

sively demonstrated the presence of a thick regolith, constitutes a serious failure to consider either the technical literature or the popular accounts of the Apollo program.

The claim that a thick layer of dust should be expected on the surface of the moon, and the claim that not more than a few inches of dust were found on the surface of the moon, are contradicted by an abundance of published evidence. The continuing publication of those claims by young-earth advocates constitutes an intolerable violation of the standards of professional integrity that should characterize the work of natural scientists.

---

---

# TIMELESS TALES

---

## FROM THE

---

## SALTY SEA

---

### 5

---

**A**LL STREAMS FLOW INTO THE SEA, YET THE SEA IS never full. To the place the streams come from, there they return again."

So says the Preacher in Ecclesiastes 1:7. But, to add a technical note to the Preacher's observation, the streams leave most of their salts in the sea each time they repeat this cycle. As water flows over or through the rocks and the soil to get to the streams, it dissolves numerous minerals and carries them down to the sea. Calcium, iron, sodium, chlorides, sulfates, carbonates and a host of other materials are carried into the oceans by earth's streams, and most of those "salts" are left in the oceans when the water evaporates and returns to the land as rain or snow, ready to repeat the salt transportation cycle.

Late last century John Joly thought that he could determine the age of the oceans by comparing the rate at which sodium is carried into the ocean with the amount of sodium salt which had already accumulated there. Using data collected by others as well as by himself, he obtained information on the amount of water that each of the earth's major rivers annually delivered to the ocean and on the average concentration of salt in those rivers. He also used estimates of the total volume of water in the oceans, and measurements of the concentration of sodium in ocean water. In 1899 he published his conclusion that the age of the earth's oceans is between 80 and 90 million years.<sup>1</sup> Notice that this is an estimate of the age of the oceans and not of the earth itself, though Joly thought the age of the earth was close to the age of its oceans.

#### The Determination of Residence Times

Since 1899 a great deal of work has been done in measuring the concentration of many materials in ocean water and in the streams that flow into the ocean. Furthermore, much progress has been made in trying to understand the several processes that go on within the oceans and at the oceans' boundaries (floor, shore and surface) which remove those materials from the ocean water.

For example, coral reefs are constructed primarily of calcium carbonate which has been extracted from ocean water by coral animals, thereby removing calcium and carbon from ocean water; deep ocean sediments contain large quantities of skeletal remains of microscopic organisms (plankton, radiolarians, etc.) which have extracted calcium carbonate or silicon dioxide from ocean water to make those skeletons, thereby removing calcium, carbon and silicon from ocean water; some elements adhere to the surfaces of clay particles which settle to the ocean floor, thus effectively removing those elements from solution in the ocean water. The global ocean is a highly complex system, and while much progress has been made in our endeavor to understand it, still many questions remain for which our tentative answers

are neither very precise nor very certain. The study of all these processes continues.

Some of the processes that remove certain materials from the ocean water occur continuously, such as the settling of clay particles to the ocean floor, carrying with them those materials that adhere to the surfaces of such small particles. Some salt-removing processes must have occurred only episodically, such as the evaporation which deposited the thick layers of rock salt in Michigan, New York, Kansas and many other parts of the world. Many of these phenomena are interrelated, so that a change in one of them will affect the entire complex network. And many of these processes are also affected by changes in ocean conditions such as temperature and acidity.

Some dissolved salts stay in the ocean water a long time before being removed. Some are removed quickly by reactions which incorporate them into the solid particles that form the ocean floor sediment. The average amount of time that an atom of an element remains dissolved or suspended in ocean water is called the *residence time* of that element in ocean water. Several measurements have been made to determine the residence times of as many elements as possible. An extensive table of those data was published in the two-volume work *Chemical Oceanography* in 1965.<sup>2</sup>

The residence time for an element depends on how soluble the various chemical forms of that element are, on how reactive the element is in the ocean environment and on several other factors. The residence times range from 100 years for aluminum to 260 million years for sodium. Interesting enough, a few elements, such as boron and bromine, exhibit concentrations in ocean water that are even higher than would have accumulated there at present-day rates in 4.5 billion years; residence times for those elements are not included in *Chemical Oceanography*. In the context of all of these considerations, it should be evident that Joly's calculations did not provide a measure of the *age* of the ocean; they merely yielded the residence time for sodium (with a result somewhat too low).

### Confusing Residence Time for Age

The residence times listed in *Chemical Oceanography* are considerably less than the age of the earth as determined by methods based on radioactivity. That information has been used by some young-earth advocates as the basis of their claim that the earth cannot be as old as the results of radioactive dating indicate. In *Scientific Creationism*, for example, the residence times of several elements are listed,<sup>3</sup> the values being quoted from *Chemical Oceanography*.

The column of time values given in *Scientific Creationism*, however, has the heading "Years to Accumulate in Ocean from River Inflow" instead of the more appropriate one, "Residence Times." Accompanying comments about those times refer to them *as if* they were calculations of the *age* of the oceans, which they are not. We read, for example:

The significant thing to note, however, is that in every case the calculated apparent age is vastly less than the supposed 5 billion year age of the earth.<sup>4</sup>

And, after noting the wide range of "apparent ages,"

This situation is difficult to understand if the earth's lithosphere and hydrosphere are indeed billions of years old, and if uniformitarianism is a valid assumption in geochronology.<sup>5</sup>

These comments in *Scientific Creationism* and similar comments in other literature that advocates the young-earth hypothesis<sup>6</sup> are apparently based on a substantial misunderstanding. Residence times are *not* useful for measuring the age of the oceans nor of the earth. That they cannot be used for measuring age is already evident from the fact that residence times of several elements are less than a thousand years, and we all know that the oceans are older than that. If residence times were ages, those that are less than 6000 years would present as urgent a problem to young-earth advocates as they would to old-earth advocates, and those that are higher than about 15,000 years should present an even greater problem to young-earth advocates. But residence times of elements in the ocean are not ages.

One young-earth advocate, Melvin A. Cook, recognizes that ocean salts do not provide a way of measuring ages:

The validity of the application of total salt in the ocean in the determination of age turned out to have a very simple answer in the fact shown by Goldschmidt [1954] that it is in steady state and therefore useless as a means of determining the age of the oceans.<sup>7</sup> The closest that residence times come to indicating the age of anything is the reasonable conclusion that the *highest* residence time for any element (260 million years for sodium) would be a *minimum* age for the ocean. Even Joly took note in 1899 that elements with residence times less than that of sodium are removed from ocean water by various processes, and therefore could not be used to measure the age of the oceans.

### Ignoring Salt-Removal Phenomena

Under certain conditions the salts dissolved in ocean water may be removed by evaporation of the water. The writers of *Scientific Creationism* claim that this does not happen.

The attempt to explain the small amounts of these elements in terms of precipitation on the ocean bottom will not work. One of the world's leading oceanographers, P. H. Kuenen, said:

Under normal conditions, sea water is not supersaturated with any product, and circulation is automatically set up in areas of excessive concentrations.

Chemicals normally do not precipitate out of solution until the water is first supersaturated with them.<sup>8</sup>

Looking at the context of Kuenen's remarks is very instructive for us. Immediately following the sentence quoted above, he wrote:

However, if circulation is restricted, e.g. in shallow water or inland seas and gulfs with constricted entrances, evaporation in a dry climate will lead to abnormal concentrations. These may either cause purely inorganic precipitation or may combine with bacterial action to bring about precipitation. Calcium carbonate, gypsum or

anhydrite are then deposited, and if the process continues, various other salts may be formed (see Chapters 16 and 19).<sup>9</sup>

An example of evaporite formation from relatively recent times is described in the article "When the Mediterranean Dried Up" published in *Scientific American* in December 1972.<sup>10</sup>

Because of evaporite formation and other removal processes, the rates of influx of various elements into the earth's oceans clearly do not measure the *age* of anything. Defenders of the young-earth hypothesis, however, continue to speak as if influx rates could be employed in that way. A flyer published in 1981 by ICR Midwest, entitled "Evidence that Implies a Young Earth and Solar System," lists fourteen evidences compiled by Walter T. Brown. One of those entries states:

The rate at which elements such as copper, gold, tin, lead, silicon, mercury, uranium, and nickel are entering the oceans is very rapid when compared with the small quantities of these elements already in the oceans. Therefore, the oceans must be very much younger than a million years.

Brown gives no consideration to the processes which are removing these elements from ocean water, in spite of the fact that much literature has been published on the subject. In *The Biblical Basis for Modern Science*, Henry Morris lists 68 "Uniformitarian Estimates" for the age of the earth.<sup>11</sup> Of the 68 entries in that list, 32 are based on rates of influx of various elements into the oceans. Residence times are erroneously labeled "age."

#### When Relevant Information Is Disregarded

Now let's try to step back from the details a couple of paces and reflect on what has been happening in ocean science and in the young-earth claim that we have been discussing.

The organized, scientific study of ocean water and of the ocean environment has been going on for more than a century. In the 1840s and 1850s, Matthew F. Maury undertook and directed studies of ocean

currents, water temperatures and weather on the oceans in preparing comprehensive navigation charts.<sup>12</sup> He supervised measurements of ocean depths and collected samples of ocean-floor sediments in the course of preparing plans for laying a trans-Atlantic telegraph cable. The chemistry of ocean water and the chemical behavior of the salts in ocean water have also been the subject of study for a long time. An early summary of the average composition of the salts dissolved in ocean water from several different locations was provided by Dittmar in 1884.<sup>13</sup>

By 1942 Sverdrup and his colleagues published the results of a comprehensive study of the ocean and its processes, giving a thorough account of the behavior of elements being added to and being removed from ocean water.<sup>14</sup> In 1954 Goldschmidt provided data and discussion supporting the conclusion that the dissolved material in ocean water is in an equilibrium state, being added and removed at equal rates.<sup>15</sup> *Chemical Oceanography*, published in 1965 and revised in 1975, includes extensive discussions of the processes by which elements are removed from ocean water, although those parts of the work appear to have been disregarded by the young-earth advocates who quote from this book in *Scientific Creationism* and elsewhere.

Immense amounts of additional measurements and new information have been obtained through the studies of the International Geophysical Year (July 1957 to December 1958) and through the Deep Sea Drilling Project (begun in 1968). The ocean floors have been mapped. We have obtained many drill-core samples of deep ocean sediments. And the processes of ocean-floor spreading and plate tectonics have come to be understood and described in considerable detail.<sup>16</sup> The chemical behavior of ocean water and the processes of sedimentation are much better characterized than they were twenty years ago.

The 1975 revision of *Chemical Oceanography* includes two chapters with extensive discussion of sedimentation in the ocean.<sup>17</sup> Recent textbooks in water chemistry<sup>18</sup> and in ocean science<sup>19</sup> include discus-

sions of sedimentation processes in the ocean. An article has appeared in *Scientific American* on the subject.<sup>20</sup> All of this recent study supports the conclusion that the oceans constitute an equilibrium system, with materials being removed at the same rate as they are being added. In no way can the rates of influx of various elements into the ocean be used for any sort of age measurement.

Joly thought that he was computing the age of the oceans from his data in 1899, but not long after his work the first measurements of ages of rocks by radioactivity were published (1905-11).<sup>21</sup> Since that time radioactivity has become accepted by the professional scientific community as the basis for measuring ages of rocks and of the earth. Furthermore, we have accumulated additional data and have gained a better understanding of chemical processes in the oceans which confirm that Joly's method does *not* provide an age measurement.

Meanwhile, many young-earth advocates have continued to refer to the rate of influx of elements into the oceans *as if* they could be used as a basis for age measurement. The earliest publication which we have found which uses those influx rates to argue that the earth cannot be as old as 4.5 billion years (the age provided by radiometric methods) is *The Genesis Flood*, published in 1962. In *The Genesis Flood*, the claim is made that it is important to note that all the influx rates give an accumulation time "vastly less than 5 billion years." Nearly the same words are used in *Scientific Creationism*, published in 1974. The 1985 "Updated and Enlarged" edition of *Scientific Creationism* continues to publish those same claims. The authors of *Scientific Creationism* refer to the 1965 edition of *Chemical Oceanography* as their source of "Years to Accumulate" (actually, residence times), but they do not consider or acknowledge discussions of processes removing those elements from ocean water which are found in the same chapter as the residence times, as well as elsewhere in that work.

The writings of these young-earth advocates show no evidence of their having considered the large amount of published data supporting the conclusion that elements are continuously being removed

from ocean water by various processes. There is no evidence in their writings that they are even aware of the many publications which report and discuss those removal processes, although those discussions were included in comprehensive books published before those young-earth claims were published. The authors of *Scientific Creationism* even deny that such processes can be operating, although the very publications they consulted to obtain residence times also contain extensive discussions of those processes, with references to the primary scientific papers which reported the data supporting the conclusions that those processes do operate in the ocean system. Even in 1985 the arguments presented by young-earth advocates continue to use influx rates of elements into the oceans to support their view, and those arguments have remained unchanged in spite of the accumulation of scientific data which support the conclusion that influx rates cannot be meaningfully used in that way.

As we discussed in chapter two, it is a requirement of professional integrity that a scientist give due recognition to all relevant information. Failure to do so may be sufficient warrant to discredit one's conclusions. In the specific case that we have been reviewing, the failure to distinguish between the remarkably different concepts of *residence time* and *age*, coupled with the failure to incorporate a vast amount of published information concerning processes by which sea salts are either continuously or episodically removed from ocean water, does indeed thoroughly discredit the conclusion that oceanic salt content supports the young-earth hypothesis. The 4.5 billion year chronology of earth history is in no way weakened or disqualified by an appeal to the salt content of terrestrial oceans.

- <sup>98</sup>Hanson, "The Sun's Luminosity and Age," p. 29.
- <sup>99</sup>Ibid.
- <sup>100</sup>Paul M. Steidl, "Solar Neutrinos and a Young Sun," *Creation Research Society Quarterly* 17 (1980):63.
- <sup>101</sup>Ibid., p. 60.
- <sup>102</sup>Ibid., p. 64.
- <sup>103</sup>Paul M. Steidl, "Recent Developments about Solar Neutrinos," (Letter) *Creation Research Society Quarterly* 17 (1981):233.
- <sup>104</sup>Howard J. Van Till, "The Legend of the Shrinking Sun," *Journal of the American Scientific Affiliation* 38, No. 3 (1986), pp. 164-74.
- <sup>105</sup>Thomas G. Barnes, "The Dilemma of a Theistic Evolutionist: An Answer to Howard Van Till," *Creation Research Society Quarterly* 23 (1987):167-71.
- Chapter 4: Footprints on the Dusty Moon**
- <sup>1</sup>For a well-written and well-illustrated report on this historic landing, see *National Geographic Magazine*, December 1969, pp. 738 ff.
- <sup>2</sup>Ibid., p. 736.
- <sup>3</sup>Walter T. Brown, Jr., *Evidence that Implies a Young Earth and Solar System* (Naperville, Ill.: ICR Midwest, 1981).
- <sup>4</sup>*ORIGINS Film Series Handbook* (Phoenix, Ariz.: Films for Christ Association, 1983), p. 13.
- <sup>5</sup>John D. Buddhue, *Meteoritic Dust* (Albuquerque: University of New Mexico Press, 1950).
- <sup>6</sup>F. G. Watson, *Between the Planets* (Cambridge, Mass.: Harvard University Press, 1956).
- <sup>7</sup>E. J. Opik, "Interplanetary Dust and Terrestrial Accretion of Meteoritic Matter," *Irish Astronomical Journal* 4 (1956):84-135.
- <sup>8</sup>Fred L. Whipple, "On the Lunar Dust Layer" in *Vistas in Astronautics*, vol. 2 (New York: Pergamon Press, 1959).
- <sup>9</sup>Hans Petterson, "Cosmic Spherules and Meteoritic Dust," *Scientific American* 202 (Feb. 1960):123-32.
- <sup>10</sup>Gerald S. Hawkins, ed., *Meteor Orbits and Dust: The Proceedings of a Symposium* (Washington, D.C.: NASA Publication SP-135, 1967), and *Smithsonian Contributions to Astrophysics* 11 (1967).
- <sup>11</sup>C. S. Nilsson, "Some Doubts about the Earth's Dust Cloud," *Science* 153 (1966):1242-46.
- <sup>12</sup>Donald E. Gault, et al., "Effects of Microcratering on the Lunar Surface," *Proceedings of the Third Lunar Science Conference* (Cambridge, Mass.: MIT Press, 1972), pp. 2713-34.
- <sup>13</sup>G. Field and A. G. W. Cameron, eds., *The Dusty Universe* (New York: Smithsonian Astrophysical Observatory, 1973), p. 191.
- <sup>14</sup>J. A. M. McDonnell, ed., *Cosmic Dust* (New York: John Wiley and Sons, 1978), pp. 150-57.
- <sup>15</sup>R. B. Baldwin, *The Face of the Moon* (Chicago: University of Chicago Press, 1949).
- <sup>16</sup>R. A. Lytleton, *The Modern Universe* (New York: Harper & Brothers, 1956).
- <sup>17</sup>Ibid., p. 72.
- <sup>18</sup>Thomas Gold, "The Lunar Surface," *Monthly Notices of the Royal Astronomical Society*, 115 (1955):585.

- <sup>19</sup>Whipple, "Lunar Dust Layer."
- <sup>20</sup>J. W. Salisbury and V. G. Smalley, "The Lunar Surface Layer," in Salisbury and Glaser, eds., *The Lunar Surface Layer* (New York: Academic Press, 1964).
- <sup>21</sup>Stuart Ross Taylor, *Lunar Science: A Post-Apollo View* (New York: Pergamon Press, 1975).
- <sup>22</sup>*Apollo-17 Preliminary Science Report* (Washington, D.C.: NASA Publication SP-330, 1973).
- <sup>23</sup>See Taylor, *Lunar Science*.
- <sup>24</sup>Harold S. Slusher, "Some Astronomical Evidences for a Youthful Solar System," *Creation Research Society Quarterly* 8 (1971):55.
- <sup>25</sup>Brown, *Evidence*.
- <sup>26</sup>*Observing God's World* (Pensacola, Fla.: A Beka Book Publications, 1978), p. 76.
- <sup>27</sup>Henry M. Morris, ed., *Scientific Creationism* (San Diego: Creation-Life Publishers, 1974), pp. 151-52.
- <sup>28</sup>Gault, "Effects of Microcratering."
- <sup>29</sup>Taylor, *Lunar Science*.

#### Chapter 5: Timeless Tales from the Salty Sea

- <sup>1</sup>John Joly, "An Estimate of the Geological Age of the Earth," in *Smithsonian Institution Annual Report* for the year ending June 30, 1899 (Washington, D.C.: Government Printing Office, 1901), pp. 247-88.
- <sup>2</sup>J. P. Riley and G. Skirrow, eds., *Chemical Oceanography* (New York: Academic Press, 1965). See especially chapter five, "Minor Elements in Sea Water," by Edward D. Goldberg.
- <sup>3</sup>Henry M. Morris, ed., *Scientific Creationism* (San Diego: Creation-Life Publishers, 1974), p. 154.
- <sup>4</sup>Ibid., p. 153.
- <sup>5</sup>Ibid., p. 154.
- <sup>6</sup>John C. Whitcomb, Jr., and Henry M. Morris, *The Genesis Flood* (Philadelphia: Presbyterian and Reformed Publishing Co., 1962); Henry M. Morris and Gary E. Parker, *What Is Creation Science?* (San Diego: Creation-Life Publishers, 1982); Henry M. Morris, *The Biblical Basis for Modern Science* (Grand Rapids: Baker Book House, 1984); Walter T. Brown, Jr., "The Scientific Case for Creation," *Bible-Science Newsletter*, June, July and August, 1984.
- <sup>7</sup>Melvin A. Cook, *Prehistory and Earth Models* (London: Max Parrish, 1966), p. 73.
- <sup>8</sup>Morris, *Scientific Creationism*, pp. 154-55.
- <sup>9</sup>Ph. H. Kuenen, "Geological Conditions of Sedimentation," in J. P. Riley and G. Skirrow, eds., *Chemical Oceanography* (New York: Academic Press, 1965), chap. 14.
- <sup>10</sup>Kenneth Hsu, "When the Mediterranean Dried Up," *Scientific American* 227 (Dec. 1972):26-36.
- <sup>11</sup>Morris, *The Biblical Basis for Modern Science*, pp. 477-80.
- <sup>12</sup>See Hildegarde Hawthorne, *Matthew Fontaine Maury, Trail Maker of the Seas* (New York: Longmans, Green and Co., 1943).
- <sup>13</sup>*Report on the Scientific Results of the Voyage of H.M.S. "Challenger": Physics and Chemistry*, Vol. 1, part 1 (Edinburgh: Her Majesty's Stationery Office, 1884).
- <sup>14</sup>H. U. Sverdrup, M. W. Johnson, and R. H. Fleming, *The Oceans, Their Physics, Chemistry and General Biology* (Englewood Cliffs, N.J.: Prentice-Hall, 1942).
- <sup>15</sup>V. M. Goldschmidt, *Geochemistry* (New York: Oxford University Press, 1954).

<sup>16</sup>*Continents Adrift*, a collection of *Scientific American* reprints (San Francisco: Freeman Books, 1972).

<sup>17</sup>J. P. Riley and R. Chester, eds., *Chemical Oceanography*, 2nd ed. (New York: Academic Press, 1975). See especially chapter 33, "The Mineralogy and Chemistry of Near-Shore Sediments," by S. E. Calvert, and chapter 34, "The Geochemistry of Deep-Sea Sediments," by R. Chester and S. R. Astron.

<sup>18</sup>James I. Drever, *The Geochemistry of Natural Waters* (Englewood Cliffs, N.J.: Prentice-Hall, 1982).

<sup>19</sup>Keith Stowe, *Ocean Science* (New York: John Wiley and Sons, 1983).

<sup>20</sup>Ferren MacIntyre, "Why the Sea Is Salt," *Scientific American* 223 (November 1970):104-15.

<sup>21</sup>Robert J. Strutt (Lord Rayleigh), "On the Radioactive Minerals," *Proceedings of the Royal Society of London*, A 76 (Feb. 28, 1905):88-101; Bertram B. Boltwood, "On the Ultimate Disintegration of the Radioactive Elements; Part II, The Disintegration Products of Uranium," *American Journal of Science* 23 (Feb., 1907):77-88; Arthur Holmes, "The Association of Lead with Uranium in Rock Minerals, and Its Application to the Measurement of Geological Time," *Proceedings of the Royal Society of London* 85 (Mar. 20, 1911):248-56.

#### Chapter 6: Making Mysteries out of Missing Rock

<sup>1</sup>Walter Lang, *Geological Study Course on Grand Canyon Arizona*, p. 31. Available from the Bible-Science Association, 2911 E. 42nd St., Minneapolis, Minn.

<sup>2</sup>For a summary paper with an extensive list of references on the geology of the Canyon, see Edwin D. McKee, "Stratified Rocks of the Grand Canyon," U.S. Geological Survey Professional Paper 669-B, 1969, pp. 23-58.

<sup>3</sup>The names of formations of layered rocks are generally derived from localities where those particular formations are especially well exposed. For example, the Moenkopi Formation is named after Moenkopi, Arizona. Some of the names of formations in the Grand Canyon are derived from prominent features within the Canyon; for example, Vishnu Schist after the Vishnu Temple.

The standard geological periods have been named after localities (Pennsylvanian, Devonian), tribes of people (Silurian and Ordovician after ancient Welsh tribes), characteristic rock type (Cretaceous from creta, Latin for chalk) and relative position (Tertiary). Rocks are assigned to the appropriate geological period on the bases of characteristic fossil remains, by which they can ordinarily be identified, and their position relative to rocks belonging to other periods. The criterion of relative position succeeds because in stacks of undisturbed layered rocks around the world, rocks of younger age are invariably found overlying rocks of older age. For example, Triassic rocks always overlie Permian or older rocks, and Mississippian rocks always underlie Permian or younger rocks unless a great disturbance has overturned the rocks.

The dating of geological-period boundaries is a matter of constant discussion among geologists, and not all geologists are likely to agree on the exact same set of values. The ages used in figure 3 have been taken from one of the most recent evaluations of the geologic time scale, namely, W. B. Harland, *A Geologic Time Scale* (Cambridge: Cambridge University Press, 1982), p. 4-5.

<sup>4</sup>Some geologists have also suggested the designation Nankowep Group for some of

the layered rocks between the Unkar and Chuar Groups.

<sup>5</sup>Igneous rocks are those that have solidified either underground or on the earth's surface from previously molten rock. Metamorphic rocks are those that have been recrystallized well below the earth's surface under the influence of extremely high pressures and temperatures. Before metamorphism, such rocks may have been igneous, metamorphic or some kind of sedimentary rock such as shale, limestone or sandstone.

<sup>6</sup>The Ordovician and Silurian periods follow the Cambrian and come before the Devonian (see figure 3).

<sup>7</sup>A summary diagram of a creationist flood model can be seen in *Bible-Science Newsletter*, 15 (1977):5.

<sup>8</sup>Lang, *Geological Study Course*, and Clifford L. Burdick, *The Canyon of Canyons* (Minneapolis: Bible-Science Association, 1974).

<sup>9</sup>Lang, *Geological Study Course*, p. 6; Burdick, *Canyon of Canyons*, pp. 60-61.

<sup>10</sup>Here the term *kinds* is used in the sense of the "kinds" of Genesis 1 as translated from the Hebrew word *min*.

<sup>11</sup>Burdick, *Canyon of Canyons*, pp. 27, 59-60.

<sup>12</sup>*Ibid.*, pp. 65-74.

<sup>13</sup>*Ibid.*, pp. 41-51; Lang, *Geological Study Course*, pp. 4-5.

<sup>14</sup>"Grand Canyon 'Creation' Story," *Bible-Science Newsletter*, 14 (1976):1.

<sup>15</sup>Gary E. Parker, *Creation: the Facts of Life* (San Diego: CLP, 1980), pp. 123-4.

<sup>16</sup>"Grand Canyon Presents Problems for Long Ages," in *Bible-Science Newsletter* (an insert under the heading, "Five Minutes with the Bible & Science") 18 (1980):4.

<sup>17</sup>"A New Look at Arizona's Grand Canyon," in *Bible-Science Newsletter* (an insert under the heading, "Five Minutes with the Bible & Science") 20 (1982):1.

<sup>18</sup>"Grand Canyon Presents Problems for Long Ages," p. 8.

<sup>19</sup>Robert P. Sharp, "Ep-Archean and Ep-Algonkian Erosion Surfaces, Grand Canyon, Arizona," *Geological Society of America Bulletin*, 51 (1940):1235-70. See specifically a photograph on plate 4, figure 1, facing p. 1244 in Sharp's paper.

<sup>20</sup>*Ibid.*, p. 1244.

<sup>21</sup>*Ibid.*, p. 1245.

<sup>22</sup>*Ibid.*, p. 1248.

<sup>23</sup>*Ibid.*, p. 1252.

<sup>24</sup>*Archean* is a term that refers to the earth's very oldest rocks. These are typically, though not exclusively, igneous and metamorphic rocks that can ultimately be found beneath the layered sedimentary rocks that characterize most of the earth's surface.

<sup>25</sup>Sharp, "Ep-Archean and Ep-Algonkian Erosion Surfaces," p. 1261.

<sup>26</sup>Burdick, *Canyon of Canyons*, p. 3.

<sup>27</sup>E. D. McKee and R. C. Gutschick, *History of the Redwall Limestone of Northern Arizona* (Boulder: Geological Society of America, 1969).

<sup>28</sup>*Ibid.*, pp. 22-23.

<sup>29</sup>*Ibid.*, p. 16.

<sup>30</sup>*Ibid.*, p. 18.

<sup>31</sup>*Ibid.*, p. 21.

<sup>32</sup>Andrew H. McNair, "Paleozoic Stratigraphy of Part of Northwestern Arizona," *American Association of Petroleum Geologists Bulletin*, 35 (1951): 503-41. McNair measured 216