
FOOTPRINTS ON THE DUSTY MOON

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THE EAGLE HAS LANDED." IT WAS THE VOICE OF NEIL Armstrong, relayed by radio from his spacecraft on the surface of the moon to the many millions of us on earth who were excited by man's exploration of space.¹ This was an exhilarating and historic moment—July 20, 1969—capping a tremendous effort over several years. U.S. President John F. Kennedy had laid out the agenda eight years earlier. The United States, he said, "should commit itself to achieving the goal, before this decade is out, of landing a man on the moon and returning him safely to earth."²

About six and a half hours after landing, Armstrong descended the ladder of the lunar module to the moon's surface. The event was well documented by radio and television. Again, Armstrong's words, as

reported in the December 1969 issue of *National Geographic Magazine*:

I'm at the foot of the ladder. The LM (lunar module) footpads are only depressed in the surface about one or two inches, although the surface appears to be very, very fine grained, as you get close to it. It's almost like a powder. Now and then it's very fine. I'm going to step off the LM now. That's one small step for man, one giant leap for mankind.

Moments later, while taking his first steps on the lunar surface, he noted:

The surface is fine and powdery. I can—I can pick it up loosely with my toe. It does adhere in fine layers like powdered charcoal to the sole and sides of my boots. I only go in a small fraction of an inch, maybe an eighth of an inch, but I can see the footprints of my boots and the treads in the fine sandy particles.

And a little later, while picking up samples of rocks and fine material, he said:

This is very interesting. It's a very soft surface, but here and there where I plug with the contingency sample collector, I run into a very hard surface, but it appears to be very cohesive material of the same sort. I'll try to get a rock in here. Here's a couple.

One of the photos in that *National Geographic* article shows astronaut Aldrin carrying some instruments over the surface of the moon, and the caption of the photo noted that "Aldrin makes three-to-four-inch-deep tracks as he bypasses a crater."

And so the manned exploration of the moon began. Since that initial touchdown there have been five more manned lunar landings, culminating in Apollo-17 in December 1972.

So too, apparently, began the claim that the moon must be young (not more than 10,000-15,000 years old) because, "If the moon were billions of years old, it should have accumulated extensive layers of space dust,"³ but "the fact is that astronauts found the layer to be only about 1/8 to 3 inches in thickness. 3 inches of dust could easily have been deposited in 8,000 years."⁴

Before we can evaluate the claim that, on the basis of the thickness of its surface-dust layer, the moon must be young, we need to examine the history of the professional scientific community's investigation of lunar dust. Two questions are particularly relevant: (1) What estimates or measurements have been made to ascertain the rate at which dust accumulates on the moon? (2) What amount of dust was actually found on its surface?

The Rate of Dust Accumulation

Pulverized material on the moon's surface comes from two sources: (1) the meteoritic material which falls onto the moon's surface from space and (2) the grinding up of lunar rocks by various processes, including the fall of meteorites. These two phenomena will be discussed separately.

Several estimates of the rate at which meteorites fall to earth were published from 1930-50 based on visual observations of meteors and meteorite falls. The results, summarized in 1950 by Buddhue,⁵ ranged from 26 metric tons per year to 45,000 tons per year. (One metric ton is 2200 pounds, slightly larger than one U.S. ton.) In 1956 Watson⁶ included consideration of smaller particles falling to earth, with estimates based on faint telescopic meteors, radiometeors (meteors detected by radar) and on the still finer dust particles that produce the zodiacal light. Watson estimated a total accumulation rate on earth of 300,000-3,000,000 tons per year. In 1956 Opik⁷ estimated 250,000 tons per year (on earth), and in 1959 Whipple⁸ estimated 700,000 tons per year, both estimates including a consideration of the zodiacal light.

A considerably different technique was used by Hans Petterson⁹ in 1960. Microscopic spheres of magnetic materials had been found in ocean sediments, and most investigators concluded that these were produced by meteoritic material falling onto the earth. Petterson collected dust samples from the air at the summit of Haleakala, Hawaii, in order to capture meteoritic dust with as little contamination of terrestrial material as possible. He made a further correction for con-

tamination by terrestrial material on the basis of chemical composition. He estimated that 14 million tons of meteoritic material fall onto the earth each year.

More reliable and direct observation of micrometeors became possible with the launching of orbiting spacecraft. The earliest detectors employed microphones that used the sound of meteor impacts to determine the particle flux (number of particles per square centimeter per second) and the mass of each impacting particle. The initial results showed large variations from satellite to satellite, and sometimes from time to time for the same satellite.

Another type of detector, put into use somewhat later, detected micrometeors by their penetration through a thin metal foil or membrane. The flux of micrometeors observed by these detectors was from 10 to 100 times less than that obtained from the microphone data. The results of both types of measurement were reported at a symposium on meteor orbits and dust held August 9-13, 1965, sponsored by NASA and by the Smithsonian Institution.¹⁰ The differences were noted, but the discrepancies were not yet explained in any of the papers presented at that meeting.

The discrepancy was resolved, however, soon after that symposium. The microphone results indicated an erroneously high flux value because the data were contaminated with sounds from mechanical movement and from thermal expansion and contraction of the spacecraft and the detectors; additional spurious counts could be attributed to solar flare and cosmic ray activity.¹¹

The mechanisms producing the zodiacal light are not yet well understood, so calculations of the micrometeor flux based on the zodiacal light are considered unreliable; the results of those calculations are too dependent on which model is used for the calculations.

Additional measurements of particle flux have been based on impact pits in the windows of many spacecraft (including the Apollo vehicles) and parts of the Surveyor-3 spacecraft which were returned to earth by Apollo-12 astronauts after Surveyor-3 had been exposed

to micrometeorite bombardment for 31 months on the moon. These measurements plus continuing measurements by penetration detectors and by modified microphone detectors have provided the most reliable estimates for the accumulation of meteoritic material on earth and moon. Gault (1972) reports 20,000 tons per year on earth,¹² Millman (1973) gives 10,000-20,000 tons,¹³ and Hughes (1978) gives 16,000 tons.¹⁴ Petterson's 1960 estimate based on atmospheric dust is a thousand times higher than these results; Petterson's samples were apparently contaminated with far more terrestrial dust than he had accounted for.

To compute a reasonable estimate for the accumulation of meteoritic dust on the moon we divide the earth's accumulation rate of 16,000 tons per year by 16 for the moon's smaller surface area, divide again by 2 for the moon's smaller gravitational force, yielding an accumulation rate of about 500 tons per year on the moon. *By best current estimates, then, the accumulation of meteoritic dust on the moon would contribute a layer less than one centimeter thick in four billion years.* Because the intense cratering in the lunar highlands indicates a considerably higher rate of fall for large meteorites early in the moon's history, before the formation of the lunar maria, the accumulation of meteoritic dust on the highlands would be somewhat greater.

The second source of pulverized material on the moon is the erosion of exposed lunar rocks by various processes. One of the most striking features of the moon viewed through a telescope is that much of the surface is pocked with craters, some of them very large. Initially volcanic activity was thought responsible for the craters, with meteorite impacts being suggested as an alternative mechanism. By about 1950, however, most investigators were convinced that meteorite impact was the major mechanism involved.¹⁵ Such impacts would pulverize large amounts of rock and scatter the fragments over the moon's surface. Radar studies of the moon were consistent with the conclusion that the surface was made of fine particles. Everyone agreed that the moon's surface was probably covered with a layer of pulverized

material, but there were at that time no very good ways to estimate its actual thickness.

In 1956 R. A. Lyttleton suggested that ultraviolet light and x-rays from the sun could slowly erode the surface of exposed rocks on the moon.¹⁶ He suggested further that the dust particles produced by that erosion might be kept in agitated motion by heat energy and by cosmic ray particles so that there would be a slow "flow" of fluffy dust to lower elevations on the moon. This flow of dust would keep the rocks exposed to continuing erosion, providing a layer of dust which might be "several miles deep."¹⁷

Lyttleton noted that the lunar maria and the floors of large craters appear to be quite smooth and that the rims of many craters appear rounded and smoothed out rather than sharp. He suggested that the flow of a thick, fluffy dust layer would explain those smooth surface features. Thomas Gold also suggested (1955) that the moon is probably covered with loose dust which could present a serious hazard to any spacecraft landing on the moon.¹⁸

Fred L. Whipple, on the other hand, argued in 1959 that the dust layer would be firm and compact.¹⁹ He noted that particles in vacuum tend to adhere to each other. He also suggested that bombardment by electrically charged particles from the sun (the solar wind) would produce "sputtering" and chemical changes, which would tend to cement the particles together. He predicted that humans and vehicles would have no trouble landing on and moving across the moon's surface. By 1964 Salisbury and Smalley wrote:

It is concluded that the lunar surface is covered with a layer of rubble of highly variable thickness and block size. The rubble in turn is mantled with a layer of highly porous dust which is thin over topographic highs, but thick in depressions. The dust has a complex surface and a significant, but not strong, coherence.²⁰

When NASA engineers were designing spacecraft for landing on the moon, they considered some possible designs for landing on a thick layer of fluffy dust. By the time the designs were completed, however,

they were convinced that the surface would be firm. The foot pads for Surveyor and for Apollo were designed for landing on a relatively firm surface.

The Thickness of the Lunar Regolith

Well, so much for the predictions. What did we find when we got there? The soft landings of Luna IX and Surveyor I (1966) confirmed that the surface is firm and compacted. The Surveyor sample scoop was able to dig a trench a few inches deep. As Neil Armstrong (Apollo-11) observed, the upper part is quite soft, but it is very firm just below the surface. Apollo-11 astronauts, using a hand-operated corer, were able to get a core sample only about 5 inches deep. On later landings electric coring drills were used to obtain cores: Apollo-15 yielded 270 cm. (approximately 8 ft. 10 in.) deep and Apollo-17 yielded 294 cm. (approximately 9 ft. 8 in.) deep.

The layer of pulverized material on the moon isn't usually called moon dust; it is called lunar regolith, and the fine materials in it are sometimes referred to as lunar soil. The fine material is quite uniform throughout the depths sampled, although some layering was observed in Apollo-15 and -17 cores, probably produced by deposits from different cratering events. There are rocks of various sizes found throughout the regolith. On the basis of chemical analysis of core samples, we know that the meteoritic component is mixed uniformly throughout the depth sampled. The meteoritic component makes up about 1.5% of the regolith on the lunar maria, and perhaps up to 10% on the lunar highlands.²¹

The astronauts on Apollo-17 conducted seismic tests near their landing site to measure the thickness of the regolith. The thickness in that region was found to range from 6.2 meters (20 ft.) to 39.6 meters (120 ft.).²² Estimates of the thickness elsewhere are based on photographs taken by astronauts of the walls of craters and rills, and on the depths of some of the craters which have penetrated to bedrock. Estimates are that the regolith averages four or five meters thick

on the lunar maria, and about twice that thick on the lunar highlands.²³

Evaluating the Young-Moon Claim

We now resume our evaluation of the young-moon claim by taking a careful look at the way in which the data and argumentation are presented in several representative publications.

The handbook which accompanies the *ORIGINS* film series (1983) states the claim in these words:

Interplanetary dust, meteors and meteorites are the source of a great deal of dust which regularly falls on both the moon and Earth. Dr. Slusher points out that this dust is being deposited on the moon at a rate of at least 14,300,000 tons per year (and perhaps at a rate 10 times that amount). After 4.5 to 5 billion years there should be a 440 to 990 foot thick layer of dust on the moon. Before the first moon landings, evolutionary scientists were concerned that landing astronauts might sink out of sight in all that lunar dust! The fact is that astronauts found the layer to be only about 1/8 to 3 inches in thickness. 3 inches of dust could easily have been deposited in 8,000 years.

No references are provided for the accumulation rate given nor for the reported amount of dust found. The accumulation rate given for the moon is nearly equal to Petterson's 1960 estimate for the earth. Though this handbook was published in 1983, the authors of the claim apparently had not given any consideration to other estimates contemporary with Petterson's nor to the much lower estimates published since 1972 and supported by much better evidence. The "1/8 to 3 inches" of dust reported here appears to be based on conversations of Apollo-11 astronauts with NASA Houston Control, and no consideration was given to the numerous additional measurements and observations which confirm the presence of a considerably thicker layer.

The earliest publication we have located which claims that the

moon must be young because only a little dust was found on its surface is an article, "Some Astronomical Evidences for a Youthful Solar System," by Harold S. Slusher in the *Creation Research Society Quarterly*, June 1971. Slusher presents the claim in these words:

Estimates of the influx range considerably with different investigators. The Swedish geophysicist, Petterson, estimates 14,300,000 tons of meteoric dust come onto the surface of the earth per year. In five billion years there should be a layer of dust 54 feet in thickness on the earth if it were to lie undisturbed.

From the reports of the lunar landings the accumulation of dust on the surface of the moon is very small (not much more than 1/8 inch).^[3] The moon moves through the same region of space that the earth does and consequently should have about the same influx of meteoric dust as the earth. N.A.S.A. scientists were worried that a lunar ship would sink down into the postulated huge amount of dust that should have accumulated on the surface in about 4.5 billion years of assumed time.

Also, in the "sea" areas, where the lunar ships landed, there should have accumulated more dust than elsewhere on the moon. Yet the amount of dust is amazingly small. What could have happened to all the dust?

Although more data and calculations are needed to substantiate this conclusion, from the absence of dust, we may deduce a short period of time for accumulation, and thus a young age for the moon. If the earth is about the same age as the moon (as the Scriptures assert and as some astronomers suggest), then the earth is also young.²⁴

The reference [3] given in that article for the reported 1/8 inch of dust is the El Paso [Texas] *Herald-Post*, July 21, 1969. This claim, which apparently began on the basis of a daily newspaper report, has continued to be published by young-earth advocates until the present time.

The list of evidences compiled by Walter T. Brown, Jr., includes the

following argument:

If the moon were billions of years old, it should have accumulated extensive layers of space dust—possibly a mile in thickness. Before instruments were placed on the moon, NASA was very concerned that our astronauts would sink into a sea of dust. This did not happen; there is very little space dust on the moon. Conclusion: the moon is young.²⁵

The reference given is to Petterson, but the language “possibly a mile in thickness” is more likely from Lyttleton’s 1956 estimate. The claim gives no consideration to the large amount of data that had been published by 1981.

The January 1982 issue of *Bible-Science Newsletter* presents the young-moon claim in the form of a (“scientific”) creationist prediction that was confirmed by observation:

Evolutionists complain that creationism is not real science because it cannot make scientific predictions. Making such predictions is important for science as it attempts to put together an accurate world-view, in order to provide benefit to man. The truth is, of course, that creationist science does make predictions. Some of the predictions are so startling to evolutionists that they immediately discount them as predictions until they come true!

One such case in point is the often repeated story about the depth of the moon dust. When William Overn, now serving as Co-Director of the Bible-Science Association, was working for the Univac Division of Sperry Rand on the television sub-system for Mariner IV, he had opportunity for exchanges with the men at the Jet Propulsion Laboratory who were working on the Apollo Moon program. In 1962 the amount of dust in space had been accurately measured. Assuming that the moon was 4.5 billion years old, Apollo scientists were concerned that there would be a dangerously deep layer of dust on the moon. It was even feared that a lander might disappear below the soft accumulation, even with the wide feet which were designed for it.

Since Mr. Overn knew, as a creationist, that the moon could not be over ten-thousand years old, he also knew that the dust encountered there could only represent a ten-thousand year, or less, accumulation. He told the Apollo scientists at the Jet Propulsion Laboratory that they should not worry about finding more than ten-thousand years worth of dust. They were so sure that this creationist prediction was wrong that a bet was established. Of course we all know, now, that the astronauts found less than a quarter of an inch of dust, just as predicted!

Evolutionist-believing scientists spent some time searching for their missing dust, but never had any success in finding it. They have never been able to explain the lack of dust and have finally given up trying. In one recent debate, the evolutionist suggested that the original space dust measurements, taken in 1962, were inaccurate. But he had no explanation as to why these readings might be considered to be inaccurate.

Here we have one of many excellent examples of the creationist approach which has led to a scientific prediction which proved accurate. Even more important is that the outcome of the prediction remains a total enigma to those holding the evolutionistic world-view.

One hardly knows where to begin in evaluating such a report. The statements about the amount of dust predicted and the amount found reflect both gross misinformation and ignorance of research results published before 1982. The conclusions presented in this account appear to be based on hearsay, or on secondary and tertiary sources. No references are provided, and there is no evidence that any of the primary technical literature on the subject was consulted. Nor is there any indication that the author consulted even the popular accounts of the Apollo program, such as those found in publications like *National Geographic Magazine*.

The comments about scientists “searching for their missing dust” are pure fancy; they found plenty of “dust,” in good agreement with

what might reasonably have been expected. (This is not to deny that some individual scientists had predicted more than was found, but by 1969-72 those high estimates were no longer considered reasonable.) The anecdote about William Overn may well be true, although it is likely that NASA engineers were influenced far more by Fred L. Whipple's arguments in 1959 than they were by William Overn's reassurances in 1962.

The sixth-grade science textbook *Observing God's World*, published by A Beka Book Publications in 1978, also makes the claim that the moon must be young:

Space explorers have discovered that a thin layer of meteoritic dust covers the hard crust of lunar soil. This discovery came as a surprise to many scientists who expected a very deep dust layer. Evolutionists predicted a thick layer of dust because they believed it would have accumulated over billions of years. The very thin layer of dust indicates that the moon is just several thousand years old, which supports the creationist theory that the universe is very young.²⁶

The misinformation about the amount of dust expected and the amount found that was noted above in other publications is here being passed along to schoolchildren. The confusion between meteoritic dust and lunar soil may have come from a misinterpretation of the conversations of the Apollo-11 astronauts. The looser layer on top and the firmer material below are actually the same type of material, that is, pulverized lunar rock with a little meteoritic material mixed throughout. The list of consultants for the A Beka Book science textbooks includes two engineers and a chemist as well as a physician and a pharmacist. It is apparent, however, that they did not do their "homework" in evaluating the scientific accuracy of the moon-dust claim printed in this sixth-grade text.

The widely distributed book *Scientific Creationism* presents the thinly dusted young moon picture in its 1974 edition as follows:

It is known that there is essentially a constant rate of cosmic dust

particles entering the earth's atmosphere from space and then gradually settling to the earth's surface. The best measurements of this influx have been made by Hans Petterson, who obtained the figure of 14 million tons per year. This amounts to 14×10^{19} pounds in 5 billion years. If we assume the density of compacted dust is, say, 140 pounds per cubic foot, this corresponds to a volume of 10^{18} cubic feet. Since the earth has a surface area of approximately 5.5×10^{16} square feet, this seems to mean that there should have accumulated during the 5-billion-year age of the earth, a layer of meteoritic dust approximately 182 feet thick all over the world!

There is not the slightest sign of such a dust layer anywhere of course. On the moon's surface it should be at least as thick, but the astronauts found no sign of it (before the moon landings, there was considerable fear that the men would sink into the dust when they arrived on the moon, but no comment has apparently ever been made by the authorities as to why it wasn't there as anticipated).²⁷

The foreword and the back-cover description of our copy of *Scientific Creationism*, 1975 printing, characterize the book as having been "prepared by an outstanding team of creationist scientists" and as being "thoroughly documented and authoritative." The book has been widely used and quoted as an authoritative source of information for readers who have had little or no scientific training. Yet, quoting the dust accumulation rate by Petterson as a product of "the best measurements of this influx" fails to take into account the many other measurements that have been made, especially by satellite penetration sensors, which are considered to be the most reliable by workers in the field and which were available well before *Scientific Creationism* was first published.

The statement that "the astronauts found no sign" of a dust layer on the moon fails to take into account those many results of the Apollo program which had reported the thickness and the character of that layer. *Scientific Creationism* has gone through twelve printings, the most recent one being a 1985 updated and expanded version, but

no change has been made in the claims related to moon dust. Apparently no consideration is being given to modifying or relinquishing that claim in spite of the many evidences that the claim is founded on erroneous information.

There are some patterns in the claims that the moon must be young which should be noted. For this claim to be credible, there must be *much* less dust found on the moon than would be consistent with known rates of dust accumulation over 4.5 billion years. All the claims of young-moon advocates assert that very little or no dust was found on the moon by Apollo explorations. This assertion is plainly shown to be false by many reports of the results of the Apollo program which have been published in the technical literature, as well as in accounts found in popular publications such as *National Geographic*.

Anyone who seriously tries to find out how much pulverized material was found on the moon by the Apollo investigations can easily confirm that a thick layer was found. In spite of this, however, the assertion that little or none was found has persisted for a dozen or more years after the Apollo flights. The failure to take into account the published data pertinent to the topic being discussed is a clear failure to live up to the codes of thoroughness and integrity that ought to characterize professional science.

Young-moon claims would also be supported if the rates of meteoritic dust accumulation and the rates of lunar rock erosion were found to be very high, so that the accumulation expected over 4.5 billion years would greatly exceed what was found. The reference for meteoritic dust accumulation most commonly quoted by young-moon advocates is Petterson's 1960 value. Apparently no consideration is given to the more recent direct measurements by satellite-borne instruments, which are considered by knowledgeable researchers in the field to be the most reliable means of data collection currently available. Petterson's estimate is about 1000 times higher than the best recent estimate given by Hughes in 1978 (see ref. 14).

Young-moon advocates most commonly quote Lytleton's 1956

book for a pre-Apollo estimate of lunar rock erosion and accumulation of erosional dust. Lytleton's estimate is the highest that we are aware of in the professional scientific literature. More recent laboratory studies and results of the Apollo program show that estimate to be much too high. The agents of erosion which Lytleton suggested, x-rays and ultraviolet rays, are not effective in rock erosion on the moon. The most effective agent of erosion on the moon is the fall of micrometeors, and the rate of erosion on exposed rock surfaces is only about 0.3 millimeters per million years²⁸—much less than Lytleton's estimate of a few hundred inches per million years.

Furthermore, after a thin layer of erosional fragments has covered the surface, the micrometeors no longer produce any additional erosion. Only the larger impacts will produce cratering and bring more rocks to the surface, where they will be subject to further erosion. Although very precise rates of cratering and erosion are still not available, the thickness of the regolith is close to what would be expected if the moon is about 4.5 billion years old.²⁹ Again, the failure of young-moon advocates to consider pertinent data that have been published indicates a failure to follow expected procedure for professional science.

It is easy to understand that sixth-grade teachers would not be in touch with the current professional scientific literature, although they certainly have access to popular publications such as *National Geographic Magazine* and *Scientific American*. In contrast, there is little excuse for writers with advanced degrees in scientific fields who do not keep themselves informed of technical publications on topics about which they choose to write.

The persistence of young-moon advocates in quoting accumulation rates from Petterson and Lytleton, even though those estimates have been conclusively discredited as being vastly too high, demonstrates a failure to employ the best-published data on that topic. The persistence in asserting that little or no dust was found on the moon, even though core samples, seismic tests and photographic evidence conclu-

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

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ALL 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.

⁹⁸Hanson, "The Sun's Luminosity and Age," p. 29.

⁹⁹Ibid.

¹⁰⁰Paul M. Steidl, "Solar Neutrinos and a Young Sun," *Creation Research Society Quarterly* 17 (1980):63.

¹⁰¹Ibid., p. 60.

¹⁰²Ibid., p. 64.

¹⁰³Paul M. Steidl, "Recent Developments about Solar Neutrinos," (Letter) *Creation Research Society Quarterly* 17 (1981):233.

¹⁰⁴Howard J. Van Till, "The Legend of the Shrinking Sun," *Journal of the American Scientific Affiliation* 38, No. 3 (1986), pp. 164-74.

¹⁰⁵Thomas 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

¹For a well-written and well-illustrated report on this historic landing, see *National Geographic Magazine*, December 1969, pp. 738 ff.

²Ibid., p. 736.

³Walter T. Brown, Jr., *Evidence that Implies a Young Earth and Solar System* (Naperville, Ill.: ICR Midwest, 1981).

⁴*ORIGINS Film Series Handbook* (Phoenix, Ariz.: Films for Christ Association, 1983), p. 13.

⁵John D. Buddhue, *Meteoritic Dust* (Albuquerque: University of New Mexico Press, 1950).

⁶F. G. Watson, *Between the Planets* (Cambridge, Mass.: Harvard University Press, 1956).

⁷E. J. Opik, "Interplanetary Dust and Terrestrial Accretion of Meteoritic Matter," *Irish Astronomical Journal* 4 (1956):84-135.

⁸Fred L. Whipple, "On the Lunar Dust Layer" in *Vistas in Astronautics*, vol. 2 (New York: Pergamon Press, 1959).

⁹Hans Petterson, "Cosmic Spherules and Meteoritic Dust," *Scientific American* 202 (Feb. 1960):123-32.

¹⁰Gerald 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).

¹¹C. S. Nilsson, "Some Doubts about the Earth's Dust Cloud," *Science* 153 (1966):1242-46.

¹²Donald 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.

¹³G. Field and A. G. W. Cameron, eds., *The Dusty Universe* (New York: Smithsonian Astrophysical Observatory, 1973), p. 191.

¹⁴J. A. M. McDonnell, ed., *Cosmic Dust* (New York: John Wiley and Sons, 1978), pp. 150-57.

¹⁵R. B. Baldwin, *The Face of the Moon* (Chicago: University of Chicago Press, 1949).

¹⁶R. A. Lytleton, *The Modern Universe* (New York: Harper & Brothers, 1956).

¹⁷Ibid., p. 72.

¹⁸Thomas Gold, "The Lunar Surface," *Monthly Notices of the Royal Astronomical Society*, 115 (1955):585.

¹⁹Whipple, "Lunar Dust Layer."

²⁰J. W. Salisbury and V. G. Smalley, "The Lunar Surface Layer," in Salisbury and Glaser, eds., *The Lunar Surface Layer* (New York: Academic Press, 1964).

²¹Stuart Ross Taylor, *Lunar Science: A Post-Apollo View* (New York: Pergamon Press, 1975).

²²*Apollo-17 Preliminary Science Report* (Washington, D.C.: NASA Publication SP-330, 1973).

²³See Taylor, *Lunar Science*.

²⁴Harold S. Slusher, "Some Astronomical Evidences for a Youthful Solar System," *Creation Research Society Quarterly* 8 (1971):55.

²⁵Brown, *Evidence*.

²⁶*Observing God's World* (Pensacola, Fla.: A Beka Book Publications, 1978), p. 76.

²⁷Henry M. Morris, ed., *Scientific Creationism* (San Diego: Creation-Life Publishers, 1974), pp. 151-52.

²⁸Gault, "Effects of Microcratering."

²⁹Taylor, *Lunar Science*.

Chapter 5: Timeless Tales from the Salty Sea

¹John 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.

²J. 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.

³Henry M. Morris, ed., *Scientific Creationism* (San Diego: Creation-Life Publishers, 1974), p. 154.

⁴Ibid., p. 153.

⁵Ibid., p. 154.

⁶John 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.

⁷Melvin A. Cook, *Prehistory and Earth Models* (London: Max Parrish, 1966), p. 73.

⁸Morris, *Scientific Creationism*, pp. 154-55.

⁹Ph. H. Kuenen, "Geological Conditions of Sedimentation," in J. P. Riley and G. Skirrow, eds., *Chemical Oceanography* (New York: Academic Press, 1965), chap. 14.

¹⁰Kenneth Hsu, "When the Mediterranean Dried Up," *Scientific American* 227 (Dec. 1972):26-36.

¹¹Morris, *The Biblical Basis for Modern Science*, pp. 477-80.

¹²See Hildegarde Hawthorne, *Matthew Fontaine Maury, Trail Maker of the Seas* (New York: Longmans, Green and Co., 1943).

¹³*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).

¹⁴H. U. Sverdrup, M. W. Johnson, and R. H. Fleming, *The Oceans, Their Physics, Chemistry and General Biology* (Englewood Cliffs, N.J.: Prentice-Hall, 1942).

¹⁵V. M. Goldschmidt, *Geochemistry* (New York: Oxford University Press, 1954).