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THE LOWER COAL MEASURES OF OHIO.

BY PROF. EDWARD ORTON.

There is no service that the mining interests of the State require more urgently from geology than an accurate and intelligible statement of the order of the coal measure, what seams of coal, limestone and ore are persistent, and what, sporadic and uncertain, what modifications occur as a seam is traced from one field to another, and what character of deposits we have a right to expect at any particular horizon of any particular field. These questions, and others of the same range and scope, underlie the demands that have been made from time to time for geological surveys of our mineral territory. Each survey has sought as best it could to answer these questions, and a great deal has been done in the way of gathering the facts upon which the final answer will rest. The work of Whittlesey and Newberry and Read in this portion of the State is quite full and accurate as to the main features of the Mahoning Valley series. They have availed themselves of the abundant exploration that has been carried on in this favored district, and of the facts developed by practical investigation. Newberry's general section of the Mahoning Valley, being built upon and comprising these facts, is in its lower portions, certainly, thoroughly founded and sure to remain. It has passed into the stock of common knowledge, and every one uses it without question or acknowledgment.

The work of Andrews in Southern Ohio was of the same general character. He gathered up and put in order the elements of the important section of the Hanging Rock district. This section, being a faithful copy of the facts as they occur in nature, must stand. Such an arrangement is not exposed to the changes of men's opinions, but it must stand as long as the hills, of which it gives a faithful account.

But even in these centres, where the best work has been done, much more remains to be done. The fault of Ohio Geology so far is its indeterminateness—the lack of instrumental precision in its data. It does not close the questions that it raises; it puts opinion against opinion, and leaves both to be sometimes set aside by practical development. The geological investigations of Ohio have been very useful in many ways, and have abundantly repaid the State for all that they have cost, but they hardly deserve the name of surveys. They are *reconnoissances* rather. A geological survey of the State yet remains to be begun—that is, such an investigation of our resources as will meet the demands of science in our day.

I have been engaged for the last year in completing one of these reconnoissances of the State; I have made a rapid review of the coal measures; I have traced the order of the series from Pennsylvania westward, as my predecessors have done; I have departed in a few points from the work done by the distinguished geologist who preceded me in this field; I have satisfied myself that I have found a true scheme, but I have not been able to *prove* it, as a larger measure of time and means would have enabled me to do, provided it were a true order. According to my opportunities, however, I have sought to establish and settle certain leading points.

I wish briefly to lay before the Association at this time a few of the conclusions that I count most important. I invite and shall welcome your criticisms and corrections. If I am in error, it is a good time for me to find it out. I am well settled in my own mind as to a few points that may not at once command general assent, and I gladly use the opportunity to get for them a hearing.

Forty years ago, Rogers divided the coal measures of Western Pennsylvania into five great sections, viz. :

Upper Barren Measures,	950	inches	in	thickness.
Upper Coal Measures,	250	“	“	“
Lower Barren Measures,	500	“	“	“
Lower Coal Measures,	600	“	“	“
Conglomerate Measures,	500	“	“	“

The boundaries of these divisions were for the most part clear and easily applied, but some trouble was found with the lowest division. No base could be assigned for this that was uniform and easily recognizable. The Brookville coal was taken as the base of the Lower Coal Measures, and the Freeport coal (upper) made its summit. The Lower Barren Measures extended from the base of

the Mahoning Sandstone to the Pittsburgh Coal, and the Upper Coal Measures from the Pittsburgh Coal to the Waynesburg Coal. The Conglomerate Series was always recognized as a coal-producing formation. It was never represented as a mere pebble-rock or sandstone. Rogers said of it that it contained "regular and even thick beds of coal." The Sharon Coal was always counted below the Conglomerate, as this term was understood by the Pennsylvania geologists.

The present Geological Survey of Pennsylvania has, in the main, recognized and confirmed these old divisions. It has worked out the structure of the Conglomerate Series very clearly, and proved it to be a complex formation. The series holds not one, but three great sandstones—the Sharon Conglomerate, the Connoquenessing or Massillon Sandstone, sometimes divided into a lower and an upper, and the Homewood Sandstone. Between these come in several regular seams of coal, limestone and iron ore. Its structure, as now given, is as follows:

Homewood, (Tionesta) Sandstone—upper bed, Pottsville Conglomerate.

Tionesta Coal.

Upper Mercer Ore.

Upper Mercer Limestone.

Upper Mercer Coal.

Lower Mercer Ore.

Lower Mercer Limestone.

Lower Mercer Coal.

Connoquenessing Sandstone (Massillon)—Upper.

Quakertown Coal.

Connoquenessing Sandstone—Lower.

Sharon Shale and Iron Ore.

Sharon Coal.

Sharon Conglomerate—(Conglomerate of Ohio Reports.)

Immediately above the Homewood Sandstone is found the Brookville Coal, the base of the Lower Coal Measures. The structure of this latter division is shown to be as follows:

Upper Freeport Coal—Big Vein of Salineville.

Upper Freeport Limestone—White Limestone of Ohio.

Upper Freeport Sandstone or Shale.

Lower Freeport Coal—Whan Seam of New Lisbon.

Lower Freeport Limestone—Cement Rock of New Lisbon.

Lower Freeport Sandstone—Often called Mahoning in Ohio.

Middle Kittanning Coal—No. 6 of Tuscarawas Valley.

Lower Kittanning Coal—No 5 of Tuscarawas Valley.

Kittanning Clay.

Feriferous Limestone and Buhrstone Ore.

Clarion Coal—Upper—or Scrub Grass.

Clarion Coal—Lower.

Brookville Coal.

Sometimes another seam is counted, the Upper Kittanning.

These are the elements in the Pennsylvania Scale. The order is settled here. The facts of nature are fairly represented in this system, and, so far as this is true, the system will prove a final one. Our *grouping* of these elements is, however, a different question. This is an arbitrary division. We can, with Rogers, make two sections of these twelve coal seams, or we can count all the seams in the Lower Coal Measures, as Newberry and others have always insisted. I agree with the latter. The Pennsylvania divisions would never have been made if the work had begun in the western part of the State. Putting the two sections together, we get eleven, twelve or thirteen seams of coal, according to our method of numbering. They are as follows:

Lower Coals of Pennsylvania.

Freeport Upper Coal.

Freeport Lower Coal.

Kittanning Middle Coal.

Kittanning Lower Coal.

Clarion Upper Coal.

Clarion Lower Coal.

Brookville Coal.

Tionesta Coal.

Mercer Upper Coal.

Mercer Lower Coal.

Quakertown Coal.

Sharon Coal.

But this is the Pennsylvania System, you say. It is the Ohio System as well. State lines are not apt to mark geological boundaries. The series can be traced across the border without a break. It can be followed with equal ease and certainty around the entire margin of the Ohio field. How can it be followed? Not by natural sections, certainly; for they are too short to contain the series, and the drainage divides interrupt such as we find. We must find some common and recognizable elements that will maintain the section as we advance from point to point. What elements are

most available? Seams of coal often answer an excellent purpose. There may be in them characteristic partings, or characteristic features of floor or roof, that make it easy to identify them wherever found. Iron ore seams can sometimes be used. In the charcoal furnace districts we have little else to follow. Sandstones are often appealed to, but they are deceitful witnesses. Beware of a sandstone geologist.

All explorers, practical and scientific, have agreed that the *limestones* of the Coal Measures are the most available guides. Their thickness is small, but their horizontal extent is very wide. There are three sets of limestones, each containing a pair, that maintain the section throughout the Ohio field. They are the Mercer, or Blue Limestones, the Putnam Hill and the Ferriferous, or the Grey Limestones, and the Freeport, or Buff Limestones. All have been used by those who have already worked in the field, but more stress can safely be laid on some of the series.

The Mercer Limestones—Lower and Upper—are best known. The Lower Mercer especially is wonderfully persistent and widespread. Whittlesey, Newberry and Andrews have all made large use of it as a guiding horizon. It is not necessary to characterize the little Blue Limestone here. It is the same in Mahoning, in Holmes, in Perry and in Jackson counties. The Upper Mercer is its duplicate in every respect but steadiness. It is sometimes lighter colored than the Lower. The horizon is trebly marked, a coal and an iron ore coming in to reinforce the limestone. The great value of this horizon is its acknowledged and indisputable continuity. It gives us a common and accepted base 150 feet above the lowest coal seam that can be taken up at any point in the field. To weld the strata into one series without the Mercer Limestones would be a hopeless task, but with their assistance it becomes easy and sure.

The Ferriferous Limestone is the great landmark of Western Pennsylvania. From it all measures are taken, above and below. Oil sands and Pittsburgh coal are alike counted from this important stratum. It is the thickest and most valuable limestone of the Lower Measures. It is the main dependence of the furnaces of Western Pennsylvania and Northeastern Ohio. Its buhrstone and ore help to emphasize the horizon. It is not steady, however. It is subject to rapid diminution of volume, and even to frequent wants. The changes which it undergoes are unaccountable, and have given rise to many misinterpretations of geological order, but

White has called attention to the fact that, when very thin or even disappearing as a limestone stratum altogether, its horizon is marked by a calcareous band of *conc-in-conc*. I have found this mark very serviceable in Northeastern Ohio. The short of it is that this limestone is the best of guides where it exists—very conspicuous, very well marked and well known, but the trouble in Ohio is that it is absent at the critical points. It crosses the line only to disappear with surprising suddenness.

But just where it disappears, its counterpart, the Putnam Hill Limestone of Andrews and the Gray Limestone of Newberry, comes in. Its horizon is 30' to 40' below the Ferriferous. Occasionally we get both in the Ohio Sections, but the Putnam Hill is very reliable. The fact is that the latter disappears in Pennsylvania, and the former for a long interval in Ohio, has made great trouble. There were seen to be left three limestones in each field:

In Pennsylvania—
Ferriferous,
 Upper Mercer,
 Lower Mercer.

In Ohio—
 Putnam Hill,
 Upper Mercer,
 Lower Mercer.

The inference was, and a very natural one certainly, that the two series were identical, but no amount of matching would make these ends meet. They were broken from different series, and could not be put together harmoniously. The same thing had already been worked out in the southern portion of the field. Mr. Roy long ago asserted that the Putnam Hill Limestone of Andrews became the Ferriferous of the Hanging Rock district. I followed him in this view, but both of us were obliged to abandon it at last. The facts were against it. I found the former limestone running under the latter, about 30' lower in the series, and could trace the horizon clearly to the southward. I might have been prepared for a similar result here, but I was not until driven to its recognition by stubborn facts. The Ferriferous Limestone is thus seen to lie on both sides of the axis in Northeastern and Southern Ohio, but to be wanting on the northern portion of the arc, but just where it fails, its duplicate comes in, and answers every purpose of identification through a half dozen counties.

The Freeport Limestones are another pair of widely-extended and very characteristic beds. They differ very much from the limestones already noted. They are buff colored, nodular, and not in even beds, non-fossiliferous, and often becoming thin iron ores. The Upper Freeport is by far the most constant and important.

It is Newberry's White Limestone of Columbiana county, and of Chapman's Hill, Mahoning county, and it is my Shawnee Limestone of Perry county and southward. The horizon is also strengthened by fire-clay and coal. This horizon has been often called into service, but not nearly enough use has been made of it. If hold of it had been kept, the Coal Measures would not have been dislocated as they now are in our Ohio Reports.

These three limestone groups help to bridge the chasm. By their means we can advance with confidence from State to State and from county to county.

I do not propose to follow the series around the State, but I will briefly give one or two applications of this system to our Coal Measure strata:

The Lowellville Section is a clear and important section. It is absolutely common to Pennsylvania and Ohio. The two Mercer Limestones are traced thither and identified without a question by the Pennsylvania geologists. The Ferriferous Limestone is also traced here. The Lowellville Limestone, so called, is the Ferriferous Limestone of Pennsylvania, if there is any such stratum. It lies 85' above the Upper Mercer Limestone and 140' above the Lower Mercer, a somewhat greater interval than usual. Thirty feet above it, the Lower Kittanning Coal is mined. The Brookville and Tionesta Coals are shown below, but they are thin. The Ferriferous Limestone is here seen in its last undisputed outcrop, for a long distance. It is the furthest north that it appears in the Mahoning Valley, but the Mercer Limestones are everywhere present at the northward. They are quarried in Austintown and Canfield for furnace use. The Mercer Coals are both mined in the latter township—the Lower by Wick & Wells, the latter in many small banks, being known as the Bruce Coal. What of the Putnam Hill Limestone? It is not found in outcrop, but it seems to be represented in a limestone represented by Newberry as occurring in the Fosterville Shaft, about 40' above the Upper Mercer. We shall get traces of this stratum again.

To obtain a good section, we can leave the main valley where Indian Creek puts into it. Ascending the last-named stream, we pass over the outcrop of the Sharon Conglomerate, the Sharon Coal and the Massillon Sandstone. On the farm of D. Heintzelman, Section 22, Canfield, we find the Lower Mercer Limestone in clear and well exposed section. Above it is the Upper Mercer

Coal, which is mined here. The interval is 35'. At 120' above the Lower Mercer, and at 85' above the upper Mercer, a well-known coal seam comes in—the Canfield Cannel. This has been carefully followed by bore-holes across the township. It becomes a double seam on John Ewing's land, in the southwestern corner of the township, a few feet of fire-clay intervening between the main coal and a foot of coal that lies below. A fossiliferous limestone also occurs here. This duplication of the coal becomes an excellent mark. The interval of 85' between the Upper Mercer Coal and the Canfield Cannel is said to be occupied by a massive sandrock, but this rock must be made up of more than one regular sandstone. This is the most crowded portion of the series, and no such interval as this is left barren in the general scale. Following the cannel seam further south, we find it mined at Cook's Crossing, on the railroad. The coal is here doubled, as where last seen. It lies 29' below the railroad. The White Limestone of Goodman's Hill comes in at a short distance, but about 150' higher. What is this White Limestone? There is no difficulty in determining it. It is a Freeport Limestone, probably the Upper, as characteristic in all respects as can be found anywhere. It is not the Ferriferous. It lies 150' higher than that. This is not less than 420' above the Block Coal, while the Ferriferous is only 300' above the same seam. What, then, is the Canfield Cannel? Is it the coal called No. 4 in Tuscarawas? By no means. That seam underlies the Putnam Hill Limestone, and this is 40' above it. This can be no other than the Upper Clarion Coal, and its horizon is that of the Ferriferous Limestone. To make assurance doubly sure, we have only to go still further down the valley. At the Walters Mine, as also at Reichstadt's, another seam comes in, viz: the Lower Kittanning Coal. This lies about 40' above the cannel seam. The latter is opened here, and both are worked. The cone-in-cone and the fossiliferous black shales of the Ferriferous horizon here come distinctly to view and complete the demonstration. The Lower Kittanning Coal becomes in this vicinity a very important seam, being known as the Leetonia Coal, and furnishing the purest and best coke of the State. It is true that it has been styled No. 4 in this neighborhood, but it is not either of the No. 4s that we have already found. In this same field we shall find this number attached to still another seam, viz: the Hammondsville Strip Vein. The facts are as follows:

No. 4 in Tuscarawas Co. is the Limestone Coal or Brookville.

No. 4 in Canfield township is the Upper Clarion Coal.

No. 4 in Leetonia is the Lower Kittanning Coal.

No. 4 in the Yellow Creek Valley is the Middle Kittanning Coal.

The Leetonia Coal being the first coal above the Ferriferous horizon or the Lower Kittanning, what ought to be found below it if holes were bored or shafts sunk? The answer is easy. At 40' should be found the Clarion Coal; at 80' to 90' should be found the Brookville, if present in the section; at 125' should be found the Upper Mercer, and at 160' should be found the Lower Mercer. Fortunately for our purposes the holes have been drilled, and we have the records of six of them. They agree fairly well. The Grafton boring No. 1 gives the following record:

O.	Lower Kittanning or Leetonia Coal... thickness,	32''
	Interval,	47'.6.
47'	Upper Clarion, or Canfield Cannel.....	36''
		27'.8.
	Lower Clarion.....	40''
		14'.8.
90'	Putnam Hill Limestone.....	16''
		32'.1.
122'	Upper Mercer Coal.....	7''
		31'.7.
154'	Lower Mercer Limestone.....	19''

By comparing this table with the predicted results, that is with the sections obtained to the northward, we see that they agree almost exactly. The lowest coal found at Leetonia is not, then, the Sharon or No. 1 of Newberry, but lies at least 150' above the horizon of that seam.

The Gray Limestone (Putnam Hill) is found in three of the six borings. The seams can be followed by the railroad levels with equally satisfactory determinations, but it is not necessary to add these facts here.

Following the series to New Lisbon, we can complete the section by bringing in the Freeport Coals and Limestones. The Canfield Cannel seam appears all the way along the Creek, and at many points has its normal cover, viz: the Ferriferous Limestone. The Lower Kittanning Coal, and also the Middle Kittanning, are both thin, but are clearly in place. The Lower Freeport Limestone is the New Lisbon Cement Rock, while the Lower Freeport Coal is the Whan Coal, an uncertain but sometimes very valuable coal. The Upper Freeport Limestone is shown every-

where, and its coal is the Big Seam, as it is called, or the Arter and Teegarden coals. All the intervals match in this rendering. These upper coals connect unmistakably and without dispute with the Pennsylvania series. Everybody knows that they are the bodily continuations of the Freeport horizons. There are but few Ohio coals that agree with the Pennsylvania seams without dispute or question, but these Freeport coals of Columbiana county are in this small list.

These are specimens of the sections that I have found all along the line. Still clearer and more compact proofs of the duplication of the numbers 3, 4, 5 and 6, particularly, can be got in the Big Sandy and Connotton Valleys. The Lower and Middle Kittanning Coals are Nos. 5 and 6 everywhere in the Tuscarawas Valley. The Lower and Upper Freeport Coals are Nos. 5 and 6 in the southern parts of the field.

When this is recognized, what system of designating the coals will be adopted? Shall we retain the old numbers with their confusion and errors, or shall we adopt a new scheme?

A few statements as to these points will be here in place:

In the naming of the coals of the Appalachian field two systems are in use. The first, which is by far the most widely employed, gives a name to the coal seam from some locality where it is well developed or mined on a large scale. The Pittsburgh Coal, the Nelsonville Coal, the Massillon Coal, are examples of this.

The second system designates the seams by letters or numbers. Lesley used letters in the First Pennsylvania Survey, naming the Brookville Coal Coal A, the Clarion Coal Coal B, etc., but he emphatically discards and repudiates the system now.

Newberry introduced numbers in his reports on Ohio Geology. There is much to be said in favor of such a system. It is easily applied. It is easily remembered. It carries with it the true order as to position in the scale. It is popular on all of these accounts. If the facts were all in when the numbers were applied, little fault would need to be found with the system.

If numbers should now be applied to the Pennsylvania Coals, it would not be necessary to change it hereafter, for all the horizons are thoroughly understood. No important and regular seam can have been missed in the practical and scientific explorations that the State has called forth within the last twenty years.

But whatever advantages a numerical system might possess, it

seems necessary to abandon the system now in force on the following grounds:

1. It is inadequate. There are but six numbers for the Lower Coal Measures, which have been shown to contain from eleven to thirteen separate seams. One-half of the seams must therefore be belittled by intercalated numbers.

2. The system is inconsistent. The No. 2, for example, is fixed upon a horizon in which there is not a coal mine in the State, except in one district of one county, while several widely distributed seams are left without any place in the scale. The Upper Mercer Coal is mined in Mahoning, Holmes, Coshocton, and other counties. It furnishes in Coshocton the greatest cannel seam of the State, but it is left without a number, and must be known as 3A. The Lower Freeport Coal must be recognized as No. 6A west of Tuscarawas county, though one of the important seams of the series.

3. The system is misleading and confusing to a great degree. This has become apparent from the previous discussion. No. 4 means nothing until you learn where it is to be applied. So of other numbers.

The system is a hindrance rather than a help to Ohio Geology as it now stands. What shall be done with it? One answer will be—correct the more glaring errors, and leave the framework as it is; call the Kittanning Coals 5 and 6 and the Upper Freeport 7, since these numbers in part of the field have been fixed upon them. The objections are that the errors of the scheme will be kept in conspicuous sight forever by this scheme, and all the inconsistency and relative injustice remain.

A second answer may be given in these words: Begin at the bottom of the scale as now determined, and apply the numbers in a true order, which would make the Kittanning Coals 8 and 9, or 9 and 10, according as the Clarion Coals are counted as one or two seams. A third method will be found in the adoption of the Pennsylvania names. Why will not the laws of geological nomenclature require this? If a ledge of barren sandstone shall be known through three or four States as the Mahoning Sandstone, why shall not the valuable coal seam that it covers retain *its* name as the Upper Freeport, as far as it can be followed?

To this latter view I incline, but I recognize the convenience

and popularity of the numerical system. I append the order, with the different schemes shown side by side:

Pennsylvania Names.	True Numbers.	True Numbers.	Newberry's numbers revised and corrected.
Upper Freeport Coal.....	11	XI.	7
Lower Freeport Coal.....	10	X.	6a
Middle Kittanning Coal.....	9	IX.	6
Lower Kittanning Coal.....	8	VIII.	5
Clarion (Upper) Coal, }.....	7	VII.	4a
Clarion (Lower) Coal, }			
Brookville Coal.....	6	VI.	4
Tionesta Coal.....	5	V.	3b
Upper Mercer Coal.....	4	IV.	3a
Lower Mercer Coal.....	3	III.	3
Quakertown Coal.....	2	II.	2
Sharon Coal.....	1	I.	1

But whatever system is adopted, no one who will make himself understood when writing on the Coal Measures of Ohio, will be able to dispense with a wearisome list of synonyms for a long time to come. The Pennsylvania names seem to promise the quickest relief.

DISCUSSION.

MR. CHAMBERLAIN.—I desire to express the deep interest I have felt in Prof. Orton's paper. The subject has been before me for twenty years. I have been looking for some order that would reach through the whole coal field and show me the Geological horizon whenever I might happen to be in Ohio. We are constantly changing in locations and need some such general scheme as has been set forth in Prof. Orton's paper.

In regard to the designations of coal beds I confess a strong preference for numbers. They are retained so much more readily and tell so much more than other names. I think, however, the missing seams should be represented by intercalated numbers.

A. B. CORNELL.—I have felt unusually interested in the paper just read. In regard to the connection that has been shown between the Ohio and Pennsylvania series I am glad to see Prof. Orton working out this problem. I prefer to retain numbers in naming coal beds, on account of their simplicity. People who read or

think little on Geology have not time to muster all the local names. I feel a repulsion to the Pennsylvania system and an attachment to our own.

THE PRESIDENT.—I agree with the preceding speakers as to numbering the seams. But coals will have local names in any event. For example, the Briar Hill Coal, the Massillon Coal and the Jackson Shaft Coal, which are all No. 1, are known in markets by these local names rather than by No. 1. The numbers, however, are of more importance in written use. I would not willingly abandon the present numbers for the nomenclature of the Pennsylvania Geologists. If Dr. Newberry's enumeration is not complete the plan already adopted of interlocating the missing beds seems to me to be the proper way of building up and naming the series. We may not yet have a perfect scale. A complete geological survey of the State, as Prof. Orton has well remarked, would require many years of constant field work.
