"We may well call it black diamonds. Every basket is power and civilization."
— *Ralph Waldo Emerson*

Coal: How Did It Originate?

by
Harold G. Coffin

Call it black diamond. Call it basket of power. Or call it coal. It is one of the most useful natural resources found in the earth. It's composed of vegetable matter, modified by heat, pressure, catalytic activity, and decay. But how did the vegetable matter originate? The question has long been a point of controversy. The majority of those who have studied coal believe that it is derived from natural organic accumulations such as peat bogs, marshes, and swamps that became buried. A minority suggests that some, if not most, coal developed from plant material transported from elsewhere.

In the 1700s and early 1800s, students of the earth largely held that coal came from plant materials buried during a major catastrophe (Noah's Flood). These individuals pointed to evidence suggesting that the formation of coal did not resemble any modern processes. They observed that modern bogs, swamps, and similar areas are not comparable to coal seams in lateral extent, depth, and composition.[1]

Catastrophic burial or gradual accumulation?

With the rise of uniformitarianism,[2] scientists began to explain all geological phenomena by observable processes. Charles Lyell, who promoted the uniformitarian principle, visited some of the coal regions, both in Europe and North America.[3] He and other researchers noted the association of upright petrified trees with seams of coal. They argued that coal could not be the product of burial during a worldwide catastrophe because the growth of trees associated with coal beds required too much time (Figure 1). This observation and argument were important factors in shifting opinion about the origin of coal from that of rapid accumulation and burial of plant debris to processes of gradual growth, accumulation, and burial.

Whichever view one finds most convincing–catastrophic burial or gradual accumulation—depends somewhat upon the paradigm with which one approaches the subject. Since the author and most of the readers of this article hold a worldview influenced by the Bible, we will concentrate more on evidences that support biblical history. However, some of the arguments for growth and gradual accumulation must be examined also.

Most coal is clearly composed of vegetable matter such as tree trunks, branches, bark, leaves, needles, and macerated plant debris. Carboniferous coals (usually the harder kind) are composed of ferns, club mosses, horsetails, and other plants not classified with the seed-bearing plants (evergreen and deciduous trees and flowering plants). The softer coals (usually higher in the geological column) are mostly the product of buried evergreen and deciduous trees. Because coal reveals that it is composed of plant remains, the plants must have grown where the coal is now located (*autochthonous*) or they must have been transported to the present location of the coal beds (*allochthonous*).

Questions from coal beds

Perhaps the first obvious question one might ask is, "Does a coal bed resemble a buried peat bog or marsh?" To answer that question we need to know something about bogs and marshes. A peat bog is usually composed of a special type of moss (*Sphagnum*). There may be other plants associated with the peat, but the dominant plant is Sphagnum moss. A marsh or swamp may have a greater variety of plant types—mostly the kinds of plants that thrive in wet environments. For peat bogs, the answer to the above question is a clear "No." Most coal is clearly not buried peat.[4] For a swamp or marsh, the answer is not so clear, especially for the Carboniferous coals. Many of the plant types found in these coal beds are extinct.[5] We cannot be certain that they preferred a wetland habitat. Study of modern relatives of those plants indicates that most of them were not swamp dwellers. The Cretaceous to Eocene coals were derived mostly from forest trees. Some trees such as the cypress often grow in swamplands today, but many of the others could not survive in such an environment.

Another obvious question is, "Do modern wetland environments provide an adequate model for the great deposits of coal?" For this question the answer is more definite, and was used by early geologists to support their Flood hypothesis. Although a few swamps and marshes cover large areas, for example the Dismal Swamp of Virginia, in the U.S.A., many coal seams are much more extensive. The Pittsburgh bed covers parts of the states of Pennsylvania, Ohio, and West Virginia, U.S.A., an area of 5,000 square kilometers, and averages a little more than two meters thick. The Appalachian coal basin extends over some 180,000 square kilometers. The extent of minable coal runs into the thousands of millions of tons. The Powder River basin of Wyoming, U.S.A. (30,000 square kilometers) is calculated to have nearly 22 billion tons of minable coal. The Latrobe Valley in Australia is estimated to be able to yield 70 billion tons of coal. The depth or thickness of coal beds is even less comparable with modern organic accumulations.

Problems for accumulation theory

Under more detailed examination, problems for the autochthonous theory arise. Some coals contain animal remains, usually sea animals.[6] One common example is *Spirorbis*, a small coiled tubeworm less than 5 mm in diameter (Figure 2). The presence of a sea worm in peat or swamp beds that are considered to be autochthonous does not fit well into a uniformitarian hypothesis. To avoid this problem, *Spirorbis* is said to have lived in a freshwater environment during the Carboniferous period even though it is commonly found throughout the geological column and in modern oceans attached to corals, mollusks, and seaweeds.[7] Obviously, a marine worm mixed with coal is an argument for the sea being involved in the formation of coal.

Coal often shows detailed preservation of the original organic debris. If coal were the product of plant accumulations in bogs and marshes, some degree of decay would be expected. Sometimes exquisite fossils of fern fronds and leaves are located directly below the root systems of standing petrified trees (Figure 3). If the trees truly grew where they now stand, any organic remains such as leaves or fern fronds would have decayed during the time required for the growth of the trees and before burial and petrification.

One of the strongest arguments for coal being plant debris buried in place comes from the "roots" (*Stigmaria*) of the upright petrified trees associated with the coal. These are giant clubmosses with trunks a meter in diameter and up to 35 meters high. The *Stigmaria*, usually several centimeters in diameter and sometimes many meters in length, support numerous "rootlets" (appendages) that penetrate into the sediments (Figure 4). They can be likened to a giant bottle brush in appearance. The radiation of these appendages into the sediments is considered to be evidence of their being in growth position.[8]

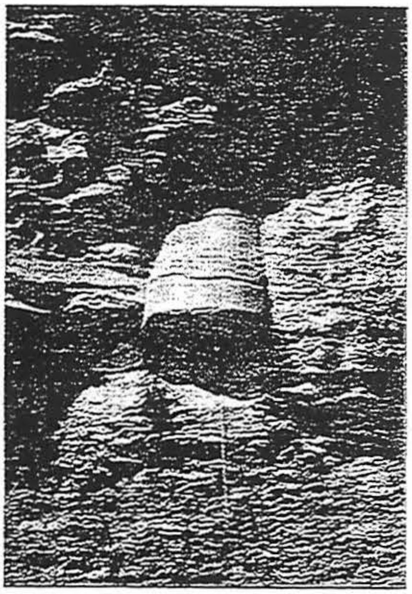
Controversy over the nature of the "roots" of *Stigmaria* has waged ever since the study of coal began, but as yet no clear consensus has developed. Modern clubmosses (small trailing plants seldom over a meter high) have underground creeping rhizomes similar in structure to the *Stigmaria* of the giant clubmosses. But if the *Stigmaria* of these clubmosses are underground creeping rhizomes, where are the true roots? None have been found with these fossil giants. Perhaps these *Stigmaria* served the function of true roots as well as propagating more shoots.

Although superficially the *Stigmaria* with their spreading appendages look as if they are in their position of growth, certain details suggest otherwise. Usually, the *Stigmaria* are isolated pieces unconnected with the base of any tree. Yet even these pieces show the appendages spreading out into the sediments. The trunks of the large upright petrified clubmosses are hollow and filled with sediments. Occasionally, pieces of *Stigmaria* were washed in with the muds and sands that filled the hollow stumps.[9] In these cases also, the appendages radiate outward from where they are attached in spiral rows to the *Stigmaria*. Apparently, the appendages were sufficiently stiff to prevent collapse when buried in the mud and sand. Perhaps the shale beds were slurries of mud in which the pieces of *Stigmaria* with appendages were carried. Or the *Stigmaria* and appendages along with fine sediments settled out of a muddy suspension of water. If pieces of severed *Stigmaria* were transported by water or mud, they might show a preferred current alignment. This has been reported at two locations in Nova Scotia, Canada, and in Holland.[10]

Although the problem of the *Stigmaria* and radiating appendages cannot be fully solved, a study of *Stigmaria* supports arguments for transport just as well as for growth in position.

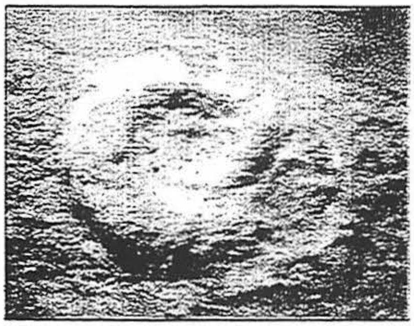
Changing plant debris into coal

The process of changing plant debris into coal has been of interest for many years. Laboratory experiments have succeeded in changing plant tissue into coal in a year or less.[11] Timbers used in

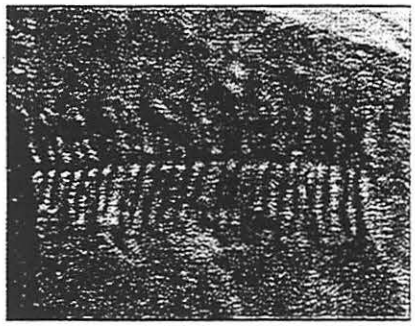


◀ **Figure 1. An upright lycopod tree in coal-bearing sediments in Nova Scotia, Canada. For scale, a tape measure is suspended below the tree.**

▼ **Figure 2. A fossil *Spirorbis* tubeworm from Carboniferous sediments.**



▼ **Figure 3. A fossil fern frond taken from a stratum lying directly below the bases of upright petrified trees exposed along the sea cliffs near Sydney Mines, Nova Scotia, Canada.**



ancient coal mines that have been re-entered in modern times are sometimes coalified. A recent important discovery has been the role of clay as a catalyst for the coalification process.[12] If clay was a necessary ingredient for changing plant material to coal, a worldwide flood would better explain the source of clay than would a uniformitarian wetland environment.

The amount of vegetable matter necessary to produce a meter of coal is estimated to be somewhere between 5 and 20 meters, depending upon the hardness of the coal. Modern accumulations of plant remains (as in a peat bog) are seldom deeper than 10 to 20 meters. According to this formula, a 20-meter-deep bog would produce one to four meters of coal. Many coal seams are much thicker than that. Coal beds 30 meters thick are not uncommon. Some are more than 100 meters thick, and Australia contains one over 240 meters thick! The accumulation of vegetable matter 1,200 meters or more thick (5 x 240) needed to produce such thick coal deposits is astonishing, even when considered in a Flood model. However, unusual as it may be, a catastrophic accumulation of plant remains in a sinking basin is easier to visualize than the formation of *in situ* bogs of such dimensions.

Successive layers of coal separated by a few centimeters to a few meters of sediment are common. If these beds are autochthonous, the successive development of bogs or marshes one above another over ages of time is required. Bog and marsh environments require special conditions. The repeating of such conditions time after time to produce numerous successive levels of coal in the same location is unrealistic (Figure 5). The geologic processes that brought about the burial of one layer of vegetable matter would likely erase the conditions needed for the production of another bog in the same location.

The repeated transport and deposition of mats of floating plant flotsam and their subsequent burial provides a more reasonable explanation. Recent research suggests that tides, with their daily rise and fall of water, could be involved in the repeated transport and deposition of suspended plant debris.[13]

In the Indiana basin, I have observed rhythmic deposits (considered to be the result of tidal action) associated with the typical features of Carboniferous coal-bearing sediments. However, daily tidal fluctuations would deposit mud too rapidly to permit the growth of plants. Their presence in such deposits requires transport. Observations of floating trees reveal that with sufficient time and water many will float and sink upright.[14]

The catastrophic burial of plant debris and its subsequent change to coal is not accepted by most coal geologists. However, the dominant "peat bog" theory presents problems that have remained unanswered for more than a hundred years. A Flood model for the formation of coal answers some of these problems and provides a scientifically reasonable explanation for the origin of the vast quantities of coal that exist worldwide. ❑

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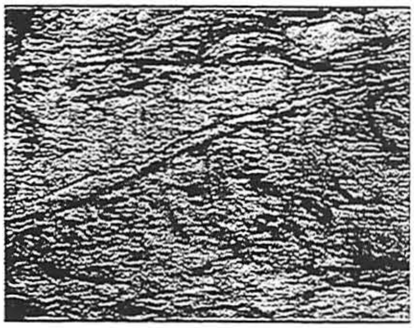
▶ **Figure 5. A road cut exposes several successive coal seams near Castlegate, Utah, U.S.A.**

▼ **Figure 4. A *Stigmaria* (the nearly diagonal line that stretches across the photo) is the source of numerous appendages that extend up and down in this cross-sectional view.**



Notes and References

1. Among the first to advance the diluvial origin of fossils and sedimentary strata was Nicolaus Steno (1630-1687). In his time these were novel suggestions. Other notable deluge geologists who followed him were John Woodward (1667-1727), and Jean-Andre Deluc (1727-1817).
2. The uniformitarian interpretation of earth history established especially by James Hutton and Charles Lyell attempts to apply present rates of geological processes to the past. For instance, average rates of erosion and sedimentation seen occurring today were assumed to be satisfactory models for understanding past similar processes.
3. Charles Lyell, "On the Upright Fossil Trees Found at Different Levels in the Coal Strata of Cumberland, Nova Scotia," *Proc. Geol. Soc. London* 4 (1843), pp. 176-178.
4. Wilfrid Francis, *Coal, Its Formation and Composition* (London: Edward Arnold Publishers Ltd., 1961).
5. A. C. Seward, *Fossil Plants* (New York: Hafner Pub. Co., Inc., 1898-1919, 1963).
6. Sergius Mamay and Ellis L. Yochelson, "Occurrence and Significance of Marine Animal Remains in American Coal Balls," *U. S. Geol. Surv. Prof. Papers* 354-I (1961), pp. 193-224.
7. Harold G. Coffin, "A Paleoecological Misinterpretation," *Creation Res. Soc. Quart.* 5 (1968), p. 85. Spirorbis (phylum Annelida) has a trochophore larva. Several other phyla also have species with trochophore larvae. No species with trochophore larvae have been found in fresh water.
8. W. E. Logan, "On the Character of the Beds of Clay Immediately Below the Coal-Seams of S. Wales," *Proc. Geol. Soc. London* 3 (1842), pp. 275-277. This interesting note by Logan was one of the first to point out the abundance of stigmaria and appendages in the underclays below coal seams. Logan proposed that this clay was the soil on which the coal-producing plants originated and the stigmaria and appendages represented roots still *in situ*. Research since then fails to support that these clays are soils. See Leonard G. Schultz, "Petrology of Underclays," *Geol. Soc. Am. Bull.* 69 (1958), pp. 363-402.
9. Richard Brown, "Section of the Lower Coal-Measures of the Sydney Coalfield, in the Island of Cape Breton," *Quart. Jour. Geol. Soc. London*, 6 (1850), p. 127. While doing research in the Nova Scotia, Canada coal beds, I also documented two examples of pieces of stigmaria inside hollow stumps. See Harold G. Coffin, "Research on the Classic Joggins Petrified Trees," *Creation Res. Soc. Annual* (1969), pp. 35-44, 70.
10. N. A. Rupke, "Sedimentary Evidence for the Allochthonous Origin of Stigmaria, Carboniferous, Nova Scotia," *Geol. Soc. Am. Bull.* 80 (1969), pp. 2109-2114; W. F. M. Kimpe and A. A. Thiadens, "On the Occurrence of Coal Raft Above and Rhizome Inclusions in Seam Finefrau B, South Limbourg, Holland," *Proc. Third Inter. Cong. of Sedimentology*, Groningen-Wageningen (1951), pp. 167-173.
11. John Larsen, "From Lignin to Coal in a Year," *Nature* 31 (March 28, 1985), p. 316.
12. R. Hayatsu, et al., "Artificial Coalification Study: Preparation and Characterization of Synthetic Macerals," *Organic Geochemistry* 6 (1984).
13. "Blame it on the Moon," *Scientific American*, February 1989, p. 18.
14. Harold G. Coffin, "The Puzzle of the Petrified Trees," *College and University Dialogue* 4:1 (1992), pp. 11-13, 30-31.