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THE ORIGIN OF PENNSYLVANIA COAL.*

By

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If it was hard for the average doughboy who first saw northern France torn and trampled by war to picture to himself that same region as it was before the war, how much harder it is for the average man to picture Pennsylvania before the surface of that great state was changed from a gentle plain to a tumbled mass of ridges! Who, when thinking of the coal beds of today, visualizes the great forests and swamps from which they were derived?

Let us look back a few geologic ages, say 200 odd million years (that is the latest and best estimate of the geologists), to the time when the coal measures were being formed. If 200,000,000 seems long, cut it down to suit yourself, only leave plenty. For a long time, say 75 million years, more or less, the earth's crust had been restless, and the part of it that now is Pennsylvania was sometimes above and sometimes below the level of the sea. At times when the land was just above sea level, vast swamps were formed, some of them scores or hundreds of feet deep. Then the land would sink and be overrun by the sea. The rivers brought mud and sand to the sea, and the submerged swamp deposits were buried. When the basin was filled or the sea bottom emerged, forests grew and the swamp-forming process began again.

This was repeated with many variations until the region stretching from Pennsylvania to Alabama became a graveyard of old swamp deposits. At times the land was raised slightly, and streams carried away part of the mud which had been deposited during the submergence; in places the streams washed away parts of the marsh

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deposits. After each such rise came a sinking; the newly-eroded gulleys were soon washed full of sand, and the downward movement went on. The sinking more than counterbalanced the rises and the general movement was downward.

The period of repeated formation of marsh deposits was near the close of a long age of sinking, that had been going on in the Appalachian region for hundreds of millions of years. The original rock surface had been bowed down in places as much as 40,000 feet, and during this time of subsidence additional sediments had been deposited on top of the sinking area, the thickness of the deposits corresponding to the amount of sinking. In the latter stages of this action the whole mass had been blanketed with the buried swamp deposits. Sinking continued until the swamp deposits themselves were covered with hundreds of feet of sediments.

Then came the grand climax! Just what happened or how it happened I shall not attempt to describe, as it is beyond the scope of this paper. After such a great accumulation of rock material something was bound to happen. Or was this sinking of the crust and accumulation of sediments the effect of something which had happened previously? You cannot stretch a rubber indefinitely; nor can the earth's crust sink indefinitely at one place without upsetting the crustal balance. Perhaps the upsetting of the crustal balance caused the sinking. Who knows? This much we believe; that not suddenly, though probably with countless earthquakes, the crust of the earth began a movement that folded and faulted the rocks as though they had been crumpled by a titanic hand. How long the movement lasted I do not know, but probably for millions of years.

It appears as if the crust of the whole Appalachian region had been shoved, or squeezed, or had shrunk, and in the process had been wrinkled into many folds. It is possible or probable that the movement was so slow that the tops of the folds were worn down as they rose, and never were nearly so high as they would have been if the uplift had occurred suddenly.

The rocks and marsh deposits, the latter now changed to coal beds, were more sharply folded at the east and less strongly at the west. The rocks at the east were, so to speak, in the front line trenches. In fact, along what is now the Allegheny Front, just west of Williamsport, Lock Haven, and Altoona, the rocks seem to have made a final stand as though, to carry through the simile, they "had their backs to the wall". West of that line the rocks were crowded back on themselves and slightly folded, but in general held their places. This line of holding is nearly straight from Alabama to central Pennsylvania where it turns eastward. The northeastern part of Pennsylvania appears to have formed a hinge or buttress that held in place. Whether the rocks there were more resistent or whether the compressing force had less energy than was expended further south, I do not know.

Then came a long period of quiet, through what has been called the Age of Reptiles, when there roamed the earth such great creatures as are shown in the Carnegie Museum at Pittsburgh, and in other large museums. During this time the earth's folded crust was worn down by rain and running water, until Pennsylvania was again a great, rolling plain. In this wearing down of the surface, cubic miles of rock were carried away. In what is now the anthracite region a large part of the then newly formed coal beds was removed with the other rocks. Here and there a little coal was left because it lay in the bottom of a fold below the level of the new erosion plain. It was thus that the coal in the anthracite fields, the Bernice, and the Broad Top fields, escaped being carried away and remains to this day.

What has become of the rest of the coal? It has washed away, going down the rivers toward the sea. Fragments of coal from beds outcropping along or in a creek having a steep grade may be recognized as "float" for a few hundred feet below the outcrop, but seldom more than one-fourth of a mile. It may therefore be put down as fairly certain that this coal removed long ago did not accumulate somewhere, nor is it waiting for someone to dig it up.

After the upfolded ridges had been eroded nearly to a plain over which rivers flowed southeastward to the sea, there began an upward movement over a broad area, the center of which was in the Appalachian region. With the elevation of the surface the rivers increased their activity, and continued to wear their way downward. They cut narrow channels across the hard rocks and wider ones in the softer rocks. Branches of the main streams eroded valleys in the soft rocks between the massive beds of upturned sandstone. This uplift and erosion continued until central Pennsylvania became a region of flat topped ridges of hard sandstone, separated by wide valleys cut in shales or limestones, and thus it remains today. The flat tops of the main ridges are remnants of the old plain on which the rivers originally acquired their southeastward course.

But the great disturbance did more than fold the rocks; In the process of folding, the rocks were compressed and fractured, and were heated somewhat. The final effect of all these actions in the area of folding was to drive out of the black shales their bituminous matter, as though it had been distilled out, and to drive out of the consolidated marsh deposits more or less volatile matter or gas, at the same time helping to consolidate the carbonaceous matter into coal. As with folding, the effect on the swamp deposits was most pronounced at the east and decreased westward.

In what is now the anthracite region nearly all of the volatile matter in the coal was driven off, and the coal was compressed into the well known "hard anthracite". At the western end of the Southern and Western Middle anthracite fields the action was less severe, some of the volatile matter remained, and the coal was not so hardened by compression. So we have our "soft anthracite" or "Bernicite" (as I have recently suggested calling this type of coal) in which the fuel ratio, that is, fixed carbon divided by volatile matter, is between 7 and 10.

Farther west the coal was affected still less. In southern Cambria County, most of Somerset County, and in the Broad Top field, the coal contains about 20 per cent of volatile matter. Most of the coals of the Johnstown, South Fork, Somerset, and Meyersdale fields are of this type. This coal is called Pocahontite because it is the same type as the Pocahontas coal of West Virginia, which is known the world over. (Later called Lōvōl B).

The coal in the northern part of Cambria County, in the Moshannon and Snow Shoe fields, and most of that in Tioga and Bradford counties contains 20 to 25 per cent of volatile matter. This type has been called Sewellite, from the Sewell coal of the New River district, West Virginia. (Later called Lōvōl C).

Still farther west the effects of the regional compression were less pronounced and the coal now contains about half as much volatile matter (by weight) as of fixed carbon, the fuel ratio being from 1.85 to 2.5, or about 2. This type includes the famous Connellsville coking coal, from which it has been named "Connellsite." (Midvōl coal). Most of the coals in the same belt to the northeast, including the Latrobe basin, western Indiana County, and the Punxsutawney field belong to this type.

West of the belt just indicated is found the typical Pittsburgh gas and steam coal, to which the name Pittsite (Hivōl A coal) has been applied. Pittsite carries 33 to 34 per cent of volatile matter, and has a fuel ratio of 1.4 to 1.85. This coal differs markedly in its physical character from the coals farther east. It is strong and can be mined and shipped in large blocks without crumbling. The size of these blocks is determined by the distance between vertical joints. Farther east the vertical joints are increasingly more pronounced and nearer together. In Clearfield, Cambria, and Somerset counties the coal is split up by such close-set vertical joints that it tends to mine in long blocks or "sticks," the long side of the blocks standing vertically in the bed. These joints are the result of structural failure caused by the pressure to which the coal has been subjected.

The coals of the northwestern part of the State, including the Beaver field, the Mercer-Butler-Lawrence county fields, and the coal fields in the adjoining counties in Ohio carry a still higher percentage of volatile matter, commonly 30 to 40 per cent. That part of the State was least affected by the forces that so strongly folded the crust in the central part of the State. This type of coal, which has been called "Belmontite" (Hivōl B Coal) from Belmont County, Ohio, has a fuel ratio of less than 1.4.

As just described, there appear to be seven types of coal in Pennsylvania with possibly an eighth type not yet generally recognized. These are as follows, the fuel ratio being the basis for the classification: (all recalculated to 6 per cent of ash)

Types of Coal in Pennsylvania

Type Letter	Type	Fuel Ratio	B.t.u.	Moisture	Volatile matter	Fixed Carbon	Ash
A	Anthracite "Hard Anthracite"	10.	13850-13250	3	5	86	6
B	Bernicite "Soft Anthracite"	10.0-7.0	14000-13650	3	9	82	6
*C	Brushymontite (Lovol A)	7.0-5.0	14600-12000	3	13	78	6
D	Pocahontite (Lovol B)	5.0-3.5	14850-14250	3	17	74	6
E	Sewellite (Lovol C)	3.5-2.5	14640-14000	3	22	69	6
F	Connellsite (Midvol)	2.5-1.85	14350-13750	3	27	64	6
G	Pittsite (Hivol A)	1.85-1.4	14250-13700	3	33	58	6
H	Belmontite (Hivol B) less than	1.4	13750-13000	3	40	51	6

*Represented by a few samples from the Broad Top fields.

Space does not permit a detailed study of the character of the coal of Pennsylvània, nor are sufficient data available at this time for such a study. To obtain these data, the State Survey in cooperation with the U. S. Bureau of Mines has undertaken comprehensive sampling of the coals.

The work already done shows that even in the same districts the coals are not altogether of the same type. For example, in southeastern Washington County, the Pittsburgh coal at Marianna shows 34.6 per cent of volatile matter to 57.7 per cent of fixed carbon, giving a fuel ratio of 1.66 while the Waynesburg coal of the same region shows about 33 per cent of volatile matter to 47 per cent of fixed carbon, giving a fuel ratio of 1.42. In the same way it is found that in fields which structurally and geographically appear to be similar, the coals may be of quite dissimilar type. Thus the Johnstown and South Fork fields contain coal of the Pocahontas type, while the Barnesboro-Patton field in the northwestern corner of Cambria County contains coal of the Sewell type. But coal in the Mountain field in the eastern part of Cambria County tends to the Connellsite type which is much lower in percentage of fixed carbon, showing that by some cause not yet recognized the coals in that field were not so greatly altered as the coals farther west.

Therefore it is impossible to designate the coals in each of the fields as of a single type, though as sampling becomes more complete, it will be possible to give the general type of the coal in each of the fields.

SELECTED TYPICAL ANALYSES OF PENNSYLVANIA COALS

Analyses by U. S. Bureau of Mines

Fields	B.t.u. (As rec'd.)	Moisture	Volatile matter	Fixed Carbon	Ash	Type of Coal
Northern Anthracite	13,830	2.2	5.7	86.2	5.9	A
Southern Anthracite	13,300	2.8	1.2	88.2	7.8	A
Bernice	13,380	3.1	8.5	78.0	10.1	B
Blossburg	13,810	1.7	21.5	67.6	9.2	E
Snowshoe	13,862	3.5	22.1	66.6	7.8	E
Moshannon	14,150	3.1	21.0	69.0	6.2	E
Mountain	14,072	1.1	25.6	64.4	8.2	E
Barnesboro-Patton	14,175	3.0	22.5	67.9	6.4	E
Nanty-Glo	14,620	1.2	20.5	72.1	6.0	D
Johnstown	14,081	2.0	14.4	75.3	8.1	D
South Fork	14,278	3.5	17.3	73.2	5.8	D
Broad Top	14,414	2.4	18.2	73.4	6.2	D
Somerset	14,170	3.0	15.5	74.5	6.8	D
Meyersdale	14,290	2.7	19.3	71.2	6.6	E
Ligonier	13,370	3.3	23.0	62.5	11.2	E
Conemaugh (eastern)	13,820	2.5	17.9	70.4	9.2	D
Clearfield (western)	14,000	4.1	23.0	66.8	6.1	E
Connellsville	13,990	2.8	30.0	60.0	7.2	F
Indiana	14,310	1.3	26.7	64.4	7.6	F
Glen Campbell	14,054	3.4	23.1	67.2	6.3	F
Punxsutawney	14,300	2.5	27.8	64.0	5.7	F
Bennett Br.	14,020	2.7	32.4	58.6	6.3	G
Shawmut	13,280	2.9	34.7	52.8	9.6	G
Klondike	13,270	4.2	32.3	54.0	9.5	G
Greensburg	13,610	2.7	30.3	57.8	9.2	F
Irwin	14,150	2.0	33.6	58.1	6.3	G
Freeport	13,100	2.7	35.7	50.9	10.7	G
Sagamore	13,510	1.0	34.1	54.1	10.8	G
Pittsburgh	14,000	2.6	34.9	56.3	6.2	G
"Thick Vein" Freeport	13,940	1.2	35.9	55.4	7.5	G
Kittanning	13,310	1.4	36.2	52.5	9.9	G
Low Grade Division		3.3	33.8	56.8	6.1	G
Clarion		4.8	37.9	50.3	7.0	H
Greene County (western)		2.8	36.0	48.4	12.8	H
Washington Co. (central)		1.4	37.1	53.8	7.7	G
Washington Co. (northern)		2.2	39.2	52.6	6.0	H
Beaver	13,770	2.5	38.0	54.5	5.0	G

The analyses given were made by the U. S. Bureau of Mines, but were selected as far as possible on the basis of low ash. To that extent they may not be fair averages of the several fields, for in one field the analyses given may contain the typical amount of ash and in another the ash given may be much lower than the average. In the same way the heat values given reflect the ash and moisture contained. The several analyses given are not intended to show the grade of the coal, but rather the general relation of the several constituent compounds. To compare the heat value of the coal from different fields regardless of ash and moisture, the B.t.u. value given should be multiplied by the factor (1 plus ash plus moisture) expressed as percentage.