated search for evidence supporting such ages. This situation gave rise to a naive, oversimplified, and unjustified assumption that radiometric “clocks” are

set at zero in transport of mineral by igneous processes, and also in many sedimentary processes. According to this assumption a radiometric age of mineral that has replaced organic material, that has been injected into a fossiliferous stratum, or that overlies fossils gives a minimum real-time age for the association with the fossils involved. It would be both unfair and unkind to most of the individuals who have supported this assumption to describe it as "the graveyard hoax"; yet such description emphasizes an important consideration that is generally overlooked. Radiometric ages for the mineral components of the soil in a cemetery plot are not expected to date the burials made there.

There is ample evidence that radiometric chronometer systems are often set to zero time in natural processes that transport or metamorphose minerals, as popularly assumed. It is not so well recognized that the inheritance of previously established radiometric age characteristics through metamorphic and transfer processes is also well established in the scientific literature. Situations are known in which even fission track and potassium-argon age characteristics have survived through a subaerial volcanic event. The survival may be anywhere between total and zero. A potassium-argon age of 465,000 years has been reported for volcanic material overlying trees that were buried by the eruption and have a carbon-14 age of only 225 years (McDougall et al. 1969). It has become recognized that the radioisotope characteristics of intrusive and volcanic material may be related more to the crustal material through which the magma was ejected and to the characteristics of successive zones in the magma chamber than to the time at which the transfer took place. There also is evidence that the radioisotope age characteristics of sediments may be related more to the source from which the material was derived than to the time at which sedimentation occurred. Extensive references to the literature on inherited radiometric age are appended to this paper.

RADIATION DAMAGE (22, 23)

Radioactive decay produces structural and electronic damage tracks in the host mineral. These damage tracks can be quantitatively analyzed to determine the total radiation exposure. A quantitative analysis of the amount of radioactive material available for producing the observed damage tracks readily leads to a computation of the irradiation time. The result is a radiometric age based on the evidence left by the radiogenic products, rather than on an assay of the products themselves. The evidence may be trapped excited electron states produced by alpha, beta or gamma radiation; or it may be crystal lattice dislocation produced by alpha particles, recoil of alpha-emitting parent nuclei, or fission products.

The excited electrons are detected by observing the optical radiation produced when the mineral is heated sufficiently to free the trapped electrons and allow them to return to their ground (lowest energy) state. The

technique involved is known as thermoluminescence or electroluminescence dating. Since the excited electrons slowly return to the ground state at normal temperatures, this technique has a relatively short time range. Although a 300,000 year range has been claimed (Göksu et al. 1974) other authorities limit its usefulness to about 4000 years (Michels 1973). This method of dating further suffers in lack of precision.

The crystal lattice dislocation tracks produced by radioactive decay can be seen with a microscope after suitable etching. Where high concentrations of radioactive material have existed regions that contain alpha-particle damage tracks can be seen without resort to etching techniques, as in pleochroic halos (more correctly termed radiohalos). The density of these halos can be related to the concentration of radioactive material at their center to obtain a crude estimate of the minimum exposure time involved in producing the halo. Microprobe analysis permits relatively precise evaluation of radiogenic daughter to radioactive mother ratios in the halo nucleus. These ratios can readily be expressed in terms of a radioisotope age.

Radiometric ages obtained from tracks produced by parent nucleus recoil, alpha-particles, or fission fragments often are in agreement, or at least consistent, with ages obtained from daughter/parent ratios. Discordant but consistent situations arise when there has been total or partial annealing of radiation tracks by elevation of temperature, or migration of either parent or daughter atoms as a result of heating or contact with water.

The existence of isolated polonium radiohalos in uraniferous fossil wood (Gentry et al. 1976) indicates that radiohalos may be formed as a result of prolonged deposition of radioactive material at a halo center site, and are not always dependent on an initial concentration of radioactive material.

CHONDRITE STRUCTURE FEATURES (24)

Radiation damage track investigations have turned up some remarkable evidence concerning the history and formation of meteoroids. Meteorites that have been classified as chondrites are made up of units called chondrules that are cemented together in a matrix to form the meteorite body. Some of these chondrules from inside the meteorite body have been found to be marked on their surfaces by micro-meteoroid impact pits, and to contain in a thin layer of their surface solar wind atom implants and damage tracks from the low energy cosmic radiation produced by the Sun. Identical phenomena are found on the surface of rocks obtained from the Moon. (Ablation during passage through Earth's atmosphere removes such features from the surface of meteorites). Some chondrules have sharp fracture edges. This evidence strongly indicates that chondrites have been formed from an accretion of smaller meteoroid bodies which had been in

existence long enough to acquire substantial exposure to solar radiation and cosmic dust.

SUMMARY

The picture that emerges from all the data that relate to cosmic chronology appears to be one of dynamic physical processes operating over extended periods of time, during the last 4.5 billion years of which discrete entities of the Solar System have been in existence.

THEOLOGICAL ISSUES

It would not be appropriate to conclude this presentation without some consideration of related theological issues.

Any interpretation that is made of the available inspired testimony must satisfactorily accommodate the various lines of evidence concerning geo and cosmic chronology in accord with the basic hermeneutic principle that the books of nature and the Scriptures should be consistent with each other.

It is possible to interpret the book of Genesis to require that all matter in the Solar System came into existence *ex nihilo* by fiat creation less than 10,000 years ago. This interpretation requires that all the features of mineral, meteoroid, planetary body, and planetary satellite age were the immediate expression of deliberate design on the part of the Creator, and have no relationship to actual age. We should recognize that God has the prerogative to produce a creation in this manner, and that doing so would be less extraordinary than producing the total complex of organic life on this planet within four 24 hour days.

It also is possible to interpret the inspired testimony concerning creation as an eyewitness-style account using language of appearance to describe creative activity that within six consecutive 24-hour days equipped this planet with the total complex of its organic life and established the physical circumstances on which this life depends. According to this interpretation our planet may now contain matter that was in existence as a consequence of creative activity prior to the Genesis Creation Week, matter that was brought into existence during Creation Week, and a relatively minute amount of matter that came into existence in connection with Christ's miracles (specifically His feeding of the multitudes).

Let everyone be persuaded in his own mind as to which interpretation he should favor, giving appropriate respect to the considerations that may lead others to choose differently.

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NEWS AND COMMENTS

ARKANSAS ACT 590

Is the teaching of creation in science classes of public schools unconstitutional? This question has been put to the legal test in the State of Arkansas, one of the first states in recent times to pass a creation bill (Arkansas Act 590) into law.

On 19 March 1981, Governor Frank White signed the "Balanced Treatment for Creation-Science and Evolution-Science Act," scheduled to go into effect beginning in September 1982. The act was quite extensive, requiring balanced treatment as a whole in classroom lectures, textbook and library materials for both the sciences and the humanities, and in other educational programs in public schools, to the extent that they "deal in any way with the subject of the origin of man, life, the earth, or the universe."

A further section defined "creation-science" as being the scientific evidences for creation and related inferences that indicated:

> *(1) Sudden creation of the universe, energy, and life from nothing; (2) The insufficiency of mutation and natural selection in bringing about development of all living kinds from a single organism; (3) Changes only within fixed limits of originally created kinds of plants and animals; (4) Separate ancestry for man and apes; (5) Explanation of the earth's geology by catastrophism including the occurrence of a worldwide flood; and (6) A relatively recent inception of the earth and living kinds.*

In contrast, "evolution-science" was defined as being scientific evidences and their inferences that indicate:

> *(1) Emergence by naturalistic processes of the universe from disordered matter and emergence of life from nonlife; (2) The sufficiency of mutation and natural selection in bringing about the development of present living kinds from simple earlier kinds; (3) Emergence by mutation and natural selection of present living kinds from simple earlier kinds; (4) Emergence of man from a common ancestor with apes; (5) Explanation of the earth's geology and the evolutionary sequence by uniformitarianism; and (6) An inception several billion years ago of the earth and somewhat later of life.*

The law also emphasized the presentation of scientific models for origins and the exclusion of "any religious instruction or references to religious writings." It did not require instruction in the subject of origins, but simply

"instruction in both scientific models (of evolution-science and creation-science) if public schools choose to teach either."

Similar or identical bills have been introduced in at least 16 other states, and a few months after the Arkansas bill was signed, a similar measure was passed into law in Louisiana. The careful wording can be credited to Paul Ellwanger, head of "Citizens for Fairness in Education," a **"**concerned citizens**"** group from South Carolina, who received advice from sympathetic lawyers, including Wendell R. Bird, a constitutional specialist. Bird described the bill as being consistent with the neutrality towards religion that is required by the First Amendment to the U.S. Constitution.

The Arkansas Academy of Sciences and the 300 faculty members of the University of Arkansas requested that the law be rescinded. To no one's surprise, on 27 May, the American Civil Liberties Union (ACLU) filed a complaint in Federal District Court to declare Act 590 unconstitutional because it violates the principle of church-state separation. It also maintained that the law abridged academic freedom. More than half of the 23 plaintiffs were individuals or organizations representing several branches of religion. The complaint stated that the plaintiffs were "neither anti-religion nor asserting the final truth of any theory of evolution." Though the creation-evolution controversy is no stranger to the courtroom, it is the first time that the creation model *as a science* has been legally challenged. Previous court cases have concentrated on whether evolution was a fact or a theory. The ACLU hoped that this lawsuit would provide a test case whereby creation science would be evicted from the public schools nationwide.

Described by Bruce Ennis, ACLU's legal director, as "one of the most important First Amendment cases to be held this century," the trial opened on 7 December. The ACLU argued that creationism is a religion, not a science; that the academic freedom of both teachers and students is abridged by Act 590; and that the statute is vague because it "does not give teachers fair notice of what can or what cannot be taught, and it gives school officials virtually unfettered discretion arbitrarily to enforce its provisions." The state maintained that the ACLU was attempting to censor the teaching of creationism, "shutting out from the 'marketplace of ideas' those ideas with which they disagree because they are incompatible with their personal, religious or philosophical views."

ACLU attorney Robert M. Cearley, Jr., opened with a statement of intent to prove that creation science is pseudoscience. He characterized Act 590 as an attempt by religious fundamentalists to "arrogate unto itself the power and authority to define what science is and force the teaching of religious beliefs in the classroom" under the guise of science. Among the 17 witnesses who testified against creationism as a science during the first week of the trial were science philosopher Michael Ruse, theologian Langdon Gilkey, biophysicist Harold Morowitz and paleontologist Stephen Jay Gould.

The state constructed its defense upon the theory that creation does not necessarily imply the existence of a creator. State Attorney General Steve Clark

said that the issues were scientific, not religious, and that "creation-science is at least as scientific as evolution-science." Among the list of potential expert witnesses who support creationism were 60 scientists, all but one having an earned Ph.D. in some field of life science.

In the second and concluding week of the trial, Clark presented 11 witnesses for the state. One science teacher testified that true academic freedom was abridged by the exclusion of creation from the classroom and stated that he was not presently allowed to give evidence for creation in his science classes. Another stated that while there was no strong scientific evidence for either the creation or evolutionary models of origins, biological and biochemical data pointed to the concept of a Designer. A Buddhist astronomer labeled evolution science as being religious in assuming the development of life from non-life. Scientific evidences from the fossil record, catastrophism, and questions about the origin of life were also presented in support of creation.

The trial concluded on Thursday morning, 17 December. U.S. District Judge William R. Overton announced that he would need at least a week to study his 300 pages of notes taken during the trial before making a decision. He clearly stated that his opinion would concern only the narrow question of whether the creation model was religion, and that he would not "undertake to decide the validity of the biblical version of creation nor the theory of evolution."

The judge did not issue his ruling until 5 January. In his 40-page decision, he stated that the law was unconstitutional because it was "simply and purely an effort to introduce the biblical version of creation into the public school curricula." According to him, the definition of creation-science reflected "an inescapable religiosity," and it would be impossible for teachers to present the Genesis account of creation in a secular manner.

While the ACLU attorneys applauded the decision as dealing a "fatal blow" to creation-science, supporters of the law vowed to continue their efforts to legislate the teaching of creation-science. Attorney General Clark is considering appealing to the 8th U.S. Circuit Court of Appeals in St. Louis. On the same day as Judge Overton's ruling of the Arkansas law, the Mississippi Senate opened its 1982 session by approving overwhelmingly a similar bill requiring public schools to present a balanced treatment of origins.

Meanwhile, a modified version of the original bill under the title of the "Unbiased Presentation of Creation-Science and Evolution-Science Bill" has already been drafted by Paul Ellwanger and is expected to avoid many of the problems faced by the Arkansas law. It will also be interesting to watch the forthcoming trial over the Louisiana law, as well as further events in Mississippi.

Katherine Ching

LITERATURE REVIEWS

Readers are invited to submit reviews of current literature relating to origins. Mailing address: ORIGINS, Geoscience Research Institute, 11060 Campus St., Loma Linda, California 92350 USA. The Institute does not distribute the publications reviewed; please contact the publisher directly.

THE ULTIMATE ORIGIN

GOD AND THE ASTRONOMERS. Robert Jastrow. 1978. NY: W.W. Norton & Co. 136 p.

Reviewed by Katherine Ching, Geoscience Research Institute

With the dawn of reasoning and the discovery of the concept of cause and effect, a child begins in earnest to search out the beginnings of objects and organisms about him. For many the search ends in childhood; for the lucky few it is a lifelong quest. In this highly readable book Jastrow describes the steps taken in the last few decades that have led to the formulation of a cosmological theory known as the Big Bang. With its roots in Einstein's theory of relativity, the Big Bang predicts an expanding universe.

Astronomical evidence by Hubble and Humason in the form of a red shift provided remarkable confirmation for ideas proposed by early theorists. Further substantiation is found in the work of Robert Wilson and Arno Penzias who discovered an isotopic microwave background radiation in every examined part of the universe, in agreement with predictions of Big Bang theorists. For this work they won the Nobel Prize in physics.

Descriptions of both the people and processes of cosmological development are highly readable, with the technical aspects explained so that nearly all readers will understand the basic principles of the methods used. Interesting picture sections are dispersed through the book which show experimental results along with portraits of the scientists involved and marvelous views of stars and galaxies. Were this all, it would be a fine book with which to begin a tour into modern cosmology. But more good things follow.

In addition to examining the data, Jastrow also sheds light on the philosophical and emotional stresses caused by the Big Bang theory. He shows that the Big Bang implies a beginning, and that this upsets many who would prefer a steady-state system — one that has no beginning or

end. Einstein seemed particularly stressed about this point and long resisted the evidence because it was contrary to his philosophical biases.

An admitted agnostic, the author delicately works with the possibility of a Divine presence in the universe. Though his feelings are most clearly stated in the title, he contrasts the theological mind with the scientific and sees that the theological has perhaps accommodated itself to the dissonance caused by the concept of a beginning.

Jastrow closes his book with a statement which will probably become highly quoted wherever theologians and scientists meet:

> *Now we would like to pursue that inquiry farther back in time, but the barrier to further progress seems insurmountable. It is not a matter of another year, another decade of work, another measurement, or another theory; at this moment it seems as though science will never be able to raise the curtain on the mystery of creation. For the scientist who has lived by his faith in the power of reason, the story ends like a bad dream. He has scaled the mountains of ignorance; he is about to conquer the highest peak; as he pulls himself over the final rock, he is greeted by a band of theologians who have been sitting there for centuries.*

GENERAL SCIENCE NOTES

THE AGE DATING OF BIOLOGICAL MATERIALS — SOME INTERESTING PROBLEMS

By Richard D. Tkachuck, Geoscience Research Institute

Two seemingly unrelated papers when juxtaposed provide some interesting insights into the problems of dating biological materials. The paper by Weiner et al.[1] describes an analysis of aspartic acid racemization in collagen removed from the Dead Sea Scrolls. In most of the natural world, L-amino acids are incorporated into proteins. Upon death of the organism, a slow racemization of the L-forms to the D-forms takes place. Finally an equilibrium is reached where an equal abundance of both is observed. Under constant laboratory conditions this racemization takes place at predictable rates. It the assumption that the laboratory conditions approximate field conditions over the long haul is valid, it should be possible to determine the age of an organic sample. This method was used by Bada[2] to date human fossil remains found in Sunnyvale, California, at 70,000 years. (A few years earlier a sample from Del Mar, California, was dated at 48,000 years by Bada).

In the work of Weiner et al., racemization data was collected from two different sites of the same manuscript. Several different manuscripts were examined in such a manner. An interior site was chosen which showed little morphological change, while the other site which was along the edge showed morphological change in the collagen form. A sharp boundary between the two regions indicated that the edges of samples became wet sometime in the past. In one case, sample areas were only 5 mm apart. When the various samples were examined for the D/L ratios, significant differences were observed between the two portions of the same scroll fragments. It is suspected that water acts on the collagen to change its physical characteristics to that of a gel. In the gel state, it appears that racemization takes place at a much more rapid rate. Thus relatively minor alterations in the environment of the sample can drastically affect its apparent age.

The paper by Bischoff & Rosenbauer[3] reexamines the Del Mar and Sunnyvale materials which Bada had dated. The skeletal remains were of modern affinities and the dating by Bada has caused some consternation among anthropologists who feel that this is much too early a date for modern man in the new world. Basing their analysis using uranium series dating age for Del Mar was 11,000 years and Sunnyvale was 8300 years.

In conclusion, it can be seen that there are still unresolved difficulties in the age-dating of fossil materials and that caution is urged before the acceptance of a particular interpretation.

ENDNOTES

1. Weiner S, Kustanovich Z, Gil-Av E, Traub W. 1980. Dead Sea Scroll parchments: unfolding of the collagen molecules and racemization of aspartic acid. Nature 287:820-823.
2. Bada JL, Helfman PM. 1975. World Archaeology 7:160.
3. Bischoff JL, Rosenbauer RJ. 1981. Uranium series dating of human skeletal remains from the Del Mar and Sunnyvale sites, California. Science 213:1003-1005.

EDITORIAL

SCIENTIFIC CREATIONISM?

The United States public is becoming increasingly aware that there is no justification for evolutionary dogma to have exclusive domination of the public schools, whether on the basis of sound science, academic principles, or constitutional rights. But the opportunity to attain a scientifically sound, academically fair, and constitionally just treatment of origins in the public schools is placed at hazard by some creationist literature and by the attitudes of some creationists.

Opponents of a balanced treatment of creationism and evolutionism in the public schools rightly affirm that the public schools should not foster any uniquely religious teaching. At all costs the public schools must be preserved from becoming instruments for religious indoctrination. On the basis of the contention that creationism is a religious doctrine promoted by only certain segments of the Jewish and Christian communities, it is effectively argued that creationism has no proper place in public school curricula, particularly in science instruction.

Abundant examples from the creationist literature indicate that the motivation for promotion of creationism is often religious, rather than scientific, philosophical or academic. A recent example is provided by a paper entitled "The Creationist and Neo-Darwinian Views..." by Dennis W. Cheek that appears on p 93-110, 134 of the *Creation Research Society Quarterly* for September 1981. Note the following excerpts: "The creationist model rests on the premise of the primacy of Scripture as the absolute standard in all matters of life and conduct" (p 95). "The creationist model also postulates the occurrence in the earth's recent past of a global flood as recorded in Genesis" (p 96). "...the creation model postulates a youthful earth, and thus would necessitate a complete rewriting of earth history from a creationist perspective" (p 96). Efforts to achieve an appropriate treatment of origins in the public schools would have been better served if the author of these statements had properly qualified his terms by saying "Biblical creation(ist) model, " for the salient idea in each of these statements is derived from the Bible and is not a natural product of scientific observation or inductive reasoning from such observation.

Creation by a superior intelligence is a valid scientific and philosophical concept — just as valid as the concept that all current features of the universe may be accounted for by the random, undirected, natural behavior of eternally existent matter-energy. With equal philosophical justification, one can base his cosmogony on an intelligence with the capability for creating the universe, or on mindless matter-energy with the inherent property of evolving the universe. Reasoning based on principles derived from the Second Law of thermodynamics and on information theory, and also the conclusions from chemical thermodynamics, probabilities of

molecular structure, design at all levels of the universe, molecular biology, genetics, and some aspects of paleontology clearly favor the creation account.

Creationism can be treated on a basis that is neutral with respect to religion, including religion based on the Judaeo-Christian scriptures. Such treatment of creationism belongs in the public schools if science is to be taught soundly, in a climate of academic freedom and fairness, and with proper regard for constitutional guarantees. Such creationism may be identified as Neutral Scientific Creationism. Neutral Scientific Creationism operates independent of religious concepts and traditions. It may involve hypothesis and deduction, but it places principal emphasis on inductive logic. Individuals who follow this approach to creationism see in the available data abundant evidence for a designer.

Creationism that derives its basic ideas from the Hebrew-Christian scriptures, and then uses science to further develop those ideas, is Biblical creationism, a subcategory of Apologetic Scientific Creationism. In contrast with Neutral Scientific Creationism, the emphasis of Apologetic Scientific Creationism is on deductive reasoning. It begins with a religion-based theory and uses that theory as an aid in interpreting scientific data. In my judgment, it would be inappropriate to include Apologetic Scientific Creationism in a science course offered by a public school that serves a pluralistic constituency. A public school social studies course that aims to acquaint students with the history of human thought and develop an understanding of the contemporary culture could appropriately survey Apologetic Scientific Creationism.

Having pointed out a distinction that I am convinced should be made with respect to teaching creationism in public schools, I should express an additional conviction, which is that Apologetic Scientific Creationism, when functioning on a rigorous basis of sound scientific principles and methods, can be a superior instrument for arriving at truth. This superiority is elucidated by contrasting two reconstructions of an event (such as an automobile accident, an explosion, a bank robbery, the demise of dinosaurs, or the origin of life, e.g.), one based on only after-the-event consequences, and the other based on both after-the-event consequences and the testimony of reliable eyewitnesses. The individual who believes that the narratives of the Hebrew-Christian scriptures are reliable eyewitness accounts can have confidence that these accounts are helpful in correctly interpreting data that pertain to earth history.

Neither the discredit that has resulted from efforts to force data in an unscientific manner to support a religious viewpoint nor the misidentification of creationism as a purely religious concept should be allowed to obscure a sound approach to scientific creationism.

R. H. Brown

ARTICLES

HISTORICAL DEVELOPMENT OF THE CURRENT UNDERSTANDING OF THE GEOLOGIC COLUMN: PART I

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WHAT THIS ARTICLE IS ABOUT

In the past 250-300 years a major paradigm shift has taken place regarding the history of the earth. It would be safe to say that prior to this time period a large majority of practicing scientists either held a strong belief in a biblical account of origins or at least were not antagonistic to such a concept. Parallel to this belief was the development of geology, a separate discipline or science. Observations that showed similarity of rock and fossil types over large geographical ranges were begun to be appreciated as well as the uniqueness of certain strata with respect to the presence or absence of various life forms. These studies resulted in various theories which attempted to explain the geologic picture.

A major influence early in this time of new models was A. C. Werner (1749-1817). Werner held that the various rock layers were formed by precipitation of materials from turbid seas. Werner and his followers (the Neptunists) presented a major diversion from the traditional interpretation. James Hutton (1726-1799) recognized the true nature of some rocks as being volcanic in origin and overemphasized this source of material in the fossil record. The concept of erosion and deposition was also developed by Hutton with the slowness of this process recognized.

William Smith (1769-1839) recognized the widespread occurrence of various layers and his work implied major geologic changes over wide areas. In addition to the stratigraphic studies, analysis of fossil remains also began. Dominant in these areas was the work done by Georges Cuvier (1769-1832). A comparative anatomist, Cuvier was able to make identifications of fossil fragments and place them into taxonomic groups. With these studies came the realization that fossils might be used as indices in identifying similar but widely separated strata. Cuvier also developed the concept that the geologic record is the result of short catastrophic bursts with long, quiet intervals between. These forerunners provided a milieu in which the future formulators of the geologic column could now work.

INTRODUCTION TO THE COLUMN

The crucial questions on the relationship of Genesis and geology, of religion and geological science nearly all hinge in some way on one's understanding of the meaning and significance of the geologic column. It is important, therefore, to understand something of its origin as a system.

Most commonly the term *geologic column* is applied to a composite columnar section in which there is an attempt to superimpose rocks representing every period of time for the world as a whole. In this way it is thought that the

TABLE 1

Units of Geologic Time	Units of Strata: Time-Rock Units
Era	--------
Period	System
Epoch	Series
Age	Stage
-----	Zone

column can be used somewhat like a calendar for dating rock formations and as a unifying concept, a datum in relation to which a large part of the vast fund of geological information and theory can be organized. In the various major regions of the world, locations with favorable exposures and typical deposits for individual segments of the column (epoch or series divisions) may be selected as *type sections* for use in correlation, as, for instance, the magnificent, little disturbed Middle Cambrian formations of the Canadian Rockies (the Albertan Series) to which Middle Cambrian rocks throughout North America are compared.

Time units used in the geologic column include *eras*, the major divisions such as Paleozoic, Mesozoic and Cenozoic; *periods*, the first subdivisions of eras including Cambrian, Ordovician, Silurian, etc.; *epochs*, the subdivisions of periods such as Lower, Middle and Upper Cambrian, or Paleocene, Eocene and so on in the Tertiary period; and *stages*, divisions of the epochs used primarily by specialists. For each time division there is a unit of strata equivalent (see Table 1 above). Only eras, periods and epochs are usually listed on most geologic columns, and sometimes only the epochs for the most recent periods (see Table 2).

Upon reflection it is obvious that substantial deposition cannot normally occur over the entire earth's surface at the same time. There must always be a source for every particle of gravel, sand, lime, silt or lava which is deposited. It follows that no single interval or moment in earth history can be everywhere represented by deposits. There are no universal formations.

Moreover, since there is much evidence to support the view that no single region has continuously received deposits from the time of the creation of the planet until now, in developing a complete "geologic column" for the world it is necessary to attempt to correlate strata so that any level where non-deposition or an erosional break has occurred may be represented by rocks from other areas laid down at the time of the missing interval. This introduces a subjective element, but fortunately there are hundreds of regions with extensive series of superimposed strata representing major segments of the column, and there are diverse criteria for correlation available so that correlations necessary may generally be quite firmly established.

TABLE 2

GEOLOGIC COLUMN

ERAS	PERIODS	EPOCHS	Selected Series, Groups, or Formations from England and Wales*
Cenozoic	Quaternary	Pleistocene	Glacial tills, gravels, Cromer Forest, Red and Norwich Crag
	Tertiary	Pliocene	Lenham Beds (remnants)
		Miocene	
		Oligocene	Hamstead Beds, Bembridge Marls
		Eocene	Bracklesham, Bagshot, London Clay
		Paleocene	Woolwish, Reading, Thanet Sands
Mesozoic	Cretaceous		Chalk, Gault, Greensand, Wealden
	Jurassic		Purbeck, Portland, Corallian Shales, Oxford Clay, Cornbrash Marble, Oolite, Lias
	Triassic		New Red Sandstone (part)
Paleozoic	Permian		Magnesian Limestone (New Red part)
	Carboniferous		Coal Measures Millstone Grit Mountain Limestone
	Devonian		Old Red Sandstone
	Silurian		Ludlow Siltstones Wenlock Mudstones Llandovery Beds
	Ordovician		Ashgill, Caradoc Shales, Llandeilo Flags, Llanvirn Shales, Arenig Shales, Tremadoc
	Cambrian		Dolgelly Beds, Ffestinog Beds, Clogau Shales, Harlech Grits
PRECAMBRIAN			Longmyndian and others

*To conform to space limitations, it was necessary to leave out many of the units and subdivisions in this column.

Approximately three quarters of the total land area of the planet is blanketed by many layers of sediments, commonly transformed into stratified rock (Putnam 1964:21). With an average aggregate thickness of several thousands of feet, these strata vary from level to level. More often than not traces of past life called *fossils* are preserved in these layers. Sequences of these layers or strata which have similar lithological, fossil and structural characteristics, hence distinguishable in the field from other such sequences, are called *rock formations*. Formations are usually given names associated with a location where the unit is typical and well exposed — the *type locality*.

While generally there are no more than two or three dozen rock formations, and often only one or a few exposed on any single canyon wall, mountain slope or well core, it is estimated that in aggregate there may be 13,000 formations in North America and possibly 100,000 in the world (Dunbar & Rodgers 1957:289). Information about just the fossils in a single important formation is, in many cases, the subject of a score or more of technical articles and/or perhaps one to several book-length volumes. Studies on the lithology, sedimentary features, solution phenomena, ores, etc., may occupy more articles or volumes.

The data are vast. It is essential to be able to correlate beds from one basin to the next, and even from one continent to another as far as possible. Several of the characteristics used include: assemblages of fossils which appear to be restricted to a limited vertical range in the column (guide or index fossils), relative position in a sequence, direct physical continuity in the field, lithological characteristics, geophysical and geochemical characteristics, etc. Guide fossils and relative position are often most useful.

Because of the great ages commonly assigned to the periods and epochs of the geologic column, and because it is often alleged that the column of fossil-bearing rock documents, at least in a partial way, the record of the evolution of life on the earth, the geologic column has been the subject of sharp controversy. It has been totally rejected by some, and partially or completely reinterpreted by others. Students who use the terminology of the column are sometimes viewed with considerable suspicion. Many conservative Christians and fundamentalists believe that the geologic column represents a scheme by which the strata of the earth have been arranged in an artificial order so as to support false claims of evolution. Some have felt that the true relation of fossils to one another and to living forms has been concealed by a disguising terminology deliberately constructed to deceive by scientists who have been seeking to escape the moral imperatives set forth in the Holy Scriptures (Price 1926: e.g., 112, 175, 205).

The purpose of this paper is to attempt to reconstruct as far as possible significant presuppositions, beliefs and biases — the crosscurrents influencing thought and interpretation of those men who established the foundations of geology and the geologic column. It is beyond the scope of this study to evaluate the relative merits of competing viewpoints. This paper cannot more

than sample the lines of evidence interpreted by geologists of those decades as requiring a greatly expanded time frame for earth history, nor to more than mention the existence, much less the interpretations and arguments, of the conservative opponents since they were not involved in the formulation of the geologic column.

Part I (this issue) includes a definition of the geologic column, together with several basic terms, an outline of early systems of classification of strata, samples of typical views concerning fossils in the prescientific period of geology, and a brief consideration of men who laid the foundation for the scientific study of geology in the early 19th century. Part II (*Origins* 9, #1) focuses on the men who formulated the geologic column between 1820-1850, their attempts to harmonize geology and Genesis, and conservative opposition to their views.

EARLY OBSERVATIONS AND VIEWS

Before 1800 — Systems of Classification

In the eighteenth century, associated with an increased utilization of earth materials — coal, metals and other minerals — several proposals for classification of the rock layers of the earth's crust were introduced. Deserving of special mention are three which embody a recognition of a chronological sequence, of an orderly succession of strata, and of geological processes involved in erosion, sedimentation and preservation of fossils — accepted concepts today, but largely unappreciated before the 18th century. Preflood, flood, and postflood formations were postulated. These three were largely free from the fanciful speculations so characteristic of most contemporary authors.

In 1756 Johann Gottlob Lehmann, a mining engineer and teacher in Berlin who investigated the rocks of Prussia, published a wealth of careful observations together with his ideas on the origin and composition of the earth's crust (Adams 1938:374-478; Zittel 1901:35). Lehmann recognized three major categories of mountains:

1. The most ancient class of mountains composed of rocks of a crystalline nature, hard, structurally complex, and chiefly without fossils, were designated *Primitive* (equivalent to *Primary* of Arduino). These primeval mountains were generally of higher elevation, with strata often inclined or vertical, plunging to unknown depths. They were thought to have been formed before the universal deluge in the early periods of creation.
2. The *Flötzgebirge* or horizontal mountains were composed of successive, stratified, water-laid sediments and often contained animal and plant fossils (designated *Secondary* by Arduino and later authors). Many of these formations were thought to have been deposited at the time of the universal deluge. Such strata were considered "secondary" in the sense that they were composed of particles eroded from the older rocks of the "primitive" or "primary" mountains. Lehmann gave accurate descriptions, with sections and

diagrams, of thirty successive "bands" in the Permian rocks of Thuringia. The recognition of a definite order and the aqueous origin of the sediments enhanced the merit of his work on secondary formations.

3. Later deposits, including mountains formed from time to time (e.g., volcanic mountains), and loosely consolidated surficial sands and gravels, commonly termed *Alluvial*, comprised his third division.

George Christian Füchsel (1722-1773), a less well-known contemporary of Lehmann living in Prussia, worked on Triassic strata and contributed significantly to the foundation for later studies in stratigraphy. Füchsel developed the concept of a rock formation as a depositional unit representing a certain epoch of time. Such formations were not thrown out at random, but deposited initially in a horizontal position as part of a clearly delineated, orderly succession under circumstances that may be inferred from the lithology and characteristic fossil assemblage. He felt that the most recent deposits in his district, which contained only terrestrial fossils, were from "the action of a great deluge." Lyell (1834:76) states that Füchsel manifested a "strong desire ... to explain geological phenomena as far as possible by reference to the agency of known causes."

Giovani Arduino (1713-1795), an inspector of mines in the province of Tuscany, and later Professor of Mineralogy in Venice, gave us the threefold division of the rocks of the earth's crust: *Primary*, *Secondary* and *Tertiary*. "Tertiary" is still retained for a period, or system, of the Cenozoic.

1. *Primary or Primitive* — These were unfossiliferous rocks including schist, gneiss, quartz veins, highly folded rocks, etc.
2. *Secondary* — Included were several groups of strata with limestones, marls, clays, etc., all with fossils. Rocks recognized as Cretaceous by later workers were included as the uppermost unit in this division. In most of the 18th and 19th century literature, "Secondary" was applied to the vast series of strata from the mid-Paleozoic through Mesozoic (see Table 3).
3. *Tertiary* — "Arduino's *Montes tertiarii* consists of younger and highly fossiliferous series of limestones, sand, marl, clay, etc., and he observes that the material of these can in many cases be shown to have been derived from the Secondary series" (Zittel 1901:38).

   This observation of the recycling of material from older to younger fossil-bearing strata, which was encountered in many rock formations, also impressed many later workers with the need for successive epochs. It seemed necessary to account first for initial deposition and burial of fossils, followed by lithification, then by break-up, erosion of the formation, transport, incorporation into another sediment, followed by lithification of the new deposit (see, for example, Conybeare & Phillips 1822:xiv).

4. In addition to the three major divisions, a series of submarine lava and tuff deposits were placed in a *Volcanic* division.

It is not surprising that in Italy, a land where strata of the mountains to the north were twisted and contorted and where volcanoes and earthquakes resulting in change of the level of the land in relation to the sea were of repeated occurrence, Arduino would conclude that the earth had "undergone repeated upheavals and subsidences, many 'revolutions' and 'metamorphoses'" (Adams 1938:374). The gradual evolution of the concept that many of the formations represented deposits at successive periods of time served to pave the way for views that were to become widespread in both Britain and Europe during the early years of the next century.

Before 1800 — Concerning Fossils

There are isolated examples before 1800 of philosophers and scientists whose writings give penetrating insights on the origin and nature of fossils and fossil-bearing strata. Leonardo da Vinci (1452-1519), the Italian artist and sculptor, exhibited an understanding of processes involved in fossilization, lithification and subsequent exposure of fossils. Two centuries later Robert Hooke (1635-1703) recognized the value of fossils for reconstruction of the life and climate of former times, and Niels Stensen (Steno) perceived in the strata evidence of a chronological sequence of events in earth history (for the past "6000 years," mainly during and since the flood) including principles of superposition, original horizontality, and concepts of the role of sedimentation and erosion in burial and exposure of fossils.

But such references are generally secondary to a primary interest, and are widely separated in space and time. Far more pervasive were myths and fanciful speculations, not infrequently from men of stature from whom such statements seem strangely out of character. Teeth and bones of large animals such as mammoths (fossil elephants) were often attributed to antediluvian man, and were sometimes placed in the foyer of churches as a witness to the giant race which perished at the time of the flood. St. Augustine, in the fifth century, used as evidence of giants before the flood a large fossil tooth from which at least a hundred teeth of an ordinary size might be made (Howorth 1887:18). In 1726 J. J. Scheuchzer identified the skeleton of a giant salamander as from "one of those infamous men whose sins brought upon the world the dire misfortune of the deluge," naming it appropriately, *Homo diluvii testis*, which means "witness of deluge man" (Zittel 1901:20). Ezra Stiles, President of Yale, in response to an inquiry from Thomas Jefferson (1784), suggests that the "mammoths of Siberia all truly belong to an animal race in the shape of men, called Giants in the Scriptures" (Dunbar & Waage 1969:60-61).

Insofar as the nature of fossils and strata were understood, however, they presented little if any problem at that time for biblical views, generally being used rather as confirmatory evidence that the flood once covered the earth. Tertullian (c.160 - c.230 A.D.) and other early church fathers cited as evidence

TABLE 3

SELECTED CLASSIFICATIONS OF ROCK STRATA

ARDUINO 1759	WERNER 1790s	WILLIAM SMITH 1789, 1812, 1815	CONYBEARE & PHILLIPS 1821-1822	DE LA BECHE 1833
TERTIARY — Volcanic	ALLUVIAL Volcanic		SUPERIOR ORDER or TERTIARY: Alluvial; Diluvial; Upper Marine; (Freshwater: London Clay Plastic Clay)	Modern Group; Erratic Block Gr.; Supracretaceous Group
		London Clay		
SECONDARY	STRATIFIED (FLÖTZ)	Chalk	SUPERMEDIAL ORDER: Chalk; Chalk Marle; Green Sand; Weald; Iron Sand; Oolitic Series	Cretaceous Group; Oolitic Group
		Greensand; Brick-Earth		
		Purbeck, Portland; Coral Rag. Cornbr.; Upper Oolite; Under Oolite; Red-ground	Purbeck, Portland; Coral Rag. Oxford; Onferior Oolite - Lias; New Red Sandstone	Red Sandstone Gr.; Red Marl; Muschelkalk; Red Sandstone; Zechstein
		Magnesian Limestone; Coal Measures	MEDIAL ORDER (Carboniferous): Magnesian Limestone; Coal Measures; Millstone-Grit; Carboniferous or Mountain Limest.	STRATIFIED: Carboniferous Gr.; Coal Measures; Carboniferous Limestone
		Mountain Limest.		
		Red and Dunstone	Old Red Sandstone	Old Red Sandstone
	TRANSITION	Killas and Slate	SUBMEDIAL ORDER: Transition Limest.; Serpentine; Sienite; Greywacke; Clay Slate	Grauwacke Group; (Inferior strati. Nonfossilif.)
PRIMARY	PRIMITIVE	Granite, Sien Gneiss	INFERIOR ORDER: Granite	UNSTRATIFIED: Serpentine. Trap Granite, Volcan.

TABLE 3 (Continued)

	LYELL 1841	J.P. SMITH 1854	HITCHCOCK 1860 US	1981
POST-PLIOCENE	Recent	(River and Lake Deposits)	Alluvium	Quaternary
	Post-Pliocene	TERTIARY Pleistocene	CENOZOIC Recent Pleistocene	CENOZOIC Recent Pleistocene
TERTIARY	Newer Pliocene Older Pliocene	Pliocene	Tertiary Pliocene	Tertiary Pliocene Miocene
	Miocene Eocene	Miocene Eocene	Miocene Eocene	Oligocene Eocene Paleocene
SECONDARY	Cretaceous	Cretaceous	Cretaceous Chalk Gault Greensand	Cretaceous
	Wealdon Oolite or Jura Lias	Oolitic	MESOZOIC Jurassic Wealdon Oolitic Lias	MESOZOIC Jurassic
	Trias or New R Sandstone	SECONDARY Triassic	Triassic	Triassic
	Magnesian Limestone	Permian	Permian	Permian
	Carboniferous Coal Measures Millstone Gr Mountain Limestone	Carboniferous Coal measures Millstone Gr Mountain Limestone	Carboniferous Coal Measures Millstone Gr Mountain Limestone	Carboniferous Pennsylvanian Mississippian
	Old Red Sandst or Devonian	Old Red Standst (Devonian)	PALEOZOIC Devonian Upper Middle Lower	PALEOZOIC Devonian
PRIMARY FOSSILIFEROUS	Silurian	PRIMARY FOSSILIFEROUS Upper Silurian	Upper Silurian (9 units)	Silurian
		Lower Silurian (Cambrian)	Lower Silurian (4 units)	Ordovician
	Cambrian	Lowest Silurian (Cumbrian)	Cambrian	Cambrian
		META-MORPHIC	AZOIC	PRE-CAMBRIAN

of a universal flood the existence of marine shells on hilltops (Rudwick 1976:36-37). The well-known skeptic Voltaire (1694-1778), perceiving fossil evidence as a threat, contrived a variety of arguments in an attempt to discount the weight of evidence. Fearing that news of the discovery of marine fossils in various upland regions of Europe might be used in support of the Genesis flood, he "fought desperately the growing results of the geologic investigations" by proposing alternative, albeit far-out, explanations, e.g., that fossils were from the spoiled remains of fishes intended for food and discarded by Crusaders returning from the Holy Land (White 1896:229).

Fossil-bearing strata were generally attributed to a single event — the Genesis flood. Hence successive periods of time, origin of new species, and successive creations were not necessary. A literal six-day creation week a few thousand years ago was the prevailing view, although such a position had been questioned from time to time.

THE FORMATIVE PERIOD OF GEOLOGY 1785-1850

The conjunction of insights that resulted about the turn of the century from a systematic and comparative study of fossils and the recognition of the value of fossils for correlation of strata opened broad new vistas, thereby stimulating extensive studies. Students began to look again at the rocks of their own districts, as well as those of remote areas of the world, rugged mountain areas of Europe, Asia and even America. Geology earned a place in the academic disciplines, with famous men occupying the chairs: William Buckland at Oxford and Adam Sedgwick at Cambridge. This was a period of rapid change, of controversy over models of rock formation and earth history. The geologic column was introduced during these decades, and became an integrating concept. The welter of new views initiated sharp conflicts between interpreters of Genesis and of geology, many of which still plague conservative Christians today.

We shall comment briefly on several of the major innovators in the early part of this period. Our purpose is to gain an acquaintance with the persons who founded geology; to highlight relevant conceptual and methodological advances; and to understand prevailing theories, important because theories both derive from and, in turn, influence observation and interpretation.

Abraham Gottlob Werner (1749-1817)

Within a few years of Werner's appointment in 1875 as professor at a small, obscure School of Mines in Freiburg, Saxony, the school was "raised to the rank of a great university," with "men already distinguished in science" coming from all parts of Britain and Europe to study under the "great oracle of geology" (Lyell 1834:82). A penetrating mind with a rich store of knowledge, together with a charm and eloquence, attracted and kindled enthusiasm among his students, contributing to his enormous influence. Also to his credit were his use of exact methods of field observation and description, the introduction of a precise terminology for describing strata, and most of all the development

of a superior classification of rocks based on mineral composition — all essential if geology was to be elevated to a science in its own right.

Because "he indulged in the most bold and sweeping generalizations," and tended toward dogmatism on fundamental theories, several of which were proven false even during his lifetime (Lyell 1834:82), he became one of the most controversial figures in the history of geology, though it was not the great master but his students and disciples who engaged in the dispute.

Early in his career Werner developed a unique theory of the origin of strata which was to become the basis for his chronological scheme of classification. His five basic series or suites of strata were an expansion and modification of the earlier systems of Lehmann, Füchsel and others, and in certain respects an enormous step backward from them. Nearly all of the rocks — igneous,[1] metamorphic and most sedimentary — he believed to be chemical or mechanical precipitates deposited during successive epochs from a primeval turbid ocean which enveloped the entire earth. These universal envelopes, like the skins on an onion (onion-coat theory), whether folded, tilted or flat-lying, were held with few exceptions to have been deposited in the same position they now occupy. Because of the important role of the sea, his followers were often called "Neptunists" after Neptune, the god of the sea.

The discovery, about the same time, by James Hutton and his disciples of the true nature of igneous and metamorphic rocks, together with more accurate insights into the nature of sedimentary rocks, led to decades of stormy controversy. Because of Hutton's stress on the role of heat in the formation of rocks which cooled from a molten beginning, and his belief that heat also contributed to the consolidation of sediments, his followers were called "Vulcanists" or "Plutonists" after the god of the underworld, Pluto. Europe was divided into two camps: Werner's loyal students and the followers of Hutton. The overwhelming dominance of Werner's views, his position of unrivaled authority among his followers, especially on the continent where he became for geology "a kind of scientific pope," retarded the development of stratigraphy (Krumbein & Sloss 1958:11; Lyell 1834:81-82; Ospovat 1969:242-256).

James Hutton (1726-1797)

An early synthesis of Hutton's views given as a paper to the Royal Society of Edinburgh in 1785, while immediately controversial, was ultimately expanded into a two-volume work, *The Theory of the Earth*, published in 1795.

Hutton's major points, carefully reasoned and bolstered by field observations, were a refutation of the central thrust of the Neptunism of Werner. He advocated the origin of basalt from volcanoes and granite from magma. He associated the chemical and mechanical processes of weathering of rocks with the formation of sedimentary particles, thus showing clearly for the first time the essential relations between *denudation* of rock surfaces by wind, water, and gravity to transport and *deposition* of sediments in sites of accumulation where they were consolidated into sedimentary rocks (Zittel 1901:71). In contrast to Werner's view that younger rocks could be precipitated within as well as

above older rocks, Hutton enunciated the principle of superposition (Krumbein & Sloss 1958:12).

Phenomena which might appear at first sight to bespeak catastrophe could result from ongoing processes if time were interjected into the picture (Figures 1-3). Taking "the present as the key to the past," the famous dictum of uniformitarianism, he refused to speculate on origins, maintaining that "we find no vestige of a beginning, no prospect of an end." According to John Playfair, his close friend and frequent companion on geological excursions, he did not deny a beginning but only maintained that evidence of a beginning is not accessible through science.

Like Werner, Hutton did not participate in the debate, and he died in 1797 before it reached its zenith. Controversy raged not only with Wernerians but with the early catastrophists over the reality and results of cataclysmic events (later catastrophists allowed that uniformity might prevail between cataclysms). With Neptunists the origins of basalt, of granite, of sedimentary rocks, etc., were sore points. Hutton was attacked by many Christians as an infidel and charged with "warping everything to support the eternity of the world," of deposing the "Almighty Creator of the universe from His office" (see Lyell 1834:97).

Most of the principles that Hutton introduced were eventually incorporated into geology, profoundly influencing the course of inquiry down to the present time. Elements of his theory, such as the role of heat in consolidation of sediments and, more importantly, the idea that rates and magnitudes of geologic activity are approximately constant, have been or are now being rejected or revised.

FIGURE 1. Unconformable contact between vertical Silurian strata below and horizontal Devonian Old Red Sandstone above. Discovered in 1788 at Siccar Point a few miles east of Edinburgh, Scotland, by Hutton together with Playfair and Hall.

FIGURE 2. The indurated sedimentary Silurian cobbles in the basal portion of the horizontal Old Red Sandstone confirmed Hutton's conviction that some of the geologic processes involved, such as the erosion of the indurated Silurian beds, were of a "uniformitarian" nature.

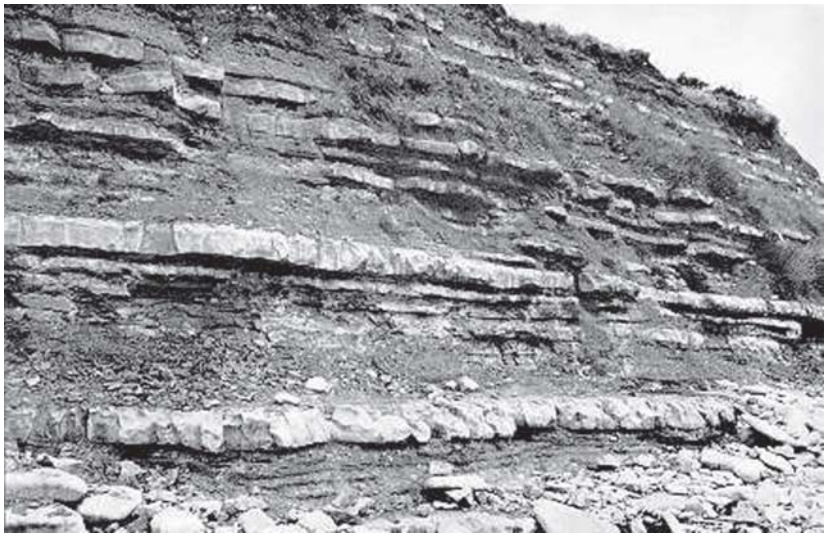
FIGURE 3. A comparable unconformable contact much higher in the column between Carboniferous and Triassic strata in South Wales near Barry.

William Smith (1769-1839)

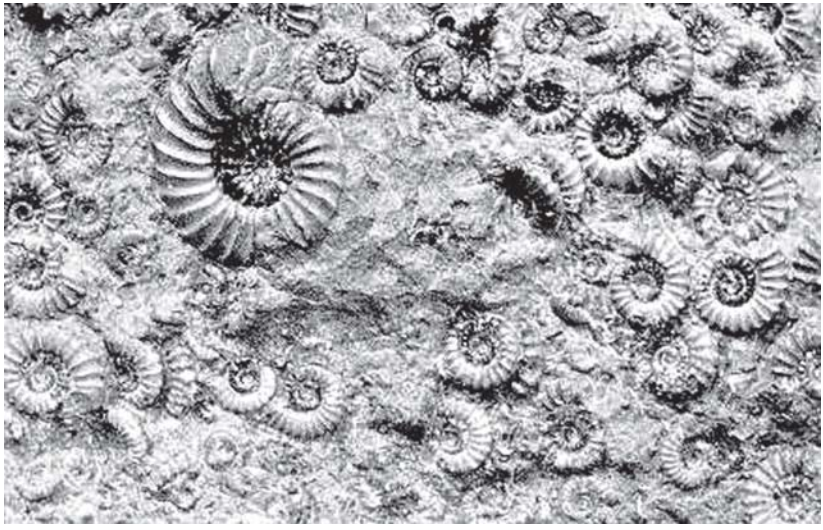
William Smith has been referred to as an "ignorant English land surveyor," (Price 1926:51) and otherwise as a "self-taught genius of rare originality and with exceptionally keen powers of observation" who was able to "elucidate the structure of his native land with such clearness and accuracy that no important alteration has had to be made in his works" (Zittel 1901:111-112).

His first major contribution was the recognition in 1798, while constructing canals through fossiliferous rock strata in Southern England, that fossil assemblages often include forms that are restricted to and typical of zones, formations or larger segments of the column (Figures 4 and 5). He determined that the occurrence of such fossils is consistent so that they may be used together with lithology and other features as "guides" in mapping and correlating strata (reported the following year in 1799). Secondly, he applied the method and within a few years (1815) had produced the first geologic map of an area of regional extent — England, Wales and a part of Scotland. Independently of Smith, Cuvier and Brongniart discovered the value of "guide fossils" while working through the series of strata in the Paris Basin in France.

As strata have been studied in all parts of the world, the order has been found to be consistently reliable in numerous sections, although extensions of the range of some "guide" or "index fossils" are made from time to time. This discovery by Smith — the value of fossil assemblages, guide fossils, in complementing other means of comparison, and making possible correlation over greater distances — was undeniably the most important geological breakthrough of the century, essential for establishing a geologic column of more



FIGURES 4 and 5. Jurassic beds near Lyme Regis on the south coast of Dorset, England, with ammonites from one of the resistant carbonate beds. While studying these beds and others about 1800, William Smith developed the concept of "guide fossils." A few years later these strata were to yield the specimens from which Evard Home, W. D. Conybeare and others reconstructed and described (1814-1824) Ichthyosaurs and Plesioseurs, two hitherto unknown great groups of extinct marine reptiles.



than regional application. As with any methodology there are various theoretical problems and limitations, but generally not seriously affecting the usefulness of the method.

Appropriately in the annals of geology William Smith is often referred to as the "Father of English Geology," or simply as "Strata Smith."

Georges Cuvier (1769-1832)

Although the structure of vertebrates is far more complex than that of sea shells, plants and other lowly forms, when known and understood in detail, even limited parts such as the individual teeth or bones most likely to be preserved as fossils can be used to determine whether a reptile, amphibian, mammal or other vertebrate is represented. And if it happens to be the right tooth or bone, accurate diagnosis of the family, genus or species is often possible.

Cuvier had the interest, the keen intellect, the drive, the originality, and the ample resources (the French government) to make, for the first time, vast comparative studies of a wide range of living as well as fossil vertebrates so that they might be accurately identified and properly related on fundamental characteristics. Thus, in the early years of the 19th century the study of fossil vertebrates advanced from almost total darkness to broad daylight. Since the basis of vertebrate paleontology is essentially the comparative anatomy of fossil forms, Cuvier is justly recognized as the founder of both comparative vertebrate anatomy and vertebrate paleontology. His *Researches on Fossil Bones* is a classic. "In the whole literature of comparative anatomy and paleontology there is scarcely any work that can rank with this great masterpiece of Cuvier" (Zittel 1901:137).

Once Cuvier had blazed the trail, others followed. William Buckland of Oxford and Gideon Mantell, the physician-paleontologist, applied the method with great success to vertebrate remains in Britain. A few years later, Sir Richard Owen produced a magnificent series of studies on fossil reptiles, and a monumental work on *Odontography* (1839-1845). Many other workers entered the field both in the old and new world. Whole new vistas of ancient land life were now, for the first time, opened to view. A key had been forged, a breakthrough necessary for meaningful study and correlation of formations in which land vertebrates are the major fossils preserved (terrestrial biostratigraphy).

But Cuvier did not confine his studies to these topics. With his friend and associate, Alexandre Brongniart (1770-1847), almost every week for four years he made excursions to the country in the environs of Paris making detailed studies of the stratigraphy, structure and paleontology of the Cretaceous and Tertiary series of formations. Their work on the Paris Basin, published in 1808 and expanded in 1811, remains a classic for accurate observation and original application of principles of paleontological and stratigraphical analysis.

These early studies on the Paris Basin during the first decade of the century led Cuvier to the theory of catastrophes, a theory that, with modifications and acceptance by many of the most respected geologists of that time,

profoundly affected geological research and interpretation for the half century during which the geologic column was founded. Only a few of the lines of evidence which led him to this conclusion will be considered.

Cuvier speaks of questions and ideas that haunted him, even tormented him all during his researches (Cuvier 1817:174). He was much impressed by the striking changes which often marked the boundaries between successive formations: the abrupt change in lithology; sometimes an erosional break; the marked changes in the fossil communities — from marine, to fresh water, to marine, to land, etc. The shells were, Cuvier (1817:8-9) observed, "almost everywhere in such a perfect state of preservation, that even the smallest of them retain their most delicate parts, their sharpest ridges, and their finest and tenderest processes." They must therefore, he reasoned, represent successive communities buried where they lived rather than being transported from distant areas and buried level upon level.

He and Brongniart early recognized the phenomena of restriction of distinctive fossils to particular zones, formations or series — guide fossils — and applied this tool in their stratigraphical studies. Moreover, they observed a pattern or trend in the change from level to level. Of the shells found in the upper, more recent levels, he states that the "eye of the most expert naturalist cannot distinguish from those which at present inhabit the ocean." Forms of life recovered from successively more ancient strata were observed to become progressively more strange and "peculiar" (Cuvier 1817:13, 108-109).

Among the numerous other features that seemed to call for a long interval of time between formations was the presence of a "breccia of chalk fragments" at the base of the overlying clay beds which was taken to indicate that the "chalk was already solid when the clay was deposited"; that is, lithified chalk cobbles were recycled into the next younger deposit (Geikie 1905:368-369). The picture that emerged then was one in which long intervals of occupation and stability were thought to be separated by tectonic revolutions, destruction of life, and eventual repopulation, possibly by migration of life from an unaffected region in the world (Cuvier 1817:125-126).[2]

A man of religious faith, he resolved the stratigraphic evidence with the biblical account by explaining that "a great and sudden revolution, the epoch of which cannot be dated much farther back than five or six thousand years ago," which had "buried all the countries which were before inhabited by men and by the other animals that are now best known," was the last great revolution now "thoroughly established in geology" (Cuvier 1817:171). This seemed to him to fit the data because man and his artifacts were only known to be associated with the most recent deposits.

An eloquent statement concluding his essay on the *Theory of the Earth* clearly reflects his attempt at reconciliation of Scripture and geology. "And mankind, to whom has been allotted only an instant on the earth, would have the glory of recreating the history of the thousands of centuries which preceded his existence, and the thousands of beings which have not been his

contemporaries" (Quoted by Gillispie 1960:290-291; cf. Cuvier 1817:171, 178-181).

Cuvier was honored by his own people and government, and he became very famous abroad. Such fame certainly contributed to the wide acceptance of his theory. Although very different in substance from the theories of Werner and Hutton, Cuvier's theory of catastrophes again called for long ages in explaining the geologic history of the world. It was strenuously opposed by many conservative theologians and laymen, while others embraced the idea.

RESUME

The work of Werner, Hutton, Smith, Cuvier and several contemporaries, although sometimes fraught with controversy and beset by imperfect theories, had succeeded in laying the groundwork that made a scientific study of geology possible. The next three decades were a time of enormously rapid progress. Workers focused on the crust of the earth in their own countries and traveled to distant parts of the world to compare the strata and fossils; the geologic column was formulated much as it exists today in its broader features; heightened tensions resulted from attempts to harmonize earth history with the biblical record. These decades are considered in Part II in the next issue of *Origins*.

ENDNOTES

1. In his classification of strata, only those lavas demonstrably associated with volcanic vents were included in the Volcanic Series, which Werner, like several before him, considered to result from subterranean fires of combustible materials such as coal. One of the stormiest controversies of the early 19th century concerned the origin and classification of extensive enigmatic basalt deposits in the British Isles, France and other parts of Europe that were not clearly associated with discernable volcanic vents. (For an extended discussion, see Geikie 1905).
2. Other workers, especially in England, introduced the idea of new divine creations of progressively higher forms of life after each catastrophe, whereas Cuvier, while explicitly denying that "new creations" were "required," from time to time made statements which clearly indicated that he considered origin at successive intervals a possibility. For example: "I do not pretend that a new creation was required for calling our present races of animals into existence. I only urge that they did not anciently occupy the same places, and that they must have come from some other part of the globe" (Cuvier 1817:125-126). Concerning man: "He may have then inhabited some narrow regions, whence he went forth to repeople the earth after the cessation of these terrible revolutions and overwhelmings" (p 131). On the other hand, "we are also led to conclude that the oviparous quadrupeds began to exist along with the fishes, and at the commencement of the period which produced the secondary formations; while the land-quadrupeds did not appear upon the earth till long afterwards, ... whence there is every reason to conclude that these animals have only begun to exist, or at least to leave their remains in the strata of our earth ..." (pp. 108-109). "... And man, to whom only a short space of time is allotted upon the earth, would have the glory of restoring the history of thousands of ages which preceded the existence of the race, and of thousands of animals that never were contemporaneous with his species" (p 181).

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ARTICLES

A REVIEW OF RECENT DATA FROM THE REGION OF THE ARK-SHAPED FORMATION IN THE TENDUREK MOUNTAINS OF EASTERN TURKEY

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WHAT THIS ARTICLE IS ABOUT

It has been widely believed that creationism would receive a significant advance if Noah's Ark were to be found. A majority of efforts, both exploratory and literary, have been focused on the traditional site — the Ararat Mountains (Agri Dagh). The present article questions the value of searching on Ararat and proposes that the boat-shaped geologic feature on another mountain several miles away be reexamined. Supporting evidence is provided by the description of two large stones which closely resemble stone anchors used by seafarers millennia ago. A case is made for the genuineness of the stone anchors, and the conclusion is that the search for the Ark's remains should be moved to the Tendurek Mountains.

I. THE SEARCH FOR THE ARK ON MT. ARARAT

Through the centuries there have been isolated attempts to locate Noah's Ark, but these searches have only been pursued with particular vigor and persistence since World War II. The basic bibliography of materials relating to this search has been compiled by Violet M. Cummings.[1] While there are some exceptions to the format,[2] more recent books and movies on this subject generally begin with a condensation of her materials followed by a description of the author's expedition to the traditional Mount Ararat.[3]

The results of these investigations might be summarized as follows.

1. Cummings' literature survey shows that there is no evidence earlier than the 4th century A.D. which identifies the traditional Mt. Ararat (Bü Agri Dagh) as the site where Noah's Ark landed.[4]
2. Aerial photographs of this mountain have located the supposed outlines of Noah's Ark on a ledge overlooking the deep Ahora gorge.[5]
3. Old wood has been brought down from this mountain on two occasions, by F. Navarra in 1955 and by the SEARCH group in 1969.[6] The wood, obviously hand-tooled, is said to be white oak and has been radiocarbon dated on several occasions to the second half of the first millennium A.D.[7] Considering the

fact that these are the only significant results that have been produced by more than thirty expeditions to Mt. Ararat over the past two decades,[8] these rather meager findings raise the question of whether the search is located in the right area.

Because of adverse political conditions, such searches have been almost completely suspended for the past five years. Two expeditions to Mt. Ararat were planned in the summer of 1979, one of which did at least travel some in eastern Turkey. Since no results of these attempts have been publicized as yet, I suspect that whatever they were able to accomplish in the field was not of major importance and does not change the picture of the results summarized above to a significant degree.

There are a number of reasons why such meager results might have been expected from this mountain, and these may be itemized as follows:

1. Genesis 8:4 merely locates the landing site of the Ark in the "mountains" (plural in the Hebrew) of Ararat. While the traditional Mt. Ararat does lie within the territory that once was ruled by the ancient kingdom of Urartu, the name of which is related to the biblical name of Ararat, Genesis does not provide any specific evidence that the mountain upon which so much effort has been expended by these expeditions is the correct one.
2. Identification of the Ark's site rests upon a very late tradition from the Christian era. This same era was one during which an extensive pilgrimage mentality developed in Byzantine Christianity. Armenian Christian inscriptions, for example, are known as far south as the vicinity of St. Catherine's monastery in the southern Sinai peninsula.
3. Deprived of any of the sites that Jesus visited personally, Armenian Christians quite naturally developed a pilgrimage tradition connected with something close at hand. From this line of thought it is easy to see why the site where Noah's Ark landed came to be attached to the traditional Mt. Ararat — the highest, most outstanding mountain in the region.
4. Evidences for pilgrimages up this mountain have been found in several stations located at intervals along the trail, each having eight crosses carved in the rock face of the mountain. These have been documented in Bart LaRue's movie on the search for Noah's Ark. These crosses obviously were intended to represent the eight persons who were in the Ark according to Genesis 7:7. Further evidence for pilgrimages up this mountain comes from Armenian inscriptions at its foot, some of which have dates in the second half of the first millennium A.D.

5. Armenian Christian pilgrims ascending this mountain may well have built a shrine to venerate Noah. Since the pieces of wood brought down from the mountain date to this period, the most logical suggestion for their origin is from such a shrine. One can argue about the corrections necessary for radiocarbon dates from the 2nd millennium B.C. and earlier, but no valid reason has been advanced to explain why these radiocarbon dates from the 1st millennium A.D. should be discounted.[9] Since they are compatible with historical data in the vicinity of this mountain from this period of pilgrimages, it is natural to associate them with this development.
6. Scientific evaluation also poses problems for the identification of Agri Dagh as the mountain upon which the Ark landed because of its volcanic origin and its isolation from other nearby mountains. In addition, the glacial action of the ice pack high on that mountain makes it unlikely that any original Ark wood could have survived the millennia since the Ark supposedly landed there.

In summary, the traditions which have located the landing site of Noah's Ark on Agri Dagh are quite late, dating only to the first millennium of the Christian era. Since many of the holy sites venerated by Christians of the same period in Palestine can now be demonstrated to be historically and archaeologically incorrect, there is no particular reason why this tradition in Turkey should be an exception. These erroneous holy sites in Palestine represent cases in which a knowledge of the authentic site was lost within a few centuries. How much more then is the Mt. Ararat tradition questionable, since it is only attested in sources separated from the Flood by millennia? Aerial photography, radiocarbon dating of the wood, and scientific evaluation have not indicated that any remains of the Ark still are on Mt. Ararat or even that this was the mountain upon which it landed. Perhaps other locations in this region should also be considered in the search for that site.

II. THE 1960 EXPEDITION TO THE TENDUREK MOUNTAINS

The only other site in this area which has received some attention in the search for the Ark is an isolated and unusually shaped formation at the 6,000 foot level of elevation in the Tendurek Mountains. It is located about 30 miles southwest of the traditional Mt. Ararat and about six miles west of the town of Dogubayazit, the home base of the expeditions that have attempted to climb Mt. Ararat. In the winter of 1959 a Turkish army captain named Ilhan Durupinar noted a ship-like outline in some aerial photographs of eastern Turkey (Figure 1). When news of this discovery reached the United States, an expedition to visit that site was organized. The story of this expedition has been told by R. Noorbergen in *The Ark*

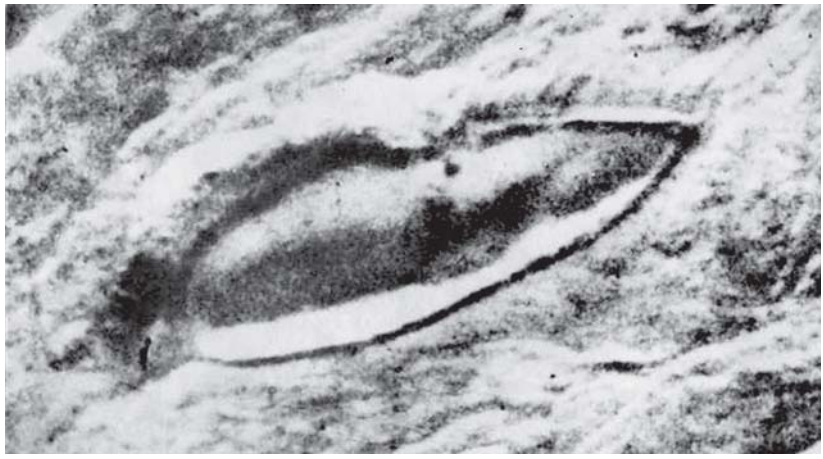


FIGURE 1. Aerial photograph of the ship-shaped formation in the Tendurek Mountains. Photograph by R. Noorbergen. Reproduced by permission of Camera Press, Ltd., London, 6036-I.

File.[10] On the negative side, the members of the expedition found no archaeological evidence for the Ark and consequently abandoned any further study there. On the positive side, the expedition confirmed the measurements of the formation that had previously been determined from the aerial photographs. The ship-like shape of this formation measured 500 feet in length, 150 feet at its widest point, and 20 feet high.

Two main criticisms might be made of the 1960 expedition. First, no geologist was included in the group, although the site turned out to be more of a geological problem than an archaeological one (see below). Second, the group might have abandoned its task prematurely. Influenced, at least to some extent, by second- and third-hand stories from then-deceased, elderly former residents claiming that the Ark was still intact at the traditional site, the team broke off exploration of this site rather abruptly when it did not meet their expectations that were based upon perhaps exaggerated legends. Given the millennia that passed between the Flood and 1960 A.D. when this expedition took place, it was rather unrealistic to expect that the Ark survived whole and intact.

III. THE 1976 REEVALUATION OF THE TENDUREK MOUNTAIN FORMATION

Noorbergen's *The Ark File* was published in 1974. After reviewing the evidence from the chapter of his book that deals with the 1960 expedition and corresponding with a geologist who had visited the site in 1973, I published the suggestion that this formation should be reevaluated as a possible location of Noah's Ark.[11] Such a reevaluation should be

undertaken without preconceived opinions about the kind of evidence we should expect from such a site.

From aerial photographs this formation looked as though it lay in a former lava flow (see Figure 1). Since no remains of the Ark are visible, it was suggested that the Ark may have burned as the result of volcanic activity. The precise nature of the flow around this formation has yet to be determined by direct geological observation. In the summer of 1977 a geologist suggested to me that this was a Pleistocene mud flow, but he still had no explanation for the ship-like formation itself.[12] Since the length of time from the flood must be measured in millennia, it is also possible that the remains of the Ark eventually disintegrated from weathering and decay. In either case the Ark itself would not remain, but rather a mold or cast of its hull made in the mud now hardened at the site where it came to rest.

The first point of special interest is the formation's obvious ship-like shape. On this I wrote earlier:

> *One need not be an expert in geology, archaeology, or nautical engineering to see that the outline in the photograph above obviously resembles that of the hull of a ship. This was what brought it to Ilhan Durupinar's attention, this was what caused some commotion when the aerial photograph of it was published in Life magazine, and this was what led to the 1960 expedition that went to examine it.*
>
> *The expert in aerial photogrammetry from Ohio State University who read the film said of it before going to the field with the expedition, 'I have no doubt at all that this object is a ship. In my entire career I have never seen an object like this on a stereo photo.' This formation certainly does have the outline of the hull of a ship, which is a fact that no one has denied.*[13]

Some have objected on occasion that if this formation were related to Noah's Ark, it should have been more rectangular in shape. This criticism rests upon a preconceived opinion about the design according to which Noah's Ark had to be built. The biblical measurements for the Ark provide no direct indication of the hull's actual design. The same measurements have been applied to modern ships of a comparable size, which certainly do not have rectangular-shaped hulls. While the Ark was only intended for flotation and not for propelled navigation, a ship shaped like the outline of the Tendurek Mountain formation would probably have been less susceptible to damage in high seas than would a more rectangular hull. At the very least the shape of the Ark's hull is an open question that cannot of itself negate the possibility that this formation could be related to it.

The second impressive point about the Tendurek Mountain formation when compared with the biblical description of the Ark is its measurements, especially its length (Figure 2; Table 1). Genesis 6:15 gives the measurements of Noah's Ark as 300 × 50 × 30 in terms of cubits. The measurements that appear with the plans of this formation in Noorbergen's

book are 150 × 48 × 7 meters respectively.[14] According to the second set of more accurate measurements taken from the aerial photographs, this formation is said to have measured 500 feet long and 160 feet at its widest point.[15] Though the ground measurements have not been reported in detail, they were said to confirm the measurements made from the photographs.[16]

To compare these two sets of figures it is necessary to estimate the length of the cubit employed in the biblical record for the dimensions of the Ark. The length of the cubit varied from place to place and time to time in the ancient world.[17] While the use of an antediluvian cubit cannot be ruled out, it is just as likely, if not more so, that these measurements were given in terms of postdiluvian cubits. It is suggested by the very use of the Semitic word for cubit here, since it derives from a particular postdiluvial language family. It one compares the Mesopotamian cubit of 19.6 inches for the Ark's cubit with the original measurement of 150 meters for this formation, they are just about the same, at 490 feet.

In the times of the Israelite monarchy the Hebrew cubit varied from the "old" cubit of 17.5 inches (2 Chronicles 3:3, Revised Standard Version)

FIGURE 2. A schematic comparison of the measurements of the Tendurek Mountain formation with the biblical measurements for Noah's Ark.

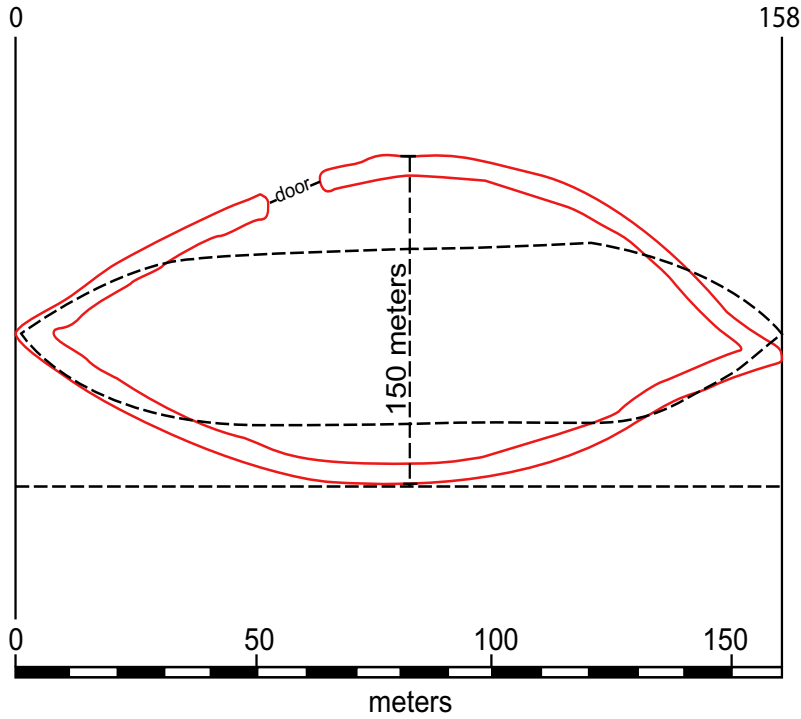


TABLE 1
Comparison of Biblical Ark Measurements with the Tendurek Mountain Formation

	Length	Width	Height
Biblical Measurements	300 cubits	50 cubits	30 cubits
1. Mesopotamian Cubit = 19.5 in = 0.498 m	149.4 m	24.9 m	14.9 m
2. Egyptian Cubit = 20.6 in = 0.523 m	156.9 m	26.2 m	15.7 m
Modern Measurements			
1. From aerial photos			
Noorbergen	150 m	48 m	7 m
More Accurate	152.4 m	48.8 m	?
2. From ground	?	?	6+ m

to the "long" cubit (Ezekiel 40:5; 43:13) which was approximately equivalent to the Egyptian cubit of 20.6 inches. Moses has been credited with the authorship of this passage of Scripture, and the cubit with which he was familiar during his Egyptian education may well have been the standard by which he set down these figures. If one compares the longer measurement of 500 feet for this formation with the biblical measurement for the length of the Ark according to the Egyptian cubit, then the latter comes out only 15 feet longer than the former. Since minor variables are involved in both figures they should not be pressed too far, but even allowing for such variables it is obvious that they correspond very closely.

This boat-shaped formation currently averages around 20 feet in height along its outer margin. By any standard of cubit, that is less than half of the 30-cubit height of the Ark given in Genesis 6:15. The way in which it was proposed above that this formation may have been formed, however, would suggest that it never was as high as the side of the Ark, even before significant weathering took place here; consequently, this discrepancy is not significant. However, the discrepancy between the width of these two objects is significant, since the 50-meter width of this formation at its widest point is about twice as wide as the 50 cubits of Noah's Ark. Several possibilities should be considered when an explanation for this discrepancy is sought.

In the first place, we do not know precisely how this biblical measurement for the width of the Ark was made. The ancients practiced mathematics differently than we do now in some respects. The use of inclusive reckoning whereby any fraction came to stand for the whole is one example (cf. 2 Kings 18:9-10). If some sort of averaging was employed to measure the width of an elliptical hull, then that figure might have come out differently than the way we now measure the widest points on this formation.

Secondly, assuming that the figure originally written in the biblical text did represent the width of the Ark at its widest point, we should consider the possibility that this original figure could have been garbled in the course of its transmission through successive recensions of the biblical text. The study of textual criticism clearly indicates that numbers were a feature of the text that suffered from alterations most easily in the course of their scribal transmission.

We also should allow for the possibility that this formation may now be wider than it was originally. It is interesting to note in this connection what marine archaeologists have learned about shipwrecks that have rested on the bottom of the Mediterranean Sea for centuries and millennia. As ships have disintegrated, in some cases, sections of their hulls have fallen outwards.[18] While the conditions under which these ships fell apart were not identical to those obtained in the Tendurek Mountains, it is possible that any remains of the Ark here could have suffered a similar fate.

Another possibility is that a geologic event(s) could have caused some spreading or fracturing. We now know that an earthquake damaged this formation between the summers of 1977 and 1979 (see below). Since this formation is located in a geologically active region, such damage could also have occurred in the more remote past.

Perhaps the most important point about this comparison of measurements is that its length corresponds quite closely with the measurements given in the Bible. Even if the bow and stern had fallen off as it disintegrated, the measurements of the remains of the Ark's length would not have altered significantly. Since the Ark was only 1/6 as wide as it was long, however, destruction or disintegration could have altered its configuration and dimensions more significantly in width. In other words, when compared with the biblical measurements of the Ark, the length of this formation is of greatest significance, its width is of intermediate significance, and its height is of least significance. In the dimension that counts the most — the length — the fit between this formation and measurements of the Ark in the Bible is most precise.

IV. THE 1977 EXPLORATION OF THE TENDUREK MOUNTAIN FORMATION

In the summer of 1977, independent of the article I published on this subject, Ronald E. Wyatt of Madison, Tennessee, visited this site to investigate its possible relationship to Noah's Ark. Although he was not able to explore the formation itself as thoroughly as he wished because of difficulties with the local villagers, he still made a significant finding in the vicinity of the formation.

There are two roads — one to the northeast, the other to the southeast — leading to this formation in the Tendurek Mountains. Wyatt approached it from the former route in the summer of 1977, whereas the 1960

expedition approached it from the latter route. He was thus able to make observations that could not have been made by members of the 1960 expedition.

The distance from the northeastern road to the ship-shaped formation is about two miles. About halfway there, Wyatt came upon a cemetery which did not look as though it has been used in modern times. Of itself this cemetery is not particularly remarkable for our present purposes. What is noteworthy is one of its stones that is distinct from those used as headstones.

For the purposes of our continuing discussion this stone has been designated Stone A. A similar stone, designated Stone B and described below, was found one-half mile west of Stone A. A side view of Stone A is shown in Figure 3. No measurements of this stone were made, but it is about the same height as Stone B, or about eight feet. The specific configuration of this stone is important. Broad when viewed from its side, it is relatively thin when viewed from an edgewise profile or end on. Byzantine crosses have been carved on one side. Further details can be determined by comparison with crosses carved in Stone B (Figure 4). More significant is the round hole that can be seen along its upper edge from the side view.

Wyatt has suggested that these distinctive stones should be identified as stone anchors. The leading authority in marine archaeology on the subject of stone anchors is Honor Frost. She has contributed a number of studies on this subject, her best summary statement being published in 1973, "Ancore, the potsherds of marine archaeology: on the recording of pierced stones from the Mediterranean."[19] Her study provides a useful background against which these two pierced stones from the Tendurek Mountains can be evaluated as possible stone anchors.

Most of the stone anchors from antiquity have been recovered by divers from the floor of the Mediterranean. The stone anchors found in excavations of sites on land, however, are particularly important because

FIGURE 3. Stone Anchor A; drawn from R. Wyatt's photograph by J. Jackson.

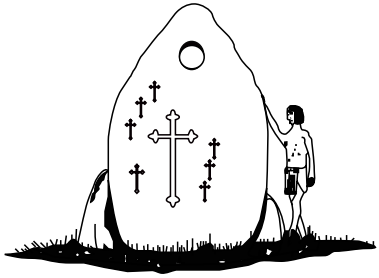
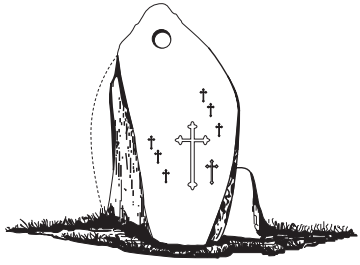


FIGURE 4. Stone Anchor B; drawn from R. Wyatt's photograph by J. Jackson.



they come from archaeological contexts that can be dated with relative accuracy. Stone anchors excavated on land have come from temples where they had been set up as sacred objects, from tombs, from stonemasons' workshops, and from the walls of various kinds of buildings where they were used secondarily as building stones. Most of the stone anchors recovered from the sea floor come from the shallows where ships that could not sail against contrary winds had to drop anchor and wait for more favorable conditions until they could resume their voyages. From the archaeologist's point of view, the number of stone anchors lost at sea by ancient ships appears to be "inexhaustible."[20] Lost stone anchors mark ancient sealanes and hint at the habits of those who used them.

Unfortunately for professional archaeologists, many stone anchors have been removed from the ocean floor by amateur divers without any recording of such finds. From Frost's corpus I have selected here five examples of some of the largest stone anchors known:[21]

1. An Egyptian anchor inscribed with the hieroglyph *nfr* which means, "good, perfect, beautiful.'' Excavated from a stratum dated to 2200 B.C. in a temple precinct at Byblos on the coast of Lebanon and now housed in the Beirut National Museum. Weight: 188.5 kg.
2. A limestone anchor excavated among votive obelisks in a temple at Byblos dated in the 19th century B.C. This triangular type of anchor was typically Byblian. Estimated weight: 30 kg.
3. A Ugaritic anchor from the temple of Baal on the coast of Syria, possibly from the 19th century B.C. level. Such anchors were squatter, thicker, and heavier than those used at Byblos. Weight: 700 kg, one of the heaviest if not the heaviest of stone anchors ever found.
4. An anchor used as building stone on Cyprus in the 13th century B.C. It is similar in shape to Ugaritic anchors. Estimated weight: over 500 kg.
5. An anchor found by the sea wall of an ancient port on Cyprus. Its incised script was dated to the 14th century B.C. Tapered at the top, it has a large rope hole. Estimated original weight: 150 kg.

The coming of Iron to the ancient world around 1200 B.C. brought the development of iron anchors and a decline in the use of stone anchors.

Pierced stones at either extreme of the weight range, wherever found, are the easiest to date and identify. They are consequently the most significant, but (particularly on land) are often cast aside. Not fitting in with preconceived notions, they are considered to be too big or too small to have served as anchors. Anchor stones that are too heavy for one man to handle (i.e., in the 50-700 kg range) will, however, almost certainly

antedate the introduction of metal and wooden anchors during the Iron Age. Once lead-stocked anchors became current on all important craft, stones became the poor man's anchors and, since the poor man had a small boat, the size of stone anchors diminished accordingly.[22]

The general and natural rule seems to be that the larger the anchor discovered by modern archaeologists the larger the ship that it must have been used on in antiquity. Frost has estimated, for example, that the use of half-ton Bronze Age stone anchors prove the existence of ships of at least 200 tons. This has implications for our understanding of other aspects of ancient shipping:

> *The existence of nineteenth-century B.C. half-ton anchors at Ugarit (and in the sea) proved that a number of Bronze Age ships were far larger than hitherto supposed — so large, indeed, that they would have been unbeachable. As a corollary, a few major proto-harbours must have existed along the shelterless Levant coast, in order to ensure trading by such large vessels.*[23]

With this survey of Bronze Age stone anchors in mind, let us compare the two pierced stones found in the Tendurek Mountains of eastern Turkey. In general configuration, the latter match the former on all important counts. These two pierced stones are, like the large Bronze Age stone anchors from the Mediterranean, tall, broad when viewed from the side, thin when viewed edgewise or end on, tapered towards the top and have rope holes at their upper ends. On all of these counts, therefore, they qualify quite readily as fitting the picture of stone anchors, as Wyatt originally identified them.

Only in size or scale do these two stones differ significantly from their Mediterranean counterparts. They are far larger than any of the anchor stones that have been recovered from the Mediterranean or from excavations along its coast. While the heaviest stone anchors from the Mediterranean weigh about 700 kg and stand about 1.1 or 1.2 meters high, these two anchor-like stones from the Tendurek Mountains stand about 2.5 meters or 8 feet high. We can give only a very gross estimate of their weight, but they must easily weigh several tons. If the size of the stone anchors implies the size of the boat or ship on which they were used, as is the case for half-ton anchors at Ugarit, how much more should it be true for these stone anchors weighing several tons that were found in eastern Turkey. Indeed they are, by this standard, Ark-sized stone anchors.

Given the conclusion that these stones are anchors, we may next ask, who made them, where did they come from, and how did they arrive at their current location? As to the question of who made them, two current possibilities appear reasonable. Either they were part of the original equipment of Noah's Ark, or they were made much later by Armenian Christians to commemorate that voyage and its participants. A later origin might be argued from the fact that Byzantine crosses were incised upon

the sides of these stone anchors. The crosses could have been cut long after the anchors had been quarried, just as the crosses cut in the rock at the stations along the trail up Agri Dagh were a late development.

One may question how familiar the Armenian Christians of this region would have been with stone anchors for sailing ships. Lake Van to the southwest is the nearest large body of navigable water, and any boats on that lake using stone anchors presumably would have used relatively small ones, similar to the small stone anchors still used by the fishermen in the Mediterranean today.[24] If Armenian Christians had quarried these stones to be commemorative stelae, there would not have been any real reason to bore rope holes in them. It seems evident that these objects were recognized as stone anchors. The least one can say is that if Armenian Christians did quarry these stones, in all likelihood they did so to connect this immediate vicinity with the commemoration of Noah's Ark.

The second question concerns the source of stone anchors. Since they lie only a mile to the northeast of the Ark-shaped formation, it is likely that Armenian Christians found them there and subsequently moved them to their cemetery. This chain of events answers the third question of how they reached their present location. A petrological analysis of pieces from these stone anchors would be of considerable interest in evaluating them. Such samples should not be difficult to obtain, since the local villagers are already chipping pieces from one of the anchors to sell to tourists as souvenirs from the Ark!

One might object that the biblical description of the Ark and the Flood says nothing about anchors, but neither does this argument from silence say that the Ark did *not* have anchors. There were probably many things aboard the Ark that were not mentioned in Genesis.

V. THE 1979 EXPLORATION OF THE TENDUREK MOUNTAIN FORMATION

In September of 1979 Ron Wyatt returned to the Tendurek Mountain formation for more surface exploration, accompanied this time by Manuk Benzatyan as his translator. This time they approached the ship-shaped formation from the southeast, the direction taken by the 1960 expedition. Of particular importance is what was seen quite clearly along the edge of the formation nearest to them as they approached it. The formation has been sectioned obliquely through its most distal or "stern" portion. This section looks like a large and prominent wall angling towards the southeast. This feature was not present in the formation in 1977 or earlier; consequently, it must have resulted from an earthquake which struck this region between the summers of 1977 and 1979. Other signs of the earthquake were evident elsewhere in this formation. A smaller concavity was knocked out of the north side or wall of this formation. Also seen

was a longitudinal fracture in the rocky spine that runs down most of the center of this formation.

While one may regret damage done to a site of potentially great interest in the study of antiquity, this earthquake damage was not without its beneficial side-effects. In effect, it opened up a fresh section of the interior of this formation, giving Wyatt an opportunity to collect a sample of soil from that freshly exposed surface for chemical analysis. For purposes of comparison he also took a sample from the soil surface beyond the geologic flow that runs by this formation.

The analysis of these specimens was performed by Galbraith Laboratories of Knoxville, Tennessee, and their results were reported to Wyatt on October 9, 1979. While there are some differences in other elements between the two samples,[25] their greatest difference lies in the amount of carbon they contained. The sample taken from the recently denuded surface of the formation revealed a carbon content of 4.95%, while the sample from the nearby countryside revealed a carbon content of only 1.88%. Thus a difference of 3% carbon is involved here, from 5% in the formation to 2% in the soil nearby. Wyatt was told by authorities in the laboratory that the amount of carbon in the former sample was consistent with that which one might find, for example, in a soil-covered peat bog. Thus while the chemical profile of this formation does not prove the presence of disintegrated wood, it does not exclude this possibility.

Stone Anchor B was also visited in 1979. Of particular interest are the shape and distribution of the crosses incised on the side of the anchor. Most obvious is the large main Byzantine cross around which all of the others are grouped. Three smaller crosses are visible in the right side, extending outwards at a 45º angle from the center of the main cross. The innermost of these three crosses is the largest and has the more formal Byzantine characteristics. To the right and above it is a smaller and more stylized cross. Above and to the right of the second cross is a third that is a little larger but also stylized.

Three smaller crosses can also be seen in the left side of the stone, extending to the left at a 45º angle from the center of the main cross. The cross that is outermost and uppermost corresponds to the cross in the same position on the right upper quadrant. The order of the two inner crosses on the left, however, has been reversed. The smaller stylized cross is now on the left while the larger cross with the more formal Byzantine characteristics is in the middle. Another formal Byzantine cross, larger than any of those above the horizontal arms, can be seen in the right lower quadrant.

The symbolism seems relatively straightforward. The large main cross around which the other seven cluster represents Noah. The next largest cross, also of the formal Byzantine type, is located in the right lower quadrant and should symbolize Noah's wife. She was next to him in

importance as the mother of his sons, and she stands under his protection. Above the arms of Noah's cross, and thus emanating from him, is a row of three crosses on one side that should represent his sons. The row of three crosses on the opposite side should stand for their wives. This representation is, therefore, of eight crosses which represent the eight persons who went into the Ark, and their crosses were designed and distributed in a particular way to say something about each of them.

This scene on the side of this anchor stone can be used as evidence that the Armenian Christians of this region connected these stones, and probably the nearby formation, with Noah and his family who came through the Flood in the Ark. Iconographically, therefore, there is an early Christian tradition that can be said to have located Noah's Ark in the Tendurek Mountains and which probably rivals in age the one that has located Noah's Ark on Mt. Ararat. While too much stock should not be put in Ark traditions dating only from the Christian era, as was pointed out at the beginning of this study, this particular tradition deserves to be taken seriously, since there is suggestive archaeological evidence here to support it. Thus it appears quite probable that Armenian Christians of the first millennium A.D. noted the same features of this area that have been discussed above and also connected them with Noah's Ark.

VI. CONCLUSIONS AND PROSPECTS

The ship-shaped formation in the Tendurek Mountains was first discovered in the winter of 1959 by Capt. Ilhan Durupinar as he surveyed aerial photographs of this region. The 1960 expedition to that site confirmed the ground measurements that had been determined already from aerial photographs, but further study there was abandoned. A reevaluation of this formation was proposed in 1976 by theorizing that it may only represent the place where Noah's Ark landed, not the remains of the Ark itself. The three prominent characteristics of this formation that were emphasized in that call for its reevaluation were:

1. It is located in the mountains of Ararat.
2. It is shaped like a ship.
3. It is the length of the biblical Ark.

The vicinity of this formation was explored again in the summer of 1977, and an additional find was made:

4. Two very large pierced stones were found that strongly resemble Bronze Age stone anchors from the Mediterranean, except they are much larger.

This formation was visited again in September of 1979, and two more finds were made:

5. The formation has a high carbon content which is consistent with the former presence of wood there.
6. Iconography incised on one of the stone anchors indicates that early Armenian Christians also held a tradition that Noah's Ark landed there.

Each new discovery at this site has strengthened the case for relating it to Noah's Ark, but the question still remains as to whether there is sufficient scientific evidence with which to confirm or deny this identification with a greater degree of accuracy. Unfortunately, the prospects are not too bright for carrying out the necessary field studies. Legitimate archaeological research in eastern Turkey has been hampered by previous violations of Turkish laws. Professional archaeologists have been caught attempting to smuggle ancient artifacts out of Turkey and in publishing antiquities by individuals other than those to whom the publication rights had been given. Amateur archaeologists engaged in the search for the Ark have also violated Turkish laws on several occasions.

Thus the archaeological and political pictures in the area remain fluid at the present time and they limit the study of this site to surface exploration only. Since some positive results have already been accomplished, the value of this kind of work should not be discounted. Six lines of evidence discussed above suggest a potentially positive correlation between the Ark-shaped formation in the Tendurek Mountains of eastern Turkey and the Ark of Noah described in the Bible. Whether or not it will be possible to add any more lines of evidence to these remains uncertain in view of the current political situation in the Middle East.

ENDNOTES

1. 1974. Noah's Ark: fact or fable? San Diego, CA: Creation Science Research Center.
2. Notably: (a) Navarra F. 1974. Noah's Ark: I touched it. Balsiger D, editor; Utt RH, translator. Plainfield, NJ: Logos; (b) Noorbergen R. 1974. The Ark file. Mountain View, CA: Pacific Press Publishing Association.
3. (a) Montgomery JW. 1974. The quest for Noah's Ark. 2nd ed. NY: Pyramid Books; (b) Balsiger D, Sellier, Jr. CE. 1976. Los Angeles, CA: Sun Classic (no personal expedition); (c) LaHaye T, Morris J. 1976. The Ark on Ararat. Nashville, TN: Nelson.
4. Cummings, Noah's Ark, p 40.
5. Montgomery (Note 3a), plates 10 and 11 between p 192 & 193.
6. See Navarra's book (Note 2) which deals with both the 1955 and 1969 expeditions. See also Cummings, Noah's Ark, p 271, 273.
7. Noorbergen (Note 2b), p 142-144. Cf. also the references in Note 9.
8. The figure is that of Eryl Cummings, an inveterate Ark searcher, in 1974. The search for Noah's Ark. A Challenge to Education, II. Lang W, editor. Caldwell, ID: Bible-Science Association, p 98.
9. (a) Bailey LR. 1977. Wood from 'Mount Ararat': Noah's Ark? Biblical Archaeologist 40:137-142; (b) Bailey LR. 1978. Where is Noah's Ark? Nashville, TN: Abingdon.
10. Noorbergen (Note 2b), p 114-129.

11. Shea WH. 1976. The ark-shaped formation in the Tendurek Mountains of Eastern Turkey. Creation Research Society Quarterly 13(September):90-95.
12. No satisfactory geological explanation for this formation has yet been advanced. For some attempts to explain it, see Ibid., p 92-94.
13. Ibid., p 92.
14. Noorbergen (Note 2a), p 154.
15. Ibid., p 124.
16. Ibid., p 128.
17. On the cubit in antiquity, see: Horn SH, editor. 1960. The Seventh-day Adventist Bible Dictionary. Washington DC: Review and Herald Publishing Assn., p 237.
18. For a random example see the Greek ship that sank off the north coast of Cyprus in the 4th century B.C. Swiny HW, Katzev ML. 1973. The Kyrenia shipwreck: a fourth-century B.C. Greek merchant ship. In: Blackman DJ, editor. Marine Archaeology. London: Butterworths, p 339-359.
19. In: Marine Archaeology, p 397-409.
20. Ibid., p 399.
21. Taken from Ibid., p 400-402. The line drawings represent the side view and the solid drawings represent the end view. Another solid drawing representing the top view has been added in the case of No. 1.
22. Ibid., p 404-405.
23. Ibid., p 399.
24. Of the on-going use of small stone anchors, Frost (Ibid., p 405) notes: "Anchors in the 20 kg range, which can be handled by one man, are still used and manufactured throughout the Mediterranean.... It follows that anchors in this weight range are almost impossible to date unless they are of exceptionally distinctive shape, or happen to be inscribed, or are associated with identifiable artifacts on the seabed."
25. The report as a whole reads as follows:

Sample No. 1 from Ark-Shaped formation	**Element**	**Sample No. 2 from nearby countryside**
0.23%	P_2O_5	0.28%
48.02%	SiO_2	51.29%
6.56%	Fe_2O_3	9.71%
14.01%	Al_2O_3	15.27%
0.44%	TiO_2	1.33%
17.41%	CaO	9.35%
3.02%	MgO	3.94%
0.17%	SO_3	0.37%
3.09%	K_2O	2.30%
0.94%	Na_2O	2.43%
4.95%	C	1.88%

The certificate of analysis indicates the samples were received by the Galbraith Laboratories on October 1, 1979, and were assigned the test run numbers 1-3968 and 1-3967 respectively. The results were reported on October 9, 1979 and the report is signed by Gail R. Hutchens, executive Vice-President. Xerox copies of the originals are on file with the editor. Used by permission of Ron Wyatt.

LITERATURE REVIEWS

Readers are invited to submit reviews of current literature relating to origins. Mailing address: ORIGINS, Geoscience Research Institute, 11060 Campus St., Loma Linda, California 92350 USA. The Institute does not distribute the publications reviewed; please contact the publisher directly.

THE "AUSTRALIAN PROBLEM"

ECOLOGICAL BIOGEOGRAPHY OF AUSTRALIA. Allen Keast, editor. 1981. Netherlands: Dr. W. Junk bv Publishers. 2142 p.

Reviewed by Richard D. Tkachuck, Geoscience Research Institute

The diversity of living organisms is perhaps the greatest source of joy and pleasure to the biologist or naturalist. Indeed, the amazement that one feels as a new form of life is seen for the first time can scarcely be matched. Thus in the age of exploration, one can appreciate the wonder expressed as the intrepid travelers discovered the southern continent of Australia. Here was represented perhaps the greatest assemblage of oddities in the natural world. The plants, the invertebrates and especially the mammals all shouted Australia's singularity. To the evolutionist this was a continental example of what had been observed on smaller islands — land mass isolation or development and then adaptive radiation of the life forms into evolutionary synchrony with the various ecological niches.

The monograph is divided into three individual volumes with a box cover and a separate large folded map of Australia. Within the three volumes are eight separate sections each containing a number of articles, 69 in all, by various specialists.

The first section logically begins with a geological study which supports the concept of Gondwanaland, its breakup and the drifting away of the continent from Antarctica, Africa and South America. Biological and geological affinities with South Africa and South America are often drawn. Some data that do not support such a conclusion are also given. However, all authors favor a drift model for the placement of the continent. The paleoclimate and the present are compared with evidence from palynological studies which support a moister climate in the past. A factor not appreciated by myself until reading this series was the role that fire plays in the distribution of life forms. The massive campaign by Smokey the Bear has left most with the understanding that fire is caused by man, and that it has no role in Nature's cycles. The reverse is true in many ecological zones.

The second section deals with the flora of Australia and its distribution. Because of the large size of the continent and its long north/south dimension, a wide variety of ecological regions are found varying from dry scrub desert to the wet tropical rain forest. An alpine area even exists in the south east. The dryer climates, however, are found on the majority of the land mass. The Eucaliptids, which are composed of nearly 500 species, are almost exclusively distributed in Australia, a few species being found on New Guinea and outlying islands. New Guinea is an area that provides good evidence of tectonic plate collision and has remarkable faunistic and floristic affinities with Australia. These affinities were often treated throughout the monograph, which was indeed welcome. Other plant forms have more cosmopolitan distribution, but even these have unique characteristics. The degree of endemic forms at the generic and even the family level is indeed impressive. With the disjunct patterns of plant habitats locations, good evidence again is presented for different climatic conditions in the past.

Section three deals with the invertebrates of Australia. Here the series is perhaps most deficient. This is to be expected, being that the invertebrates compose the vast majority of life forms, and it is not probable that they all would have received the same emphasis as have the vertebrates. Evidence is presented to show South American and African affinities between various invertebrate fauna. Yet one could wish that the treatment here was more extensive.

Section four concerns itself with the biogeography of fresh waters. Australian rainfall is largely seasonal and in most areas erratic in amount. This has resulted in a large number of organisms which have highly specific capabilities in coping with this seasonality. It is unfortunate that the biogeography of marine organisms was not treated, for there are numerous forms that have poor dispersal properties which inhabit the coastal shores, especially the Great Barrier Reef, and these certainly could have been examined with profit.

Sections five and six deal with the poikilothermic and homeothermic vertebrates respectively. The amphibians are logically dispersed in accordance with the abundance of moisture. Both the amphibians and reptiles show supposed mixed origins, a few with affinities to proposed Gondwanaland fauna and a majority having Asian affinities. Here again, the diverse habitats have allowed a high degree of local endemism to develop. An extensive presentation on both recent and fossil marsupials is next given. I was surprised at the limited amount of fossil mammal material that is extant and that it is mostly Quaternary in age, with rapidly reducing

amounts as one moves into the Tertiary. There appears to be no evidence of placental forms. Pleistocene giantism, with wombats the size of bears and kangaroos 3 meters tall, is seen in Australia, along with a massive Pleistocene extinction. Several papers on the biogeography of birds are also presented, but more from an ecological perspective, with the emphasis being on how the environment regulates their placement.

The seventh section is a group of papers on aboriginal man, his prehistory, culture and adaption to the various environments. Still unresolved is the question of multiple invasions by man as well as his possible role in the extinction of certain species.

The final section is a short synthesis which attempts to constrict the wealth of information into a manageable whole. These perhaps should be read first, as they provide an excellent overview of the entire series. The almost exclusive presence of marsupials in Australia is perhaps the greatest biogeographical and speciation puzzle faced by the creationist.

In overview, the series presents the fastest way of acquainting oneself with a vast amount of literature and provides the reader with an extensive bibliographic source. The articles are written at various levels of complexity, some to be read easily by most biologists, others intended for only the specialist. (The article on spiders was ponderous). Unfortunately, this monograph probably will not reach a wide audience as the price borders on the obscene — $500.

In my tenure with the creation movement, perhaps no other questions come up with greater frequency than those revolving about the "Australian problem." This problem is not unique to creationists. The pronounced paucity of fossil marsupials in Australia is far from a convincing argument for their evolution. The dilemma presented is as follows: Firstly, if the marsupials came from the ark, how could all the various families of marsupials have made it to Australia and nowhere else? In addition, why do none of the placental mammals arrive there also? There are the rare exceptions of a rodent family, some bats (whose source is obvious), man and his dog. Secondly, if it was possible for a marsupial type to have arrived on the continent first and later be isolated, an enormous amount of morphological change must then have taken place in that original ancestor, for there are marsupial moles, carnivores, insectivores and, of course, the unique kangaroo types. So we are presently stuck with either a highly unique dispersal mechanism or enormous amounts of morphological change. The creationist must squarely face this "Australian problem." The above series seems an efficient place to begin gathering the data for such a study.