Creation Research Society Quarterly 2013. 49:281–286.

A Survey of Lightning

Don B. DeYoung*

Abstract

Lightning is a dramatic and poorly understood display of electrostatic energy. Present thinking is reviewed on its production and behavior. The multiple purposes of lightning give evidence of intelligent design, especially the transformation of atmospheric nitrogen to a usable form for plants, animals, and people. Varieties of lightning and their control with lightning rods are briefly described. Fulgurites, popularly called fossilized lightning, are suggested as possible evidence for a young earth.

Introduction

Every second there are hundreds of ongoing thunderstorms in process around the world that produce multiple lightning strokes. The impressive display of electrical energy is frightening when a lightning bolt strikes nearby. As is the case for all severe weather, one might ask how lightning fits into the design of creation. After all, lightning causes fires, destroys property, and may cause injury or death. The basic answer is that all harmful events have their origin in a once-perfect world that was contaminated by the Fall of mankind, also called the Curse, as described in Genesis 3. Before this event, at the beginning of Creation, the earth's hydrologic cycle was different from today, with a lack of precipitation according to Genesis 1:5–6. If this lack of rain existed until the Curse, and perhaps until the Noahic Flood 1500 years after Creation, then the early earth may not have experienced lightning.

Aside from the universal, fatal effects of sin, there remains abundant evidence that details of nature, including lightning, are established for our survival and well-being. This review article approaches the topic of lightning as an essential part of the present-day creation. Mark Twain once illustrated the power of small words by contrasting the lightning bug with lightning (e.g., Bainton, 1890, pp. 87–88). Likewise, all parts of creation, from the nanoscale to cosmic structures, declare the glory of the Creator of the universe.

The Source of Lightning

More than 250 years ago, Benjamin Franklin (1706–1790) investigated lightning by flying a kite during a spring storm. This story is not a mere urban legend but occurred in Philadelphia on a dark June day in 1752. Franklin noticed that small sparks jumped to his knuckles from a key tied to the kite string. Franklin survived this dangerous storm activity and correctly concluded that the lightning overhead was a similar electrical spark on a giant scale.

The voltage, current, and energy dissipation from lightning are much greater than the familiar "snap" we experience from static electricity when shuffling across a carpet during low-humidity conditions. A lightning stroke can involve many millions of volts, if not billions, with momentary peak current surpassing 36 kilo amperes (Pearce, 1997). The actual magnitude of moving electrical charges may exceed 20 coulombs, or 10^{20} electrons (Rigden, 1996). There is little agreement in the literature on the actual numbers involved due to the great variation in lightning behavior and the difficulty of quantitative measurements.

Static electricity occurs when frictional motion separates outer electrons from their host atoms. The mechanism of this charge separation is not well understood, since negatively charged electrons are strongly attracted to positive electron-deficient atoms, or ions. Nevertheless, electron migration away from parent atoms occurs on a grand

* Don B. DeYoung, DBDeYoung@Grace.edu
Accepted for publication March 16, 2013

scale. Simply walking across a carpet or brushing one's hair readily results in an accumulation of more than one trillion unbalanced electrons.

Within an active storm cloud, updrafts and downdrafts cause water droplets and ice crystals to move past each other with frictional effects. As a result of air turbulence, large concentrations of separated positive and negative electrical charges may occur within the cloud. When a sufficient attractive force builds up between regions of unlike charge, a surge of electrons may result. The swarm of negative electrons moves to a positive region of the same cloud, or to a nearby cloud mass, or directly to the ground, each path resulting in a visible lightning flash.

Figure 1. Common streak lightning terminates on a neighborhood tree. If not shattered, the tree will be scarred and weakened (Wikipedia Commons).

Electrical current always moves along the path of least resistance. In air this route depends on temperature, density, humidity, wind speed, and other factors, hence the zigzag appearance of lightning. The multiple variables controlling the lightning path result in chaotic motion that is beyond physics analysis and prediction. One is reminded of the Creator's challenge to the patriarch Job four thousand years ago: "Do you send the lightning bolts on their way? Do they report to you, 'Here we are'?" (Job 38:35 NIV).

In one popular description, cloud-to-ground lightning is initiated when an invisible avalanche of negative electrons first rushes to the ground. This is called the stepped leader stroke. This surge provides a channel for a much more energetic return stroke. Electrons "drain out" from the bottom of the channel, followed by successively higher positions. This return stroke causes the visible lightning flash. High-speed photography reveals dozens of back-and-forth lightning strokes occurring milliseconds apart and each lasting just microseconds (Rigden, 1996).

The actual path of charged particles through the air is just inches wide at most. However, the extremely high electrical energy causes an intense light flash that persists in our vision. Nearby air is rapidly heated to more than 50,000°F (approximately 30,000°C), five times hotter than the sun's surface. This instantaneous heat produces a shock wave of outward-moving air pressure, which we hear as thunder. A weak pulse of x-ray radiation has also been detected accompanying lightning (Dacey, 2010).

The charged particles in a lightning stroke travel at 30,000–60,000 miles per second, one-sixth to one-third the speed of light. The resulting flash of light then reaches our eyes almost instantaneously, traveling nearly a million times faster than the sound of the thunder. The "five-second rule" gives an approximate distance to the lightning source. Sound speed varies with air temperature and averages about 1100 feet per second (750 miles per hour), or about one mile in five seconds (one kilometer in three seconds). Thus if thunder is heard ten seconds after seeing the flash, the lightning occurred two miles away. The continuing rumble of thunder is due to portions of the lightning stroke located higher in the sky and more distant.

Recent Developments

Ongoing research efforts seek to further understand the mechanism of lightning, and two studies will be mentioned here. First, cosmic rays may be a trigger for lightning discharges. These rays are high-speed subatomic particles that probably arise from supernovae events in space (Jaggard, 2013). As the cosmic rays interact with gases in the earth's upper atmosphere, there are indications that they generate intense, transient electric fields that trigger the initial surge of electrons through the air in a lightning stroke (Klotz, 2009).

A second area of research concerns aircraft that may be hit by lightning or may themselves initiate a lightning stroke. This is seldom a problem because of the typical outer fuselage of aluminum. If struck, the electrical current is limited to the metallic skin without affecting the interior of the plane. The new generation of aircraft, however, includes nonmetallic composite materials. Metal fasteners such as rivets are part of the structure, and they provide an electrical passageway to the plane's interior with possible damage from a lightning strike. There is ongoing study to protect such aircraft, including embedded surface layers of conducting fibers and screens (Marks, 2013).

Types of Lightning

Varieties of lightning include the names ball, bead (chain), forked, sheet, ribbon, and streak lightning. There are also upper atmospheric forms of lightning called red sprites and blue jets. Figure 1 shows a bolt of streak lightning hitting a neighborhood tree. Such trees may burn or else disintegrate into flying shards of wood as the interior sap is converted instantly to steam. If the target tree manages to survive, it will be scarred and weakened. Oak trees are especially vulnerable to lightning strikes: "Beware of the oak; it draws the stroke." Oaks tend to be taller than the surrounding trees and have high moisture content, thus attracting lightning (DeYoung, 1992, p. 89).

Aside from weather events, static lightning discharges are sometimes associated with blizzards, sand and dust storms, smoke, and volcanoes. There also are indications of static electricity and lightning discharges on other planets, including Venus, Jupiter, Saturn, and Uranus.

On rare occasions lightning apparently may take the form of a beach-ball size sphere of glowing electrical charge or plasma. The sphere may last for several seconds or minutes. The reason a small cloud of electrons and positive ions arises and persists in the air is not understood. Figure 2 is a woodcut illustration of ball lightning that has descended through a chimney and is floating across a room. Several video clips of possible ball lightning events are available on the Youtube website.

Figure 2. A London woodcut from 1886 showing ball lightning inside a home. The caption reads, "Globe of fire descending into a room" (Wikipedia Commons).

Friends tell me of an unusual lightning event occurring during the 1950s. The couple sat in their living room during a summer evening thunderstorm in Winona Lake, Indiana. Following a bright lightning flash, a glowing ball about one foot in diameter slowly floated through the window screen and directly into their living room. The ball bounced once on the carpet, then drifted over to a wall and disappeared into an electrical outlet. All that remained was a scorched spot on the carpet and a burning odor. The friends recalled being considerably shaken by this apparent close encounter with ball lightning.

Lightning Rods and St. Elmo's Fire

Objects on the ground can be strongly charged by induction due to charged clouds high above. When the cloud base is negative, for example, earth objects become positive as their mobile electrons are repelled by the cloud and move downward into the ground. Sufficient charge accumulation may cause an electrical discharge into the surrounding air. The result may be a visible glow or coronal discharge around items on the ground, especially near pointed objects where electric charge tends to accumulate. The glow has been observed at night around church steeples, towers, lightning rods, aircraft, tree leaves, and the ice axes of mountain climbers. The following paragraph describes the eerie glow of static electricity on the horns of western steers.

Writer Frank Dobie (1888–1964) had a lifelong familiarity with Texas Longhorn cattle and describes their interaction with a lightning storm during a cattle drive.

Ball lightning rolled along the ground and all about us … Finally the lightning settled down on us like a fog. The air smelled of burning sulfur … The electricity played along the horn curves as if they were lightning rods, at the same time darting around and illuminating spurs and bridle bits. Balls of foxfire ran around the wet brim of a cowboy's hat. Snakes of fire sometimes ran over the backs of the cattle and along the manes of the horses (Dobie, 1941, p. 96).

The term "foxfire" in this quote is a rare, mysterious night glow observed near the ground. It may be due to burning methane gas, bioluminescent fungi, and in the case of cattle, static electricity.

Lightning rods were invented by Benjamin Franklin. He wrote in his *Poor Richard's Almanac* in 1753, "It has pleased God in his goodness to Mankind, at length [to reveal] to them the means of securing their habitations and other buildings from mischief by thunder and lightning" (Krider, 2006). Lightning rods give protection in two ways. First, charge accumulating on a structure is dissipated from the sharp points of lightning rods as the charge moves into the surrounding air. If a building nevertheless becomes the target of a lightning strike, the surge of electric current is diverted downward into the ground by the lightning rod through an attached thick metal cable. Once a lightning strike occurs, static charge buildup can begin again immediately. For example, New York City's Empire State Building is struck more than twenty times annually. In these cases there is little or no harm because the structure is well grounded with lightning rods.

An older name for a visible coronal discharge is St. Elmo's fire, after Saint Erasmus of Formiae, an Italian bishop from the fourth century who was also called Saint Elmo. He was known as a protector of sailors on the Mediterranean Sea. The St. Elmo glow was observed around the masts of sailing ships during intense storms. The mysterious light also became associated with Castor and Pollux, twin Greek deities. Acts 28:11 records that the apostle Paul sailed to Rome aboard a ship with the figurehead of the gods Castor and Pollux. These names also are associated with two bright stars in the Gemini Twin constellation.

Lightning Mythology

The dramatic display of lightning has led to many historical traditions, including its cause being the visible anger of gods. The Greeks made shrines of locations that had been struck by lightning and consecrated them to Zeus. Ancient Greeks also believed that lightning strikes hitting the sea resulted in the formation of pearls. Some other cultures thought that mushrooms grew where lightning hit the ground (Lyons, 1997, p. 145).

Centuries ago, officials in Brescia (Brecia), Italy, declared that church buildings were safe from being struck by lightning. They reasoned that God would not damage places of worship. As further insurance, the church bells were rung during storms to ward off lightning, a dangerous activity for bell ringers. Some churches were used to store arsenals, including gunpowder. In 1769, a church tower in Brescia was struck and set afire. The resulting explosion of many tons of gunpowder destroyed part of the city and killed 3,000 people. One must conclude that lightning is no respecter of church buildings.

Fulgurites

When lightning strikes sandy soil, the intense heat may melt the silica sand and form hollow glass tubes, typically an inch or less in diameter. The fused glass is sometimes called petrified lightning, and the tubes are called fulgurites, from the Latin word *fulgur*, for thunderbolt. The fulgurite tube shapes are breakable like glass, but the resulting shards are stable. In some cases, fulgurite tubes have been excavated to a depth of 15 meters (49 feet).

I have a palm-size fulgurite that was embedded in the soil at the base of a telephone pole in Maine (Figure 3). Lightning earlier had struck and burned the pole as current moved downward into the ground. Hollow knobs on the pictured fulgurite show that the surge of electricity branched off in at least seven directions upon entering the ground. The bottom portion of the sample has a smooth, glassy appearance where molten sand pooled. The fulgurite sample somewhat resembles coral or the volcanic rock called scoria.

Consider an order-of-magnitude estimate for the number of fulgurites predicted by evolutionary deep time. With approximately one hundred lightning strokes per second occurring across the earth, throughout the alleged 4.6 billion years of earth history, at the current lightning rate, totals 1.45×10^{19} strikes. Further, suppose that one-fourth of these lightning strikes hit dry land and that just 1% of these land strikes resulted in fulgurite formation. This is a generous assumption since the large majority of lightning strikes hit land rather than water (Lyons, 1997, p. 147). Considering 1.28×10^{14} total square meters of dry land across the earth, there then should be accumulated more than 1,000 fulgurites per square meter of land everywhere (1.45×10^{17} fulgurites/$1.28 \times 10^{14} m^2$). This quick calculation assumes a constant historical rate of lightning occurrence. If this estimate is valid, the question then arises, why are fulgurites a rare find? Given the long age timescale, should not fields everywhere be choked with the glassy shard remnants of historic fulgurites? Even if the estimate of predicted fulgurites is reduced by a thousand or more, the problem of fulgurite absence remains. Perhaps there is a fundamental problem with the evolutionary timescale.

Similar arguments have been made and critiqued for the lack of meteor-

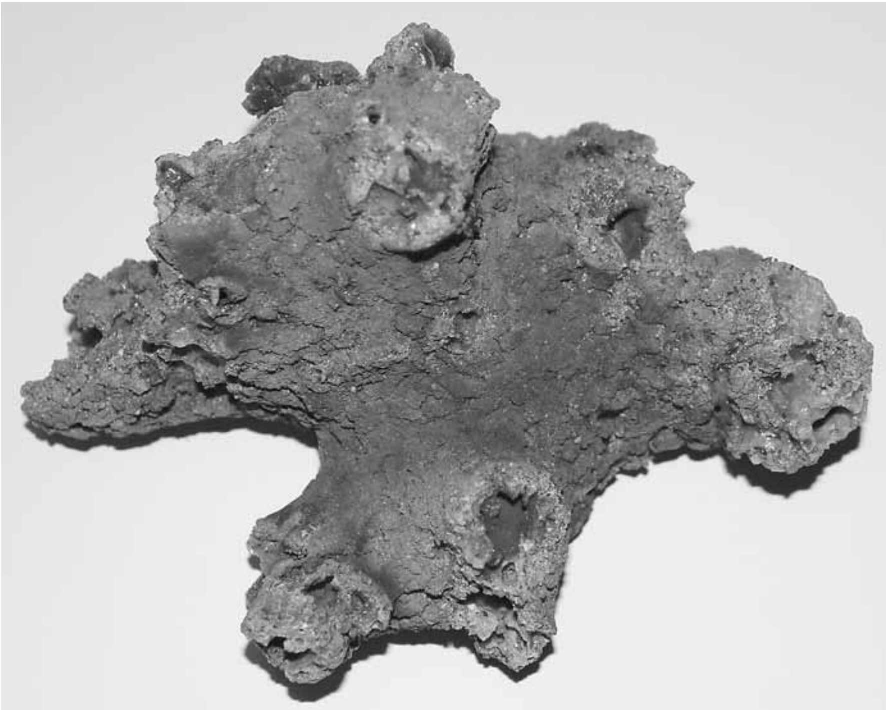

Figure 3. A fulgurite results from lightning striking the ground and fusing the sandy soil. This glassy sample is six inches (15cm) across

ites or their nickel residue in earth's sedimentary rock layers (Whitney, 1941; Stevenson, 1975; Young, 1988). There are many related challenges to the unfathomable assumption of 4,600,000,000 years of earth history, as well as the current assumption of the universe being three times older yet, at 13.8 billion years.

Purpose

Lightning and Nitrogen Fixation

The earth's atmosphere consists of 78% nitrogen (N_2), 21% oxygen (O_2), and smaller amounts of argon (Ar), carbon dioxide (CO_2) and other gases. The element nitrogen is the third most abundant element in the human body and must be renewed continually. However, our bodies cannot directly utilize nitrogen in its gaseous form because the nitrogen atoms are joined together by a very strong triple covalent bond. The nitrogen must first be incorporated into plants as part of the food chain.

Certain plants, called legumes, have nitrogen-fixing bacteria called *Rhyzobia* in their root nodules. Examples include alfalfa, beans, clover, peanuts, and peas. If the early earth did not experience lightning, as suggested earlier, then legumes could have supplied the soil with nitrogen.

The second major way by which nitrogen is transformed naturally into a useable form is by lightning. Molecules of nitrogen are broken apart by electrical energy:

$N_2 + O_2 + \text{energy}$ à $2NO$

The resulting nitrous oxide then combines with oxygen in the air:

$2NO + O_2$ à $2NO_2$

The nitrogen dioxide readily dissolves in water:

$2NO_2 + H_2O$ à $HNO_3 + HNO_2$

These two products in the diluted form of nitric and nitrous acids provide essential nitrogen for plants.

There is wide variation in estimates of the worldwide amount of nitrogen compounds produced annually by lightning. Values range from 5 to 44 million tons per year (Pearce, 1997; Postgate, 2002). Whatever the case, lightning adds an impressive amount of useful nitrogen to the soil globally.

The nitrogen-fixing property of lighting may possibly be referenced in Psalm 135:7: "He [the Lord] maketh lightnings for the rain" (KJV). When nitrogen gas molecules are broken down by lightning, it is rainwater that carries nitrogen to the plants, in apparent agreement with the verse. However, the Hebrew text also allows the adjective *with* in place of *and*: "He sends lightning with the rain" (NIV). Therefore the Psalm 135:7 reference is not a strong argument for an anticipation of our modern understanding of nitrogen fixation; however, the verse is compatible with the idea.

Other Purposes

Beyond wide-scale nitrogen fertilization, lightning provides further benefits to the earth. Fires are frequently ignited by lightning in remote forests and grasslands. These fires play a positive part in maintaining the health of wilderness areas by limiting the overaccumulation of hazardous ground fuels. Burned areas recover rapidly. For example, aspens are a pioneer tree species that grows rapidly in burned areas. Also, some pinecones need the heat from fire to melt their interior resin and release seeds. In our day, forest-fire control is controversial, as communities develop in wilderness areas. A federal government statement on fire control reads, "Though wild land fires play an integral role in many forest and rangeland ecosystems, decades of efforts directed at extinguishing every fire that burned on public lands have disrupted the natural fire regimes that once existed (National Fire Plan, 2013).

Ozone gas, O_3, is an unhealthy pollutant at ground level. However, in the lower stratosphere, 10–20 miles high, the earth's ozone layer provides protection from solar ultraviolet radiation (UV). This high-energy form of light causes skin and eye disease and is harmful to plant leaves. The UV is absorbed and prevented from reaching the ground by chemical interactions with the ozone. Studies show that substantial high-altitude ozone is made by lightning, as much as 30% of the total ozone layer (Zhang et al., 2003). Lightning may serve further beneficial purposes yet unknown.

Conclusion

We have surveyed the physical properties of lightning and its impact across the earth. The extreme electrical energy of lightning ignites fires, while it also converts atmospheric nitrogen to an essential, useable form for plants, animals, and people.

There is an attitude of fear by many regarding lightning, and for good reason with its intense flash, high energy, and accompanying thunder. However, there is good counsel in Psalm 29, which describes a Middle Eastern storm as it sweeps in from the Mediterranean Sea. Cedar trees are broken by the wind, and oaks are twisted. Thunder and lightning shake the desert floor. And what is the response of the people who know their Creator? They all shout, "Glory!"

References

Bainton, G. 1890. *The Art of Authorship*. Appleton, New York, NY.

Dacey, J. 2010. X-ray vision tracks lightning bolts. Physicsworld.com (accessed December 16, 2012).

DeYoung, D. 1992. *Weather and the Bible*. Baker Book House, Grand Rapids, MI.

Dobie, F. 1941. *The Longhorns*. Bramhall House, New York, NY.

Jaggard, V. 2013. Mystery of cosmic rays' origin solved at last. *New Scientist* 217(2905): 17.

Klotz, I. 2009. Cosmic rays could reveal why lightning strikes. *Discovery News*, June 9. http://dsc.discovery.com/news/2009/06/09/lightning-cosmic-rays.html (accessed February 1, 2013).

Krider, P. 2006. Benjamin Franklin and lightning rods. *Physics Today* 159(1): 42–48.

Lyons, W. 1997. *The Handy Weather Answer Book*. Visible Ink Press, Detroit, MI.

Marks, P. 2013. You're grounded. *New Scientist* 217(2903): 28–29.

National Fire Plan. 2013. http://nationalatlas.gov/mld/firplnp.html (accessed February 1, 2013).

Pearce, F. 1997. Lightning sparks pollution rethink. *New Scientist* 153(2006): 15.

Postgate, J. 2002. Nitrogen fixation. In *McGraw-Hill Encyclopedia of Science and Technology*, 9th edition, pp. 760–763. McGraw Hill, New York, NY.

Rigden, J. (editor). 1996. Lightning. *Macmillan Encyclopedia of Physics*, Volume 2. Macmillan, New York, NY.

Stevenson, P. 1975. Meteoric evidence for a young earth. *Creation Research Society Quarterly* 12:23–25.

Whitney, J. D. 1941. The age of the earth: comments on some geologic methods used in its interpretation. *Bulletin of Deluge Geology and Related Sciences*. December. (Henry Morris credits Whitney with the first modern defense of a recent biblical creation. See http://www.icr.org/article/822/.)

Young, D. 1988. *Christianity and the Age of the Earth*. Artisan Publishers, Muskogee, OK.

Zhang, R., X. Tie, and D. Bond. 2003. Impacts of anthropogenic and natural NOx sources over the U.S. on tropospheric chemistry. *Proceedings of the National Academy of Sciences* 100(4): 1505–1509.