KENTUCKY

GEOLOGICAL SURVEY

FOURTH SERIES
Carl F. Barth
VOLUME ONE

PART ONE

J. B. HOEING, State Geologist

FRANKFORT, KY.
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To Hon. James B. McCreary, Governor of Kentucky, and President of the Advisory Board of the Kentucky Geological Survey.

Dear Sir:

I have the honor to transmit herewith Volume 1 of the reports of the New Geological Survey prepared under the Act of the Legislature of 1912.

In the preparation of these reports I am much indebted to the hearty co-operation and uniform good work of the gentlemen who have been associated with me as assistants.

Respectfully,

J. B. Hoeing,

State Geologist.

Frankfort, Ky.

July 1, 1913.

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PREFACE.

Chapter 12 of the Acts of the Legislature of 1912 created a New Geological Survey and provided for the removal of the office of the Survey from Lexington to Frankfort, this act to take effect July 1, 1912.

The following is a copy of the act.

"An Act establishing and governing a Geological Survey and removing the present survey to Frankfort, Ky.

"*Be it enacted by the General Assembly of the Commonwealth of Kentucky*:

"1. That the Kentucky Geological Survey is hereby created and established; that the offices of said survey shall be at the seat of government; that the geological collections, records, maps, reports and accumulated property of the present Geological Survey, excepting the State Museum, be and the same are hereby directed to be removed from the State University of Kentucky to Frankfort, Kentucky, and the money necessary to remove the same is hereby appropriated from any money in the State Treasury not otherwise appropriated.

2. That the Governor shall, with the advice and consent of the Senate, appoint a competent person as State Geologist, who shall have a thorough, scientific and practical knowledge of the science of geology, mineralogy, hydrography, chemistry, and allied subjects. He shall not be connected with any school or college as an instructor and shall devote his entire time to the Survey. He shall enter upon the duties of his office on the 1st day of July, 1912, and shall hold his office for four years, unless sooner removed by the Governor for inefficiency, incompetency or misconduct, or until the office is abolished by the General Assembly.

3. That there shall be an advisory board consisting of five members, one of whom shall be the Governor, who shall be president of the Board, and the other four members shall be appointed by the Governor. All four of said mambers shall serve for four years, or until their

successors are appointed and qualified. The actual expenses of the members while attending meetings of the Board, shall be paid by the State.

4. It shall be the duty of the State Geologist to give his attention to the administration of the affairs of the survey; to visit all parts of the State so as to make himself familiar with the needs of each section; to supervise the work of his assistants; to undertake such field work as his time will permit and to perform such other duties as properly pertain to his office. He shall have supervision of the entire work of the Survey and shall be responsible for the accuracy of same. He shall make a report to the advisory board once every three months, to-wit: on second Wednesdays of March, June, September and December of each year.

Under the direction and control of the director the crops of the Survey shall proceed to make careful geological, mineralogical, chemical, physical and soil surveys of the State; to enter upon record an accurate statement of the extent of water powers and water-courses; to locate coal, oil, metalliferous deposits, clays, ores, building materials, etc.; to report characteristics and compositions of soils; to collect, analyze and classify specimens of rocks, fossils, ores, coal, minerals, soils, relics, and representative exhibits of the agricultural, archaelogical, forest, ornithological and other natural resources of the State; to cause specimens of the above-named exhibits of the State to be preserved in the Museum at the State University at Lexington, Kentucky.

5. The State Geologist is authorized to employ two competent assistant geologists and such clerical help, topographers, specialists and assistants as may be required for the proper conduct of the affairs of the survey, subject to the approval of the advisory board. He shall submit to the Governor each month an itemized statement of the expenses incurred by himself and assistants, properly verified and accompanied by proper vouchers, and the Auditor shall draw his warrant for the amount thereof, when approved by the Governor.

6. The director may enter into co-operative arrangements for geologic, topographic, soil survey and such other purposes as are within the scope of the survey, with the State experiment station, the United States Geological Survey, the United States Department of Agriculture, or other organizations of governmental departments, provided that in each case agreed upon the said organization or department shall furnish an amount of money equal to that allotted for such work by this survey; and provided, further, that such co-operative agreements shall be made and carried out so that in all things they will prove advantageous to the State and shall receive the approval of the advisory board.

7. The salary of the State Geologist shall be $2,500.00 per annum, which sum is hereby annually appropriated from any money in the State Treasury not otherwise appropriated, and is in addition to the annual appropriation made for the survey by act of March 25, 1908.

8. It shall be the duty of the State Librarian to supply the survey with all necessary stationery, printing and maps, as all other public offices are supplied, upon requisition of the director, approved by the Governor.

9. The reports of the survey shall be prepared as rapidly as possible and submitted to the advisory board, which shall have the power to approve and authorize the printing of same, the cost thereof to be paid out of the general expenditure fund, as is the case of other official reports. The director, with the approval of the advisory board, is authorized to publish in the newspapers or in pamphlet form any discoveries or results of special interest, the cost of such special publications to be paid out of the money appropriated for the survey. The advisory board shall determine the number of copies of each report to be printed, and the manner of distribution thereof.

10. The office of Curator shall be abolished on July 1, 1912, at which time the State Geologist shall take charge.

11. All of Chapter 59a except the Act of March 25, 1908, which is sub-section 10 of section 2007c of said chapter of Kentucky Statutes, compiled by John D. Carroll, be and the same is hereby repealed; and all laws and parts of laws in conflict with this act are hereby expressly repealed.

Approved by the Governor, March 7, 1912.

This statute repeals all previous statutes applying to the Kentucky Geological Survey, with the exception of sub-section 10 of section 2007c of Chapter 59a, which sub-section provides that an annual appropriation of $25,000 shall be made for the carrying on of the work of the Geological Survey and further provides that $10,000 of this amount is, under certain provisions (one of which is that the U. S. Survey shall appropriate an equal amount to be used in co-operation with the U. S. Geological Survey for the purpose of preparing topographical maps of such portions of the State as may mutually be agreed upon by the directors of the two Surveys. The remainder of the appropriation ($15,000) is to be used as directed in the Statute, for the prosecution of the general work in this State. In accordance with the above provisions of the Statute, the office, records, etc., of the Survey, with the exceptions of the State Museum, which remains in Lexington, have been removed to quarters in the annex to the old Capitol Building from which point the work of the State Survey has been carried on.

The following is a list of expenditures from July 1, 1912, to June 1, 1913:

Amount appropriated for co-operative work with U. S. Geological Survey	$10,000.00
Amount expended	6,522.41
Balance unexpended	$3,477.59
Amount appropriated by the U. S. Geological Survey	10,000.00
Amount expended	8,019.21
Balance unexpended	$1,980.79
Amount appropriated for general work in Kentucky	$15,000.00
Total amount expended	6,927.73
Balance unexpended	$8,072.27
Total amount appropriated	$25,000.00
Total amount expended	13,450.14
Total balance unexpended	$11,549.86

To these amounts are to be added the amounts spent in June. Owing to absence of assistants in the field, their June accounts could not be audited in time for this report.

These balances are not carried forward to the credit of the Geological Survey, but remain in the State Treasury.

From the above statement it will be seen that not all of the annual appropriation has been used this year. This was in compliance with a request by Governor McCreary that expenditures be kept as low as possible on account of the depleted condition of the State Treasury.

When I took charge of the affairs of the Survey on July 1, 1912, my predecessor in office, Prof. C. J. Norwood, turned over to me the manuscript and notes of some of the unpublished work accumulated during his term of office. Some question was raised as to the legality of publishing these notes out of an appropriation made expressly for the purpose of creating what was practically a new Survey and the matter was submitted to the Attorney General of Kentucky for a decision. A copy of his letter covering this point is given herewith:

Office of Attorney General,

Frankfort, November 26, 1912.

J. B. Hoeing, State Geologist, Frankfort, Ky.

Dear Sir:—From your conversation on yesterday, it appears that there are certain manuscript reports touching upon the geology of Kentucky which have never been published, and you desire to know if there is any authority in chapter 12, Acts of 1912, for having them published at this time, or if no authority under said act, if they may be published under the provisions of the old law.

By reference to section 11 of chapter 12 of the Acts of 1912, it will be seen that provisions of the old law providing for the publication of such reports have been repealed, therefore, such manuscripts cannot be published under the provisions of the old law.

Section 9 of the Act of 1912 provides what reports shall be published and an examination of this section convinces us that the manuscrpts referred to by you cannot be published under the provisions of said action.

It appears to me that there is but one way in which these reports may be published. In a report made by you you might refer to them and make them a part of your report and let them be published as a report coming from you, adopting such previous reports as a part of your report.

Yours truly,

M. M. Logan,

Assistant Attorney General.

In accordance with the above decision, reports, the work on which was done under Prof. Norwood are included in this volume. I will state, however, that these have been carefully gone over and the majority of them entirely rewritten by the gentlemen who did the original work and some of them are in considerably modified form. Others have been revised and pruned down and all are presented as valuable additions to the knowledge of the resources of our State.

A report is given by Mr. J. M. Hodge on the coals of the Upper Licking River. This is accompanied by a map of the section drawn by Mr. L. M. Sellier. A previous report on that section has been issued by the Geological Survey. This report, however, gave very little detail or really valuable information in regard to this region, and in view of the fact that a railroad survey was being made through the territory in question and there was constant demand for information in regard to the economic features to be developed it was deemed advisable to publish as complete data as could be obtained. Mr. Hodge's report shows a valuable coalfield accessible to railroad transportation in coal veins above drainage as well as a possibility of finding a large area of the Elkhorn and Van Lear coals which are there under

drainage and can only be developed by the diamond drill.

What is one of the valuable assets of Kentucky in the way of mineral resources and one which has not had the publicity which it deserves is well treated in a report by Mr. A. F. Crider on the Fire Clay deposits of northeastern Kentucky in Carter, Boyd and Greenup Counties. This report is accompanied by maps and illustrations. These fire clays are present in large quantities and are the source of the material for a very large output of refractory material of all kinds. A number of large plants are located in that section using the material locally and considerable clay is being shipped to other points. In addition to these plants a new fire brick plant is now about completed at Hitchins Station on the Chesapeake & Ohio Railroad which is claimed to be the largest of the kind in the United States. For detailed information in regard to this field reference is made to the above report.

A report on the geology of the Georgetown Quadrangle by Professor A. M. Miller with a geological map is given. This is in furtherance of the adoption of a plan by which the topographic sheets issued jointly by the Kentucky Geological Survey and the U. S. Geological Survey are to be utilized as a basis for final detailed geological work. The work on this sheet is presented as final and completes that portion of the State. This section is particularly interesting as containing the phosphate deposits of Central Kentucky as well as numerous veins of Barite. Prof. Miller has given a vertical section in which the different divisions of the Ordovician are definitely located and has traced over all of the area a well marked output of a fossil Stromatocerium which is economically important as practically marking the limit below which the phosphate deposits will not be found. Accompanying this report is a report on Trenton Horizons and one on the Chemistry of the Trenton Rocks, both by Prof. A. F. Foerste.

A report on the coals of the Tell City and Owensboro Quadrangles in the western coal field by Mr. A. F.

Crider is also based on two of the topographical sheets issued as co-operative work and completes the work on those sheets. Mr. Crider found a large area of the Hawesville coal as yet unworked and also notes a possible source of oil and gas.

A report is given herewith by Prof. A. F. Foerste on the phosphate deposits of Central Kentucky. The field work of the report was done under my predecessor, Prof. Norwood. This report has been entirely rewritten and is presented now in economic form. Prof. Foerste draws a very clear distinction between deposits which are commercially available and those which are not, the latter being quite numerous.

It should not be inferred, however, that conditions as found in this field, necessarily preclude the possibility of finding deposits, other than what are now worked, of sufficient size to warrant commercial exploitation. Over large areas in this section the horizon at which these deposits are to be looked for, is covered by a varying thickness of soil which not only may effectually conceal all evidence of the presence of phosphate, but owing to the value of the land itself and the consequent cost of prospecting, adds very considerably to the expense of uncovering the deposits.

Attention is called to a very valuable suggestion in this report in regard to the use of ground limestone which carries a small percentage of phosphate. Ground limestone for use on acid soils is being used in constantly increasing quantities and the addition of a small percentage of phosphate should make it that much more valuable. As Prof. Foerste shows in this report, there are large quantities of limestone available in this section which do carry some phosphate and which could be very cheaply quarried and ground, but will never be available as phosphate alone on account of the very small percentage of the phosphate as compared with the whole mass.

The Central Kentucky Phosphate Company has recently enlarged its plant at Wallace, in Woodford County, and is mining and shipping phosphate, the bulk of the product going to other States although the local use among farmers in Central Kentucky is increasing.

The company is reported as holding 1,700 acres of leases. This is the only plant which has been opened, as yet, for the mining and grinding of the phosphate rock.

A report on the Barite Deposits of Central Kentucky by Mr. F. J. Fohs is given. The field work for this report was completed under my predecessor, Prof. Norwood. The report has been considerably modified in extent and is presented herewith as a complete exposition of the occurrence of Barite and the different purposes for which it is used.

Prof. H. D. Easton gives a very valuable report on the Technology of Clays. The field and laboratory work were done under Prof. Norwood, but the report has been entirely rewritten. This is a class of work which should be carried to completion, the clays of this State forming one of its valuable assets. Unfortunately, the conditions under which the work of the Survey has been carried on this year, prevented anything from being done along these lines.

An urgent demand exists for reliable information in regard to the coals on the North Fork of the Kentucky River where the Louisville & Nashville Railroad has completed the extension of the Lexington & Eastern Railroad from Jackson to the head of the river at McRoberts, and large amounts of capital have been invested in the purchase of coal lands in that section. A report on the coals of the Three Forks of the Kentucky River was published in 1910, but some serious errors in the levels and correlation of the coals in this report have been found and in addition to this numerous new openings were available; it was deemed advisable, therefore, to make an entirely new investigation of the coals from and including the head of Lost Creek up to and including Carr Fork and North Fork above Carr to above the mouth of Bull Creek. The results are given in two reports on that region by Mr. J. M. Hodge. As shown by this report the Fire Clay coal is a valuable and very persistent bed, the upper bench of which constitutes a very fine steam and domestic coal. Other beds higher in the section are also of value. In this connection a word of warning in regard to the purchase of coal lands may not be out of place. Large areas have been purchased in Kentucky in the last few years apparently just because they were included within the boundaries of the Coal Measures and with the idea that all "coal lands" must be valuable, the proving up of the lands often following the purchase instead of preceding it. The limits of the Coal Measures are easily marked on the map, but it does not follow that all the territory within these limits is productive or of value.

In the Kentucky fields, as in any other, the valuable coals are in local basins and there are many areas which are practically barren of workable coals and where coal seams which are of good thickness in local basins are some of them too thin to be worked at the present time and some of them too thin ever to be workable. These same conditions are to be taken into account in computing the life of the coal fields. There is a large amount of available coal in the two Kentucky Coalfields, but any calculation based on the average number of veins per square mile and the total thickness of coal contained in those veins, as is sometimes done, is misleading and tends to give an erroneous idea of the amount of *available* coal. Kentucky coal is being mined at a rapidly increasing rate and in view of the constantly increasing demand for coal and the certainty of the end of the supply at some time in the future, every possible means of conservation of our fuels should be taken.

In two reports covering the economic features of the Warren County oolitic limestone and the Kentucky asphalt rock, by M. H. Crump, much valuable data is given concerning two of the most promising assets in the way of mineral resources in Southern Kentucky. As shown by these reports, both of these materials are found in large quantity and of most excellent quality and only need the investment of the requisite capital to develop a very large production. Data presented in regard to the oolite is mainly confined to Warren County for the reason that most of the development so far has been done in that county, but these same oolites are to be found at a corresponding horizon not only around the

border of the Western coalfield, but also extending across Southern Kentucky and as far east as Rockcastle County.

The largest deposits of Asphalt rock (with the exception of one in Carter County) so far as is now known, are found in connection with the Chester and lower Coal Measure sandstones of Western Kentucky. The use of this asphalt rock as a road material has practically passed the experimental stage and there should be a very largely increasing demand for this material as its merits become better known.

A report is given covering the general features of the Upper Big Sandy coal field. This is intended as partly preliminary and to be followed by more detailed work. Much of the data for this report was secured by Mr. W. H. Cunningham.

As mentioned above, the statute provides for an appropriation of $10,000 to be used in co-operation with the U. S. Geological Survey for the preparation of topographic maps. The U. S. Survey appropriates an equal amount for this work and a contract was entered into between the two Surveys for co-operative work for the year ending July 1, 1913. Under this arrangement field work has been carried on in both the Eastern and Western coal fields and is also under way at present. The office work and engraving is done at Washington. Field work has been completed on the Little Muddy, Hindman and Pound Quadrangles and the finished sheets for those three and the Buckhorn and Troublesome sheets will soon be issued. These sheets are sold at the normal price of 10 cents each which about covers the cost of printing and arrangements have been made by which any of the Kentucky sheets can now be obtained from the office of the Survey at Frankfort.

The State Geologist has been very much hampered by the failure of the advisory board to provide means for carrying on the chemical work of the Survey. The Survey owns a laboratory which is fairly well equipped but is of no use under present conditions and chemical work of every kind has been held in abeyance. There is constant demand for anaylses of different materials as well as the need for chemical work in carrying on the general work of the Survey. For all the analyses given in this volume I am indebted to the different coal companies who have kindly turned over to me the results of their private work.

Great interest is being manifested in Kentucky's mineral resources and there is a very large demand for specific information, a very considerable portion of which comes from outside of the State. There are numerous requests for reports and maps and a great many samples of different kinds are sent in to the office with requests for information in regard to their character and value. These are all promptly complied with and the result is a large volume of correspondence, by which it is trusted much information is given. It is estimated that about 3,000 letters of this character a year are received and answered from this office in addition to maps and printed matter distributed.

OIL AND GAS.

The effect of the recent rapid increase in the price of oil has been to induce a large amount of leasing all over the State. Many thousands of acres have been leased but, with the exception of a few localities, comparatively little drilling has been done and production has been limited mainly to the older fields in Wolfe, Bath and Wayne counties. Oil runs from the whole State for 1912 and the first part of 1913 are given below.

In Western Kentucky a pool of oil has been found five miles northeast of Hartford in Ohio County. The oil is found on a dome lying just south of the Rough Creek fault and at a depth of about 1,700 feet. The producing "sand" is a limestone lying below the Devonian Shales, whether a Devonian limestone or one lower in the section, cannot be told at present. It is, however, approximately at least, at the horizon of the Devonian limestone which forms the "Ragland" sand of Eastern Kentucky. At the present writing six wells have been drilled, four on the south side of the fault and two on the north side. The four on the south are all producing. Of the two on the north, one was dry and the other was abandoned on account of loss of tools in the hole before reaching the sand. A number of wells are projected and some now being drilled to test the territory to the east and west. There is a heavy pressure of salt water coming up the dip from the south in this field which may ultimately cause trouble. At this date, wells No. 2 and No. 4 are good producers; No. 1 and No. 3 are not being pumped.

The record of well No. 1, drilled by the West Kentucky Oil Co. in July, 1912, five miles northeast of Hartford, Ky., is given below:

Log of well No. 1 of West Kentucky Oil Company, 5 miles N. E. of Hartford, Ohio County, Ky. Drilled between November and middle of July, 1911-1912. Log as kept by M. W. Barnard, of Hartford, Ky.

Elevation of top of well, 530 A. T.

	Feet	Feet
Conductor	14	14
Lime	5	19
Shale, blue	16	35
Lime and slate (oily)	65	100
Shale, black	20	120
Lime and shale	4	124
Slate	24	148
Slate and sandy lime	22	170
Shale, blue	15	185
Sand and lime	56	241
Shale, blue	5	246
Lime, hard	17	263
Sandstone, white, soft at top (oily)	36	299
Lime, white	14	313
Sand, oil showing	8	321
Lime,	6	327
Shale, sandy	3	330
Lime, oily	9	339
Shale, black	3	342
Lime, bluish, hard	28	370
Lime, white, hard	28	398
Lime, brown	20	418
Lime, oil and some gas	10	428
Lime, white, hard	42	470
Lime, white, soft	15	485
Lime, bluisn, soft	5	490
Lime, white, soft	20	510
Lime, white, hard	5	515
Shale, blue	5	520
Lime, blue	5	525
Lime, hard, blue	5	530
Lime, brown, hard	10	540
Lime, white, hard	20	560
Lime, blue	10	570
Lime, gray	10	580
Lime ,white, hard	10	590
Lime	10	600
Lime, brown, hard	5	605
Lime, white, hard	5	610
Lime, brown, hard	10	620
Lime, gray	10	630
Lime, brown, hard	7½	637½
Lime, white, hard	5½	643
Lime, brown, hard	7	650
Lime, white, hard	27	677

	Feet	Feet
Lime, white and gray	20	697
Lime, brown, hard	5	702
Lime, white, hard	6	708
Lime with gas	1	709
Lime, soft, much water	11	720
Lime, show oil	5	725
Lime, white, hard	10	735
Lime, brown, hard	5	740
Lime, hard	15	755
Lime, brown, softer	3	758
Lime, brown, soft, oily	4	762
Lime, brown, hard	10	772
Siliceous bed, very hard	8	780
Oil sand, first strike	21	801
Lime, sandy	109	910
Lime, sandy blue, soft	100	1,010
Lime, sandy, hard	162	1,172
Lime, sandy, some oil	5	1,177
Lime, sandy	33	1,210
Shale, black	100	1,310
Shale, brownish-black	220	1,530
Shale, black, bituminous	120	1,650
Lime, sandy	21	1,671
Oil sand	15	1,686

During the last year twelve wells have been drilled in Allen County on Little Trammel Creek near Petroleum. This is in the vicinity of old wells drilled many years ago. Eight of the wells are reported to be producing and four dry. The oil, which is black and heavy, is found in a limestone below the Devonian Black Shale, approximately the same horizon as that in Ohio county, but the wells here are quite shallow, varying from 90 to 110 feet in depth. Production is small and the oil not of the highest grade but this is more than offset by the low cost of drilling. There are a number of small anticlinal folds in this and adjoining counties which may prove productive. The first shipment of oil was made in March, 1913, from three wells just south of Petroleum Station. In the adjoining county, Barren, no new wells have been drilled, but about twenty of the older wells are still producing. Some of these have been producing as long as fifteen years.

In the "green oil belt" in which these are located and which includes a strip of territory on Beaver Creek extending about two miles west and twelve miles east of Oil City, the wells are deeper, varying from about 300 feet in the western part to 600 feet in the eastern portion. New drilling is now under way in this section. Well records are given farther on.

Development is probable in Hancock, Daviess and Webster Counties and possibly other sections in Western Kentucky during the present year.

In Perry County a well has been drilled on the Kentucky River near the northern edge of the county. No information could be obtained in regard to this well but it was reported to have the tools fast at 2,200 feet. A small flow of gas was found at some point in the well Another well is being drilled across the river from this.

In Lawrence County at Busseyville, six miles west of Louisa quite a number of wells have been drilled on what appears to be a narrow strip running about east and west. The oil is found in the Berea at from 1,500 to 1,600 feet but the wells, so far, are individually small producers. The oil is dark green in color and, as tested at Charleston, W. Va., is reported to have a gravity of 39.4 Beaume. Pipe line connection has been made and the production is being taken out. An average record is given below.

In Knox County gas has been produced from the Big Injun sand for several years and is supplying the town of Barbourville. A deep well now being drilled by the Cumberland Gas Co. outside of Barbourville is now down 2,400 feet and will go deeper. In this well gas was reported at 1,800 feet in considerable quantity.

In Morgan County a producing oil well was drilled about eight months ago at Cannel City. The well struck the Morgan County sand which is just below the Devonian shales, at a depth of 1,608 feet. The estimated initial production was placed at 400 to 500 barrels per day. The well was later on cleaned out and drilled deeper, shot and put to pumping. After eight months it is reported as now pumping 65 barrels a day. At the present writing a number of additional wells have been drilled and the field, as now developed, is about one mile long by a quarter of a mile wide with the largest

development above Cannel City on the waters of Prater Fork of Caney Creek. The Kentucky Block Cannel Coal Company which drilled the first well, drilled four more, Numbers 2, 3, 4 and 5. Of these No. 2 was dry, No. 3 is estimated to produce 150,000 to 200,000 feet of gas and 12 to 14 barrels of oil per day, No. 4 is a gas well and No. 5 a small oil well. In addition to these the following wells have been drilled:

Hume Oil Co.—No. 1	Dry
Taylor Day—No. 1	Dry
Taylor Day—No. 2	Gas well
Terrell—No. 1	About 18 barrels (reported)
Carter—No. 1	Flowed 425 barrels in first 48 hours

Pumping 25 barrels 90 days after being drilled (reported).

Mason James—No. 1	Small oil well
A. E. Sebastian—No. 1	25 barrels (reported)
L. M. Conley—"Fugate"	Not completed.
Ohio Fuel Oil Co.—No. 1	About 40 barrels (reported)
Ohio Fuel Oil Co.—No. 2	About 50 barrels (reported)
Burton Fork Oil and Gas Co.	About 20 barrels (reported)

A record of a deep well drilled some years ago about two miles north of the present development is given farther on as showing the formations not only down to the producing sand, but considerably below.

In Martin County in the Kentucky-West Virginia gas field a large number of gas wells have been drilled and a heavy production secured. The gas is found principally in the "Big Injun" sand. Lexington, Mt. Sterling and Winchester in Central Kentucky are being supplied from these fields and another line supplies the towns down the Big Sandy and Ohio Rivers as far as Cincinnati.

Following are the oil runs from Kentucky for 1912 and a part of 1913:*

*From Oil City Derrick.

1912

Months.	Runs (Barrels)	Shipments (Barrels)
January	37,696.46	9,223.69
February	36,695.23	8,526.89
March	40,194.99	13,017.60
April	36,646.27	14,241.53
May	44,238.33	8,137.74
June	39,581.66	7,219.78
July	44,267.88	5,652.45
August	40,136.58	3,263.25
September	38,417.20	4,314.35
October	37,755.92	4,677.47
November	39,271.70	5,759.82
December	40,343.40	3,996.00
Total	475,545.62	88,030.57

Average run per month, 39,628.8 barrels.

1913

Months.	Runs (Barrels)	Shipments (Barrels)
January	41,982.48	5,645.09
February	36,750.50	4,070.07
March	39,194.39	5,138.48
April	38,794.48	4,252.78

For the first six months of 1913 the number of wells drilled in Kentucky was 97 with a production of 1,315 barrels, as against 80 wells and a production of 1,224 barrels for the same period in 1912. Of the wells drilled in 1913, 58 produced oil, 4 gas and 35 were dry.

Below are given typical well records from as many of the counties in the State as these could be obtained. These are merely given as a guide for future drilling by showing average sections of the formations drilled through.

BARREN COUNTY.

W. E. Peden Farm—

	Feet	Feet
Gravel	13	13
Gray lime	50	63
Blue shale	10	73
Lime shell	2	75

	Feet	Feet
Black shale (Devonian)	25	100
Dark lime	10	110
Dark lime shells	10	120
Dark lime (oil show at 125)	15	135
Blue slate	25	160
Blue lime	10	170
Blue lime (oil show at 178)	8	178
Blue lime	147	325
Gray lime	60	385
Gray lime	20	405
Lime and slate (gas at 530 and 555)	180	585
Dark lime (heavy gas flow at 585)	75	660
Dark lime (gas at 685)	25	685
Blue lime	150	835
White lime	100	935
White slate	6	941
Gray lime	125	1,066
Dark lime	18	1,084
Light lime	100	1,184
Dark lime	466	1,650

BATH COUNTY.

Ewing Farm on Clear Creek—

	Feet	Feet	
Shales and sandstones	0	430	Waverly
Black and blue shales	430	632	Devonian
Limestone	632	680	Ragland sand
Blue and red shales	680	853	Niagaran
Limestone	853	867	Niagaran
Blue and pink shales	867	886	Niagaran
Limestone	886	913	Clinton
Blue shale	913	950	Clinton
Blue and gray crystalline limestones	950	1,900	
At 1900 light green shale and top of Tyrone (Highbridge).			
Dove colored limestone	1,900	2,010	
White, magnesian limestone	2,010	2,030	
At 2,030 a dark green shale.			
Dove colored limestone	2,030	2,500	
Dark and light gray limestones	2,500	2,508	
Dark gray limestone and shale	2,508	2,516	

	Feet	Feet	
Dark shale and limy sandstone	2,516	2,522	
Light dove colored limestone	2,522	2,528	
Dark dove colored limestone	2,528	2,546	
White limy sandstone	2,546	2,599	Calciferous

Strong flow of mineral water at 2,578.

BOYD COUNTY.

Well on Shope's Creek, two miles S. E. of Summit Station—

	Feet	Feet	
Soil	0	15	
Gray sand	10	25	
Blue slate	10	35	
Coal	4	39	
Slate	31	70	
Coal	4	74	
Slate	14	88	
Sand	26	114	
White slate	56	170	
Black slate	65	235	
White slate	50	285	
Coal	3	288	
Blue slate	14	302	
Black slate	113	415	
Sand (salt water at 420)	55	470	
Slate	20	490	
Sand (salt water)	50	540	
Limestone	90	630	Big lime.
Slate	4	634	
Sand	131	765	Big Injun at top
Slate	40	805	
Sand and slate	411	1,216	
Black shale	14	1,230	
Berea	22	1,252	
Slate break	9	1,261	
Sand	44	1,305	
Black and white slate	419	1,724	Devonian
Sand	10	1,734	Devonian
Black and white slate	283	2,017	Devonian
Sand—Gas	20	2,037	Devonian
Brown limestone	50	2,087	Devonian

BRECKINRIDGE COUNTY.

Well at Stephensport—

	Depth.	
At	0 to 22	—Soil.
At	22 to 25	—Gray shale.
At	25 to 35	—Gray lime.......No. 1 Chester Limestone.
At	35 to 67	—Light brown sand.......Big Clifty sandstone.
At	75	—Gray, crinoidal limestone.
At	85	—Gray lime.
At	96	—White lime.
At	100	—Mottled, gray lime.
At	130	—Black shale.
At	135	—Light, dove-colored lime.
At	155	—Soft, white lime.
At	230	—Gray lime and pink, crystalline lime.
At	240	—Gray oolite.
At	276	—Dove-colored, lithographic lime.
At	300	—Light gray, partly oolitic lime.
At	317	—Gray and white, crinoidal limes.
At	335	—White lime.
At	350	—Gray, crystalline lime.
At	380	—Fine-grained, white lime.
At	395	—White lime.
At	420	—Light gray lime.
At	425	—Black shale—crinoidal lime—sand, mixed.
At	450	—Gray lime.
At	470	—Very light lime.
At	475	—Dark gray lime.
At	482	—Brownish-gray lime and black shale, mixed.
At	500	—Brown lime and black shale over a light gray, crinoidal lime.
At	510	—White quartzite.
At	515	—Dove-colored lime.
At	518	—Gray fossilliferous and black lime (67 to 813—Full section of St. Genevieve and St. Louis).
At	525	—Gray lime.
At	530	—Black lime.
At	535	—Thin, gray limes.
At	540	—Black lime.
At	555	—Gray lime.
At	585	—Dove-colored lime.
At	600	—Black lime.
At	620	—Light, mottled lime.
At	630	—Dark gray lime.
At	638	—White quartzite.
At	644	—Dark, dove-colored lime.

Depth.	
At 650	—Soft, brownish-white, shaly lime over brown lime.
At 656	—Gray lime.
At 662	—Dark gray lime.
At 680	—Brownish-gray lime.
At 686	—Dark and light gray limes.
At 692	—Light gray lime.
At 700	—White lime.
At 712	—Dark gray lime.
At 722	—Brownish white lime.
At 735	—Dark gray, crystalline lime.
At 755 to 807	—Dark gray lime.
At 813	—Light and dark gray limes—Base of St. Louis and top of Keokuk.
At 816	—Black shaly lime.
At 835	—Black lime—white fossils.
At 840	—Black lime.
At 865	—White, fossiliferous lime.
At 890	—Mottled, gray lime and white lime.
At 900	—Dove-colored lime.
At 915	—Very light lime.—(813 to 1,253—Full section of Keokuk.)
At 1,030	—Light gray lime.
At 1,045	—Gray, crystalline lime.
At 1,050 to 1,100	—Light gray lime.
At 1,124	—Gray, sandy lime.
At 1,130	—Gray lime.
At 1,138	—White and dark gray limes.
At 1,150	—Very dark lime.
At 1,155 to 1,185	—Impure, black lime.
At 1,230	—Fine-grained, black, limy sandstone—Base of Keokuk.
At 1,253 to 1,315	—Black shale....Devonian

(This well did not go quite deep enough to test the Ohio County sand.)

CALDWELL COUNTY.

Eugene Young well—Three miles northeast of Fredonia,—

	Thickness.	Depth.
Soil	15	15
Slate and lime	10	25
Hard, black lime	25	50
Slate	25	75
Soft, gray sand	10	85
Slate and shaly, white sand	40	125

	Thickness.	Depth.
Soft, white sand	50	175
Red soapstone	10	185
Sand	55	240
Slate	60	300
Lime (black sulphur water)	25	325
Slate and soapstone	75	400
Slate and hard, shaly lime	40	440
Hard, light lime	50	490
Sand and slate	30	520
White quartzite	55	575
Sand	25	600
Lime	35	635
Slate	15	650
Hard lime	15	665
Pink rock—slate or soapstone	15	680
Bluish lime	220	900
Hard, sharp lime	90	990
Hard sand	10	1,000
Lime	10	1,010
Sand	10	1,020
Lime	15	1,035
Sand	265	1,300
Blue and black, hard limes	1,044	2,344
Flinty in lower beds.		

Well began in the Chester series. At 740 salt water was struck. The Black Shale does not show in the record.

CARROLL COUNTY.

Well at Carrollton—

Depth.		
From 0 to 96	—Alluvium.	
At 96	—Light, crystalline lime	Trenton limestones.
At 180	—Light and dark gray limes	
At 200	—Light, crystalline lime	
At 230	—Light, brown, conglomerate lime	
At 242	—Light, magnesian lime	
At 260	—Gray, magnesian lime	
At 280	—Fine-grained, gray lime	
At 285	—Fine, light, magnesian lime	
At 335	—Light, crystalline and gray fossil lime	
At 420	—Birdseye limestone.	

Depth.			
At 430	—Birdseye limestone	Top of Tyrone at 400.	
At 475	—Birdseye lime and some magnesian lime.		
At 495	—Light, magnesian lime.		
At 500, 520, 600, 675, 700 and 800	—Chazy limestone.		
At 1,000	—A greenish-black slate and top of Calciferous.		
At 1,095	—Calciferous		Calciferous.
At 1,148	—Calciferous ("Blue Lick" water)		

CARTER COUNTY.

No. 1—Guffey Well, near Grayson—

	Thickness.	Depth.	
Quicksand	28	28	Pottsville.
Black slate	30	58	
Sandstone	12	70	
Black slate	10	80	
Limestone	20	100	St. Louis
Dark green, sandy shale	230	330	
Light gray slate and sand shells	270	600	
Sandstone and shale	50	650	
Sandstone, slate and shells	85	735	
Black slate	22	757	Berea shale.
Berea sand (oil and gas)	112	869	Berea grit.
Gray slate	25	894	Bedford.
Red slate	6	900	
Black slate	116	1,016	Devonian shales.
White slate	5	1,021	
Black slate	169	1,190	
White slate	20	1,210	
Black slate	95	1,305	
White slate	118	1,423	
Limestone (oil and gas)	2	1,425	Corniferous.
Limestone, fine and coarse	55	1,480	

(Strong flow of salt water at 1,475.)

No. 2—Well at Denton—

	Thickness.	Depth.	
Soil	20	20	Coal measures and Conglomerate.
White, sandy shale	60	80	
White slate	20	100	
Brown sand	58	158	
Coal	2	160	
White lime and sand	110	270	
Shale and fire-clay	46	316	
Lime	30	346	
White slate	10	356	
White lime	9	365	
Coal	....	.....	
White sand	60	425	
Black slate	10	435	
White lime	15	450	St. Louis.
White sand	60	510	Waverly.
White slate	14	524	
White sand	46	570	
Limestone	109	679	
White shale	443	1,122	
White lime	125	1,247	
White slate	28	1,275	
Brown shale	447	1,722	Devonian shale.
Lime and fire-clay (oil)	40	1,762	
White slate	68	1,830	
White lime	80	1,910	
White slate	10	1,920	
White lime	95	2,015	

CLINTON COUNTY.

Well on Sidwell Farm, Cartwright District—

Waverly	0	350
Devonian Black Shale	350	380
Limestones	380	1,150

Gas and oil at 649.

CUMBERLAND COUNTY.

Well at Cloyd's Landing—

Soil	42	42
Blue lime	160	202
Black lime	30	232
Gray lime	40	272
Brown lime	30	302
Gray lime	75	377

	Thickness.	Depth.
Brown lime	70	447
Black lime (gas at 445)	48	495
Brown lime	7	502
Green pencil cave	2	504
Hard, brown lime	5	509
Soft, brown lime	30	539
Brown lime and sand	131	670
Soft, brown lime	15	685
Hard, brown lime	85	770
Soft, brown lime	75	845
Gray lime	18	863
Dark brown lime	20	883
Brown lime	57	940
Brown lime	40	980
Light gray lime	60	1,040
Brown lime	40	1,080
Black lime	80	1,160
Light brown lime	60	1,220
Gray lime	60	1,280
Brown lime	20	1,300
White lime	20	1,320
Brown lime	30	1,350
White lime	30	1,380
Gray lime	80	1,460

ESTILL COUNTY.

Well near Irvine—

Black shale	0	125	Devonian.
Limestone (oil sand)	25	150	Corniferous.
Blue and gray shales	145	295	
Gray limestone	30	325	
Gray shale	10	335	
Gray limestone	8	343	
Red limestone	10	353	
Gray limestone	17	370	
Brown limestone	40	410	
Gray limestone	839	1,249	
Greenish, shaly sandstone	10	1,259	
Dove-colored limestone	425	1,684	
Hard, gray limestone	145	1,829	
White limy sandstone	65	1,894	

FLOYD COUNTY.

Well at mouth of Salt Lick Creek—

Soil	34	34	
Black slate	10	44	
White sand	50	94	
Black slate	30	124	
Gray sand	100	224	
Light slate	76	300	
White sand	20	320	
Light slate	130	450	
White sand (oil, gas, salt water)	212	662	Beaver sand.
Black slate	30	692	
White sand (salt water)	108	800	Horton sand.
Coal	1.5	801	
Black sand	12.5	814	
Dark sand	30	844	
Black slate	59	903	
White and gray sand (gas and oil)	93	996	Pike sand.
Very black slate	60	1,056	
White and gray sand (salt water)	50	1,106	Salt sand.
Black slate	11	1,117	Base of Pottsville.
Dark lime	13	1,130	
Slate and lime shells	35	1,165	
Lime and slate	8	1,173	
Slate and lime shells	19	1,192	
Lime (oil and gas at 1,269)	138	1,330	
Red shale	95	1,425	
Slate and sand shells	181	1,606	
Black slate	44	1,650	
Light-blue slate and sand shells	130	1,780	
Very black slate	200	1,980	Devonian shales.
Slaty lime (gas)	2	1,982	Devonian shales.
Black slate (gas)	225	2,207	Devonian shales.
Soft, light slate	33	2,240	Devonian shales.

HANCOCK COUNTY.

For record of typical well near Hawesville, see Report on Tell City Quadrangle, this volume.

HART COUNTY.

Well on Dog Creek—

	Thickness.	Depth.	
Drift	9.5	9.5	Chester.
Hard, gray lime	55.5	65	
Bluish fire clay	4	69	
Dark gray lime	1	70	
Dark gray sand	20	90	
Coal	.5		
Bluish fire clay	11.5	102	
Hard, bluish-gray lime	28	130	
Hard, gray sand	7	137	
Coal	.5		
Lead-colored fire clay	9.5	147	
Gray, bastard sand	12	159	
Lead-colored fire clay	27	186	
Dark gray lime	14	200	
Light gray lime	5	205	
Coal	.5		
Lead-colored fire clay	3.5	209	
Light gray lime	10	219	
Dark fire clay	3	222	
Light gray lime	33	255	St. Genevieve and St. Louis.
Dark gray lime	75	330	
Light gray lime	35	365	
Dark gray lime	35	400	
Dark gray lime	13	413	
Light gray lime	57	470	
Brownish-gray lime	35	505	
Hard, gray sand	20	525	
Gray lime	50	575	
Dark gray lime	25	600	
Light gray lime	22	622	
Dark, bastard lime	178	800	
			(Division uncertain)
Dark, gray lime—black streaks	15	815	Keokuk and Waverly.
Bastard lime and sand	25	840	
Black, bastard lime	80	920	
Hard, dark gray sand	30	950	
Very dark, bastard lime	50	1,000	
Black, bastard slate	40	1,040	
Black, bastard lime	173	1,213	
Black shale	105	1,318	Devonian shale.
Hard, gray sand	10	1,328	Corniferous.
Black slate	6	1,334	

	Thickness.	Depth.	
Gray, hard sand	2	1,336	
Light gray sand	23	1,359	Barren County sand.
Dark gray sand	6	1,365	
Hard, bastard sand	6	1,371	
Hard, bastard lime	25	1,396	
Hard, gray sand	24	1,420	
Reddish gray sand	10	1,430	
Light, open sand (strong salt water)	17	1,447	

JOHNSON COUNTY.

Well on Tom's Creek—Van Hoose Farm—

	Thickness.	Depth.	
Black slate	185	185	
Brown sand	20	205	
White slate	30	235	
Gray sand	130	365	
White slate	42	407	
White sand	265	672	Base of Pottsville.
White lime	150	822	Mountain lime.
Dark sand	100	922	
White slate	244	1,166	
Gray sand	75	1,241	
Hard, slate shell	56	1,297	
Black shale	500	1,797	Devonian shale.
White slate	143	1,940	
Black shale	13	1,953	
Gray lime	15	1,968	Corniferous.
Gray lime to bottom		2,006	

KNOTT COUNTY.

Ball's Fork, five and one-half miles from Hindman—

	Thickness.	Depth.
Soil	10	10
Light slate	10	20
Sand	4	24
Coal	5.5	29
Dark slate	5	34
Gray sand	32	66
Coal	3.5	69
Light slate	15	84
Sand	16	100
Slate	20	120

	Thickness.	Depth.	
Gray sand	27	147	
Coal	3.5	150	
Black slate	16	166	
White sand	44	210	
Coal	4.5	214	
Black slate	34	248	
Gray sand	15	263	
Light slate	60	323	
White sand	12	335	
Light slate	30	365	
Coal	4.5	369	
Dark slate	70	439	
Gray sand	12	451	
Light slate	54	505	
Sand	20	525	
Black slate	128	653	
White sand	37	690	
Dark slate	62	752	
White sand	25	777	
Shelly slate	188	965	
White sand (gas and salt water)	215	1,180	Beaver sand.
Black slate	20	1,200	
White and dark sands	126	1,326	Horton sand.
Dark slate (salt water)	12	1,338	
White sand (salt water)	312	1,650	Pike and Salt sands.

KNOX COUNTY.

No. 1—Well at Barbourville—

	Thickness.	Depth.	
Dark shale	90	90	
Fine, gray sand	20	110	Wages sand.
Dark, gray sand	90	200	Wages sand.
Gray sand	15	215	Wages sand.
Dark shale	25	240	
Sand and black shale	25	265	
Gray sand	10	275	Jones sand.
Fine, gray sand	65	340	Jones sand.
Black shale and sand	78	418	
Fine, gray sand	42	460	
Dark shale and sand	75	535	
Fine, gray sand	5	540	Epperson sand.
Fine, brown sand	10	550	Epperson sand.
Brownish sand (oil)	5.5	555	Epperson sand.
Brown sand (salt water)	25	580	Epperson sand.

No. 2—Madeline Gray Farm—Gray's Station—

	Thickness.	Depth.	
Soil	20	20	
Shale	80	100	
White sand	215	315	
Black shale	30	345	
Sand	150	495	
Shale	8	503	
Sand	129	632	
Coal	3	635	
Sand	275	910	Base of Pottsville.
Red sahle	40	950	Chester.
Black shale	20	970	Chester.
Sand	10	980	Chester.
Red shale	25	1,005	Chester.
Hard, black shale	24	1,029	Chester.
Red shale	41	1,070	Chester.
Hard lime	10	1,080	Chester.
Black shale	28	1,108	Chester.
Gray lime	70	1,178	St. Louis.
Soft shale	5	1,183	St. Louis.
White, hard lime	90	1,273	St. Louis.
Soft, black lime	4	1,277	St. Louis.
Hard, gray lime	24	1,301	St. Louis.
Blue lime	20	1,321	St. Louis.
Gray lime	15	1,336	St. Louis.
White lime	14	1,350	St. Louis.
Dark gray lime	19	1,369	St. Louis.
Sand	7	1,376	Big Injun.
Coarse, green sand	20	1,396	Big Injun.
Black shale	24	1,420	Waverly.
White shale	5	1,425	Waverly.
Dark shale	15	1,440	Waverly.
Dark sand	5	1,445	Waverly.
Dark shale	10	1,455	Waverly.
Pale-green sand and shale	20	1,475	Waverly.
Shale and sand	10	1,485	Waverly.
Dark shale and sand	15	1,500	Waverly.
Shale and sand	40	1,540	Waverly.
Sand, lime and shale	32	1,572	Waverly.
Light sand	15	1,587	Waverly.
Light shale	13	1,600	Waverly.
Sand and shale	15	1,615	Waverly.
Lime and shale	50	1,665	Waverly.

	Thickness.	Depth.	
Black shale	120	1,785	Devonian shales.
White shale	5	1,790	
Sand	5	1,795	
Light shale	25	1,820	
Lime	2	1,822	
Light shale	30	1,852	
Shale and sand	48	1,900	
Lime	35	1,935	
Light shale	20	1,955	
Sand	7	1,962	
Sand and shale	12	1,974	

LAWRENCE COUNTY.

No. 1—Well at Mouth of Big Blaine—

	Thickness.	Depth.	
Soil	20	20	
Yellow sand	15	35	
White sand	45	80	
Gray shale and red rock	35	115	
Gray sand	25	140	
White sand	170	310	
Brown shale	45	355	
Gray sand	60	415	
Black slate	15	430	
White sand	110	540	
Gray shale	50	590	
Black shale	20	610	
Gray sand (gas and salt water)	125	735	
Black slate	30	765	
White sand (gas and salt water)	95	860	
Black shale	10	870	
White conglomerate sand (Mountain lime missing)	365	1,235	Base of Pottsville.
Green sand	5	1,240	
Gray, slate shells	410	1,650	
Black slate (Berea shale)	10	1,660	
White sand (Berea grit), gas	2	1,662	
Sand, lime and shells	15	1,677	
Sand and shale	65	1,742	
Black slate	5	1,747	Devonian shales.
Sand and shells	5	1,752	
Bluish-black slate	648	2,400	
Light gray slate	192	2,592	
Limestone	5	2,597	Corniferous.

No. 2—Well at Busseyville—

	Thickness.	Depth.
Soil	0	39
Lime	39	50
Slate	50	130
Sand	130	185
Slate	185	410
Sand	410	430
Slate	430	475
Sand	475	635
Slate	635	640
Sand	640	870
Slate	870	880
Little lime	880	900
Big lime	900	1,050
Slate	1,050	1,060
Shale	1,060	1,080
Sand	1,080	1,502
Brown shale	1,502	1,517
Berea sand (oil)	1,517	1,537

MAGOFFIN COUNTY.

Well near Hendricks P. O.—

	Thickness.	Depth.	
Drift	40	40	
Black slate	260	300	
Gray sand	85	385	
Black slate	75	460	
Shelly slate	25	485	
White lime	40	525	
White sand	190	715	Base of Pottsville.
Gray lime	210	925	St. Louis L. S.
Black slate	245	1,170	Waverly.
Shelly sand	20	1,190	
Bastard, gray sand	100	1,290	
Shelly slate	100	1,390	
Black slate	400	1,790	Devonian shale.
Lime	290	2,080	
Bastard, gray sand	50	2,130	
Slate and red shale	77	3,207	

MARTIN COUNTY.

Sam Munsey Farm—Big Branch of Wolf Creek—

	Thickness.	Depth.	
Drift	56	56	
Light slate	24	80	
Gray sand	35	115	
Light slate	23	138	
Dark gray sand	37	175	
Dark slate	18	193	
Coal	2.5	195	
Dark slate	15	210	
Coal	4	214	
Sandy slate	8	222	
Shelly slate	240	462	
Light sand	16	478	
Shelly slate	167	645	
Gray sand	45	690	
Dark slate	8	698	
Gray sand	87	785	
White sand	48	833	
Coal	3.5	836	
Dark gray sand	29	865	
Dark gray slate	28	893	
White sand (black oil)	79	972	
			Base of Pottsville.
Shelly slate	38	1,010	
Red shale	15	1,025	
Black sand	14	1,039	
Black slate	6	1,045	
Red shale	10	1,055	
Black slate	18	1,073	Mauch Chunk.
Red shale	78	1,151	
Dark gray sand (gas)	12	1,163	
Dark gray slate	30	1,193	
Gray sand	36	1,229	
Black slate	6	1,235	
Dark lime	20	1,255	
White lime	155	1,410	St. Louis.
Dark gray sand	10	1,420	
Sandy slate	16	1,436	
Black slate	6	1,442	Big Injun Group-
Dark sand	15	1,457	
Dark slate	78	1,535	
Black slate	4	1,539	

Burning Well—across the river from the Warfield Well—

	Thickness.	Depth.	
Soil	26	26	
Light slate	46	72	
White sand	44	116	
Coal	5	121	
Light slate	80	201	
White sand	18	219	
Black slate	20	239	
White sand	20	259	
Light, shelly slate	57	316	
Black slate	50	366	
Light, shelly slate	75	441	
White sand	130	571	Gas, oil and salt water
Light slate	15	586	
White sand	46	632	Gas and salt water.
White slate	20	652	
White sand	112	764	Gas and salt water. Base of Pottsville.
Shelly slate	55	819	
Red shale	30	849	
Light slate	5	854	
Red shale	25	879	
Light slate	15	894	
Hard sand	18	912	
Red shale	10	922	
White sand	24	946	
Red shale	4	950	Mauch Chunk.
Light slate	22	972	
Lime	4	976	
Slate	10	986	
Red shale	2	988	
Shelly slate	20	1,008	
Dark sand	30	1,038	
Lime	162	1,200	St. Louis—Gas in the limestone at 1,098.
Slate and sand shells	138	1,338	Big Injun group—Gas in sand shells at 1,202 and 1,315.

MENIFEE COUNTY.

J. R. Lyon Farm on head of Blackwater Creek—

	Thickness.	Depth.	
Soil	0	17	
Sand ..	17	30	
Black shale ..	30	80	
Coal	80	81	
Shale	81	100	
Sandstone	100	185	
Dark shale ..	185	197	
White sandstone ..	197	201	
Dark slate ..	201	207	
White sandstone ..	207	217	
Gray shale ..	217	295	Base of Pottsville.
Limestone	295	342	St. Louis L. S.
Light shale ..	342	375	
Light sandstone ..	375	460	
Gray shale ..	460	485	
Gray sandstone ..	485	765	
Gray shale ..	765	840	Waverly.
Gray limestone ..	840	848	
Gray shale ..	848	880	
Gray sandstone ..	880	900	
Black shale ..	900	1,110	
Blue shale ..	1,110	1,120	
Brown shale ..	1,120	1,124	Bedford and Devonian Shales.
Blue shale ..	1,124	1,130	
Dark shale ..	1,130	1,134	
			Top of Ragland sand.
Limestone	1,134	1,236	
Blue shale ..	1,236	1,425	
Limestone	1,425	2,165	
Limestone and shale	2,165	2,390	
White limestone ..	2,390	2,425	
Dove-colored limestones (Green shale at base)	2,425	3,120	
White, limy sandstone (Gas)	3,120	3,131	Top of Tyrone.

MORGAN COUNTY.

Caney Creek Well—

	Thickness.	Depth.	
Drift	15	15	
Shale	10	25	
Sand (gas at 75, 125 and 200)	235	260	
Pebble rock ..	5	265	

	Thickness.	Depth.	
Sand	40	305	
Pebble rock ..	13	318	
Dark shale and sand	12	330	
Dark shale ..	10	340	
Shaly sand ..	5	345	
Sand	35	380	
Pebble rock ..	30	410	
Coal	1	411	
Dark shale ..	42	453	
			Base of Pottsville.
Limestone	15	468	
Limy shale ..	5	473	St. Louis L. S.
Limestone	52	525	
Sand and shale (oil at 625)	235	760	
Limy shale ..	5	765	
Red sand	1	766	
Dark-blue, sandy shale (gas at 850, 865 and 920)	154	920	
Hard, fine sand	5	925	
Shale	5	930	
Fine sand (salt water)	2	932	
Coarse sand ..	8	940	Waverly and Bere
Dark shale ..	33	973	
Sand	2	975	
Dark shale ..	37	1,012	
Shale and sand	16	1,028	
Very black shale (Berea sh.)	7	1,035	
Sand (oil at 1,052) (Berea Grit)	24	1,059	
Dark shale and sand	28	1,087	
Black shale (gas and oil at 1,145)	283	1,370	(Devonian black shale with a little Corniferous L. S. at the base.)
Soft, blue shale	30	1,400	
Sandy lime (Morgan County sand at 1,408) (Oil and gas at 1,408) (Salt water at 1,416) ..	50	1,450	
Lime	65	1,515	
Lime and sand (Caney sand) .. (Oil and gas at 1,525).	15	1,530	
Lime	87	1,617	
Sand	10	1,627	
Blue and dark, sandy lime	25	1,652	

	Thickness.	Depth.
Red shale	133	1,785
Blue shale	79	1,864
Hard lime	5	1,869
Blue, clay shale	22	1,891
Hard, gray lime	9	1,900
Red shale	6	1,906
Blue shale and lime	12	1,918
Red shale	4	1,922
Dark-blue shale	20	1,942
Dark-gray lime	25	1,967
Sand	7	1,974
Blue, sandy and limy shale	4	1,978
Hard, sandy lime	7	1,985
Sandy and limy shale	4	1,989
Dark-blue, lime shale	32	2,021

MUHLENBERG COUNTY.

Well one mile S. E. of South Carrollton at Muhlenberg and Ohio County line—

	Thickness.	Depth.
Drift	0	115
Coal	5	120
Black slate	10	130
Shell	3	133
White slate	27	160
Sand	40	200
Black slate	35	235
Coal	5	240
Black slate	78	318
Lime	5	323
Dark slate	20	343
Coal	7	350
Dark slate	74	424
Sand	32	456
Slate	64	520
Lime	10	530
Red rock	3	533
Slate	67	600
Sand	65	665
White slate	50	715
Sand	30	745
Slate	85	830
Sand	20	850
Slate	85	935
Sand	10	945

	Thickness.	Depth.
Slate and shell	75	1,020
Sand	20	1,040
Slate	55	1,095
Sand	10	1,105
Slate	195	1,300
Sand	105	1,405
Lime	15	1,420
Slate	145	1,565
Slate and shell	71	1,636
Sand (salt water)	50	1,686
Lime	35	1,721
Slate	10	1,731
Lime	20	1,751
Slate	19	1,770
Red rock	25	1,795
Sand and red rock	30	1,825
Slate and lime shells	40	1,865
Sand	20	1,885
Lime and shells	62	1,947
Red rock	8	1,955
Lime	62	2,017
Sand	38	2,055
Lime	35	2,090
Slate	20	2,110
Sand	12	2,122

PIKE COUNTY.

Schomberg Well—Caney Fork of John's Creek—

	Thickness.	Depth.	
Drift	42	42	
Slate	30	72	
Gray sand	32	104	
Slate	216	320	
Gray sand	35	355	
Slate	66	421	
Sand	57	478	
Slate	13	491	
Lime	8	499	
Sand	9	508	
Lime	5	513	
Sand	8	521	
Slate	20	541	
Sand	22	563	
Slate	12	575	
Sand	65	640	Beaver sand.

	Thickness.	Depth.	
Slate	15	655	
White sand	230	885	Horton sand.
Slate	30	915	
Sand	421	1,336	Pike and Salt sands. Base of Pottsville.
Red rock	18	1,354	Mauch Chunk.
Slate	5	1,359	
Sand	77	1,436	
Red shale	8	1,444	
Red shale and slate	56	1,500	
Gray and white lime	240	1,740	St. Louis, with oil and gas at 1,615.
Slate	55	1,795	Big Injun group.
Reddish sand	80	1,875	
Slate	260	2,135	Pocono slate.

POWELL COUNTY.

James Welsh Farm—

	Thickness.	Depth.	
Clay	17	17	
Black shale	8	25	Devonian shale.
Hard, brown limestone	24	49	Corniferous.
Yellow soapstone	65	114	
Hard, blue lime (oil at 133)	19	133	
Soapstone	14	147	
Blue lime (gas at 310)	509	656	
White lime	25	681	
Brown shale	19	700	
White lime	9	709	
Blue lime	66	775	
Brown lime	20	795	
Blue lime	90	885	
Bottom at		951	

PULASKI COUNTY.

Well at Eubank—

Depth.

At 80—Very light, fine-grained, soft lime..............St. Louis.

At 120—Dark shale ....(Waverly 50 to 360).

At 160—Dark shale ....

At 360 to 400—Black shale ....Devonian

Depth.

At 400—Dark gray, crystalline lime ....Corniferous.

At 510—Gray lime.

At 540—Dark, greenish-gray, shaly lime.

At 675—Light shales and lime.

At 695—Mottled, red lime.

At 700—Mottled, red lime.

At 728—Mottled, gray and white lime.

At 800—Small flow of gas.

At 800—Gray lime.

At 825—Very dark lime.

At 870—Dark gray lime.

At 928—Very dark lime.

At 986—Mixed, light and dark gray lime.

At 1,045—Light lime.

At 1,100—Mottled, gray lime.

At 1,125—Mixed, gray and white lime........Top of Tyrone about 1,200.

At 1,230—Very dark dove-colored lime........Tyrone and Camp Nelson to bottom.

At 1,235—Light dove-colored lime.

At 1,240—Dark dove-colored lime.

At 1,245—Hard, light-green sandstone, with dark specks.

At 1,250—Mottled, dove-colored lime.

At 1,330—Dove-colored lime.

At 1,400—Dove-colored lime.

At 1,520—Dove-colored lime.

Bottom at 1,520.

ROCKCASTLE COUNTY.

Well near Mullen's Station—

	Thickness.	Depth.	
Conglomerate S. S.	100	100	Conglomerate.
St. Louis limestone	100	200	St. Louis.
Fine sand	150	350	Waverly.
Shale	200	550	
Black shale	150	700	Devonian shale.
Heavy, sandy limestone	20	720	Corniferous.
Shale	30	750	
Shaly, blue limestone	300	1,050	
Sandy limestone	90	1,140	
Thin, crystalline limestones	200	1,340	
Gray, crystalline limestones	150	1,490	
White, lithographic limestones		.....	

The upper part of the 150 feet of sand shown under the St. Louis L. S., belongs to the "Big Injun."

ROWAN COUNTY.

Well on the Butts' Farm—

	Thickness.	Depth.	
Brown quicksand	25	25	Waverly.
Hard, white sand	50	75	
Open, white sand	75	150	
White shale	80	230	
White sand	110	340	
White shale	110	450	
Brown shale	40	490	Bedford and Devonian shales.
White sand	10	500	
Brown shale	190	690	
White fire-clay	5	695	
Ragland sand (salt water)	100	795	Corniferous.
Red rock	50	845	
White shale	55	900	
Lime shells	200	1,100	
Hard lime	460	1,560	

RUSSELL COUNTY.

Well on A. W. McCloud Farm—

	Thickness.	Depth.	
Dark lime	665	665	
Light sand	8.5	673.5	
Gray lime	166.5	840	
White lime	58	898	
Pencil cave	1.5	899.5	
Gray lime	600.5	1,500	
Gray lime	92	1,592	
Light sand (salt water)	35	1,627	Probably top of Calciferous.

Gas and salt water at 40 feet.
Salt water at 1,620 to 1,627.
Well starts just below the base of the Black Shale.

WARREN COUNTY.

Well at Bowling Green—

Depth.
At 0—White oolite.
At 18, 25 and 30—Gray lime.
At 36—Light gray oolite.
At 42—Fine-grained, white lime.

Depth.
At 46 to 70—Very fine-grained, white, siliceous lime.
At 77—Fine-grained, slightly oolitic, gray lime.
At 90—Gray lime.
At 94—Light gray and white limes mixed.
At 98—Light gray lime.
At 100—White lime.
At 106—Light brown lime.
At 112—Light, mottled lime.
At 117—Gray lime and white calcite.
At 130—Fine-grained, gray lime.
At 135—Gray lime.
At 140—Gray, crystalline lime.
At 144—Fine-grained, light gray lime.
At 156 to 170—Light gray lime; sulphur water.
At 183—Dark gray lime.
At 189—Gray lime shale.
At 195—Dark gray lime.
At 205—Very dark, gray lime.
At 210 to 230—Gray lime.
At 235—Black lime and light gray lime.
At 240—Dark gray lime.
At 253—Light brown, sandy lime.
At 255 and 260—Gray lime.
At 265—Very dark lime.
At 270—Brown lime.
At 278 and 284—Dark gray lime.
At 287—Brown lime.
At 288 and 290—Gray lime.
At 294 and 300—Light gray lime.
(Probable base of St. Louis and top of Keokuk).
At 305—Dark gray and white lime mixed.
At 310—Dark gray lime.
At 315—Light gray lime and white flint.
At 325—Very dark lime.
At 330—Very dark and white lime, mixed.
At 340—Gray lime and sand.
At 348—Gray lime.
At 350—Gray, fossiliferous lime.
At 358 to 380—Gray lime. Oil at 363 feet.
At 400 to 420—Hard, gray, lime shale.
At 425—Dark gray lime.
At 430—Gray and white limes, mixed.
At 435—Gray lime and white, lime shale.
At 440 and 445—Hard, dark, lime and shale.
At 450—Gray lime and shale.
At 455—Gray and white limes, mixed.

Depth.
At 460—Hard, gray, lime shale and white sand.
At 465—Gray lime and limy shale.
At 485—Dark gray lime and white, lime shale
At 490 and 495—Hard, dark, limy shale.
At 501—Hard, dark, lime shale and white sand.
At 506—Dark, gray lime and hard, lime shale.
At 510—Light gray lime.
At 515—Gray lime and lime shale.
At 520 to 530—Hard, gray, lime shales.
At 535 to 665—Very dark, hard, impure limestones and lime shales.
At 670 to 680—Black shale....................Top of Devonian shale at 670.
At 685—Very dark, lime shale.
At 690—Brown, impure lime.
At 695 and 700—Very dark, impure lime.
At 705—Mixed gray and white lime.
At 708 to 760—Black shale....................Base of Devonian shale at 760.
At 765 and 770—Dark brown, sandy lime.
At 775—Mixed black and white limes and gray, porous sandy lime.
At 780—Fine-grained, white lime.
At 785—Fine-grained, yellow lime.
At 790—Fine-grained, yellowish-brown lime.
At 795 to 875—Fine-grained, white lime.
At 880—Gray and white lime, mixed.
At 885 and 890—Gray lime.
At 895 and 900—Very light lime.
At 910—Gray lime.
At 915 to 935—Light lime.
At 940—Mottled, red lime.
At 945 and 950—Gray lime.
At 960—Gray lime.
At 965 and 975—Gray and white limes, mixed.
At 980—Light lime.
At 985—Gray lime and shale.
At 990—Mottled, gray and white lime.
At 995 to 1,010—Gray lime.
At 1,015—Dark gray lime.
At 1,020 and 1,025—Light lime.
At 1,030 to 1,095—Gray limes and shales.
At 1,100 to 1,130—Light lime.
At 1,135—Gray lime.
At 1,140—Gray and white limes, mixed.
At 1,145—Fine-grained, light lime.
At 1,150—Light, siliceous lime.
At 1,155 and 1,160—Light lime.
At 1,165—Light and dark gray limes, mixed.
At 1,170 and 1,175—Gray lime.

Depth.
At 1,180 and 1,185—Gray lime and dark shale.
At 1,190—White lime.
At 1,195 and 1,200—Gray lime.
At 1,205—Gray lime and shale.
At 1,215 to 1,230—Gray, crystalline lime.
At 1,235—Fine-grained, gray lime.
At 1,240—Gray lime.
At 1,245—Gray and white limes, mixed.
At 1,250 to 1,260—Gray lime.
At 1,265 to 1,290—Dark gray lime.
At 1,295 to 1,305—Gray lime.
At 1,310—Hard, dark gray, lime shale and white lime, mixed.
At 1,315 and 1,320—Gray and white lime, mixed.
At 1,325—Gray lime.
At 1,330 to 1,375—Dark gray lime.
At 1,380 to 1,395—Very dark gray lime.
At 1,400 and 1,405—Gray lime
At 1,410—Dark gray lime.
At 1,415—Dark gray lime and black shale.
At 1,420—Dark gray and white limes, mixed.
At 1,425—Hard, dark, lime shale.
At 1,430 to 1,440—Gray lime.
At 1,445—Black and white limes, mixed.
At 1,455 and 1,460—Gray and white limes, mixed.
At 1,465—Brown lime.
At 1,470—Dark gray lime.
At 1,475—Very dark gray lime.
At 1,480—Gray lime.
At 1,490—Very dark gray lime.
At 1,495 to 1,520—Gray and white limes mixed.
At 1,560 and 1,590—Dark gray lime.
At 1,595—Gray lime.
At 1,600 and 1,605—Light lime.
At 1,610 to 1,630—Very dark lime.
At 1,635 to 1,660—Light and dark limes, mixed............Top of Tyrone.
At 1,660 to 1,670—Light, dove-colored lime.
At 1,685 to 1,690—Light lime.
At 1,695—Light, mottled lime.
At 1,700—Light lime.
At 1,705 to 1,715—Dark gray and light limes.
At 1,720—Very dark lime.
At 1,725 and 1,730—Very dark and light limes, mixed.
At 1,735—Black lime.
At 1,740 and 1,745—Very dark, brownish lime.
At 1,750—Black lime.
At 1,755—Very dark, brown lime.

Depth.
At 1,760—Gray lime.
At 1,765—Dark gray lime.
At 1,770—Very dark lime.
At 1,775—Gray lime.
At 1,780—Very dark lime.

The well starts in the St. Louis Group and goes down to about the top of the Camp Nelson. The line between St. Louis and Keokuk cannot be drawn with accuracy. The base of the St. Louis is about at 230. The top of the Black Shale is at 670 and its base at 760, giving a thickness of about 430 for Keokuk and 90 for the Black Shale. The Black Shale is divided in two parts by a bed of dark, impure lime and shales. The top of the Trenton Group can be put approximately at 1,415 and the top of the Tyrone at 1,660.

WEBSTER COUNTY.

Well at Sebree—

	Thickness.
Clay and sand	52
Soft sandstone	6
Soapstone and clay	66
Sandrock	8
Soft sandstone	50
Slate	33
Coal	1.5
Fire clay	5
Limestone	8
Sandy shale	27
Slate	6
Coal	3.5
Soapstone and shale	40
Sandrock	29
Sandy shale	75
Soapstone	15
Sandstone	15
Soapstone	20
Sandy shale	5
Black shale	28
Hard lime	2
Coal	3
Soapstone	24
Sandrock	6
Soapstone	2

	Thickness.	
Sandrock with soft stratas	62	Oil, salt water and gas
Soapstone	3	
	695	

The "soapstone" of this record should read "shale."

WHITLEY COUNTY.

Pine Knot Well—

	Thickness.	Depth.
Sand	55	55
Coal	.5	
Sand	28	83
Slate	10	93
Sand	112	205
Slate	10	215
Sand	95	310
Slate	10	320
Slate and sand	10	330
Sand	5	335
Slate	5	340
Sand	5	345
Slate	25	370
Sand	50	420
Slate	20	440
Sand	61	501
Coal	3.5	504.5
Slate	56	560
Slate and sand	10	570
Sand	10	580
Slate	32	612
Sand	23	635
Slate	7	642
Sand	13	655
Slate	20	675
Sand	10	685
Slate	25	710
Sand and slate	12	722
Slate	19	741
Coal	6	747
Slate and sand	13	760
Slate	7	767
Sand	8	775
Slate and sand	10	785
Sand	15	800
Black slate	7	807 Base of Pottsville.

	Thickness.	Depth.	
Red sand	11	818	
Dark slate	3	821	
Sand	6	827	
Dark lime	20	847	
Brown, limy marl	8	855	
Dark blue slate	7	862	Chester Group.
Reddish lime	4	866	
Light brown, limy marl	10	876	
Dark blue slate	4	880	
Light brown, limy marl	5	885	
Gray, limy marl and blue slate	15	900	
Dark lime	55	955	
Light lime with oolite	20	975	
Dove-colored lime	5	980	
Dark lime and shale	5	985	
Light colored lime	20	1,005	
Dark lime with streaks of shale	25	1,030	
Dark shale and lime	5	1,035	St. Genevieve and St. Louis Group.
Dark dove-colored lime	20	1,055	
White and brown limes with layers of black slate	20	1,075	
Light brown lime	5	1,080	
Gray limy shale	5	1,085	
Brown lime	20	1,105	
Light dove-colored and white limes	190	1,295	
Light brown lime	5	1,300	
Light green, sandy lime	5	1,305	
Very light brown, sandy lime	15	1,320	
Very dark lime and slate	10	1,330	Oil show.
Gray lime	20	1,350	
Dark, limy sand	10	1,360	
Brownish, impure lime	10	1,370	
Dark, limy slate	10	1,380	
Very dark lime	30	1,410	
Dark, limy slate	5	1,415	
Dark lime	5	1,420	Keokuk-Waverly Group.
Dark slate	8	1,428	
White and gray limes	12	1,440	
Light lime	30	1,470	
Gray and white limes	20	1,490	
Hard, dark and white sand	5	1,495	
Alternating, gray and white sand and sandy limestones	65	1,560	
Soft, limy shale and hard sand shell	5	1,565	
Gray, sandy lime	5	1,570	
Dark, limy shale	30	1,600	

	Thickness.	Depth.	
Black shale	15	1,615	
Dark brown shale	15	1,630	
Black shale	5	1,635	Devonian shales.
Dark brown shale	5	1,640	
Black shale	5	1,645	
Dark, greenish shales	30	1,675	Niagaran.
Greenish-gray shales with streaks of lime and reddish shale	45	1,720	
(Red iron ore at 1,720)			Clinton.
Iron ore, dark shales and magnesian limestone	15	1,735	
Dark, limy shale	7	1,742	
Dark limes and limy shales	43	1,785	
Dark limes	55	1,840	
Dark gray and dark reddish limes	40	1,880	
Dark and light gray limes and dark, limy slate	35	1,915	
Dark, reddish lime	25	1,940	
Dark gray lime	35	1,975	
Dark bluish-gray and white limes	305	2,280	
Cave in dark slate at	----	2,290	
Dark, bluish-gray and white limes	102	2,392	
Blue and white limes and gray lime shale	18	2,410	
Light gray lime shale with dark slate shells	12	2,422	
Gray lime	30	2,452	
Grayish-brown and white crystalline limes	59	2,511	

WOLFE COUNTY.

Well at Campton—

Sand and shales	0	375	
White sand (settling sand)	375	410	
			Base of Pottsville.
White shale	410	420	
Big lime	420	530	St. Louis
Slate and sand shells	530	1,028	Waverly.

	Thickness.	Depth.	
Black shale	1,028	1,219	Bedford and Devonian.
Blue and white slate	1,219	1,224	
Brown shale	1,224	1,234	
White shale	1,234	1,250	
Oil sand	1,250	1,266	Corniferous.
Blue shales	1,266	1,291	Niagaran.
Limestone	1,291	1,300	

Below is given a copy of the statute requiring the closing of abandoned wells. But little attention has been paid heretofore to the requirements of this act. It is the duty of the County Attorney in each county to prosecute any violators.

CHAPTER 100.

(Act of May 14, 1892.)

PETROLEUM, NATURAL GAS AND SALT-WATER WELLS.

3910. **Person not using well to close it so as to prevent waste.** That from and after the passage of this act, any person or corporation, and each and every of them, in possession, whether as owner, lessee, agent or manager, of any well in which petroleum, natural gas or salt-water has been found, shall, unless said product is sooner utilized, within a reasonable time, not, however, exceeding three months from the completion of said well, in order to prevent said product wasting by escape, shut in and confine the same in said well until such time as it shall be utilized: Provided, however, That this section shall not apply to gas escaping from any well while it is being operated as an oil well, or while it is used for fresh or mineral water.

3911. **How abandoned wells to be closed.** That whenever any well shall have been put down for the purpose of drilling, or exploring for oil, gas or salt water, upon abandoning or ceasing to operate the same, the person or corporation in possession as aforesaid shall, for the purpose of excluding all fresh water from the gas-bearing rock, and before drawing the casing, fill up the well with sand or rock sediment to a depth of at least twenty feet above the rock which holds the oil, gas or salt water, and drive a round, seasoned wooden plug, at least three feet in length, equal in diameter to the diameter of the well below the casing, to a point at least five feet below the bottom of the casing; and immediately after drawing the casing, shall drive a round, seasoned wooden plug at a point just below where the lower end of the casing rests, which plug shall be at least three feet in length, tapering in form, and of the same

diameter, at the distance of eighteen inches from the smaller end, as the diameter of the hole below the point at which it is to be driven. After the plug has been properly driven, there shall be filled on top of the same, sand or rock sediment to the depth of at least five feet.

3912. **Penalty for violation of provision of this law.** Any person or corporation who shall violate any of the provisions of sections 3910 or 3911, shall be liable to a penalty of one hundred dollars for each and every violation thereof, and to the further penalty of one hundred dollars for each thirty days during which said violation shall continue; and all such penalties shall be recovered, with cost of suit, in a civil action or actions in the name of the State, for the use of the county in which the well shall be located. (See salt and saltpetre works, sec. 4359.)

3913. **Who, besides owner, may close abandoned well.** Whenever any person or corporation in possession of any well in which oil, gas or salt water has been found, shall fail to comply with the provisions of section 3910, any person or corporation lawfully in possession of lands situate adjacent to or in the neighborhood of said well, may enter upon the lands upon which said well is situated, and take possession of said well from which oil, gas or salt water is allowed to escape or waste in violation of said section 3910, and tube and pack said well, and shut in said oil, gas or salt water, and may maintain a civil action in any court of this State against the owner, lessee, agent or manager of said well, and each and every one of them, jointly and severally, to recover the cost thereof. This shall be in addition to the penalties provided by section 3912.

3914. **Person not owner closing well may recover costs of owner.** Whenever any person or corporation shall abandon any well, and shall fail to comply with section 3911, any person or corporation lawfully in possession of lands adjacent to or in the neighborhood of said well, may enter upon the land upon which said well is situated, and take possession of said well, and plug the same in the manner provided by section 3911, and may maintain a civil action in any court of this State against the owner or person abandoning said well, and every one of them, jointly and severally, to recover the cost thereof. This shall be in addition to the penalties provided by section 3912: Provided, This section shall not apply to persons owning the lands on which said well or wells are situated and drilled by other parties; and in case the person or corporation drilling said well or wells is insolvent, then, in that event, any person or corporation in possession of lands adjacent to or in the neighborhood of said well or wells, may enter upon the land upon which said well or wells are situated, and take possession of said well or wells, and plug the same in the manner provided for in section 3911, at their own expense.

3914a. **Abandoned oil or gas well to be closed—Penalty.** It shall be unlawful for any person or persons, corporations or companies to abandon any oil or gas wells, either dry or producing, in this Commonwealth, or to remove casings therefrom, whether same be either oil or gas, either producing or dry, or for any cause abandon said well or wells without first plugging same in a secure manner by placing a plug of pine, poplar or some other material which will prevent said well from becoming flooded, said plug to be placed above the oil-producing sand or sands, and filled in above for the distance of seven feet with sediment or clay and placing upon same another plug of similar material as that of the first and also placing about ten feet below the said casing another plug of like material as above referred to, seven feet of sediment or clay, and then another plug, all plugs to be securely driven in so that no water can pass the same, before the casing is removed.

Any person or persons, corporations or companies refusing or failing to comply with the foregoing provisions as provided for in section 1 herein, shall, on conviction, be fined in any sum not less than one hundred dollars, or not more than one thousand dollars, in the discretion of the jury.

All acts or parts of acts in conflict herewith are hereby repealed. (This section is an act of March, 1906, p. 280.)

OIL AND GAS WELLS DRILLED THROUGH COAL VEINS.

In other states where the production of oil and gas has been greater than in Kentucky and the number of wells therefore considerably larger, much trouble has been caused by the escape of gas into coal veins passed through, and particularly so from old forgotten wells where there is some gas produced but not enough to justify the use of the wells. A meeting of State Geologists and others interested was held recently in Pittsburg and measures suggested for the correction of this trouble. In Kentucky there has not, as yet, been much trouble from this source, although it is possible that some of the unexplained gas explosions in the mines may have been caused in this way. As a partial preventive for future explosions it is here suggested that the Legislature pass an act requiring any person or corporation which may drill a well to make a survey accurately describing the location of every well drilled to be made and filed for record with the County Clerk of the county in which the well is to be located and after completion of the well to file a correct copy of the record or log of the well.

This with the act already in force in regard to plugging abandoned wells, would enable the mine owner in the future to protect himself knowing the location of each well and the record of the well and at the same time work no hardship on the oil prospector.

BARITE, FLUORSPAR, ZINC AND LEAD.

CENTRAL KENTUCKY.

The Carolina Barytes Company, of Nicholasville, Ky., has a Barite mill at Nicholasville and are operating three mines in Central Kentucky, two in Jessamine County and one in Fayette. The Jessamine County mines are two miles from Brooklyn and the barite is hauled in wagons to the plant at Nicholasville, where it is ground into flour. The Fayette County mine is located near the Russel Cave pike, five miles north of Lexington. The barite is hauled in wagons to Lexington and shipped from there by rail to Nicholasville. The barite from this mine carries about three-fourths of one per cent of galena and a small percentage of fluorspar. Below the 70 foot level the vein also carries calcite. The Jessamine County mines carry neither Galena or Fluorspar .

In addition to the ore from their own mines this company buys from 5 to 40 tons of barite a day from small prospect pits within a radius of 10 miles from Nicholasville, these pits being operated irregularly by the farmers owning the land. The mill at Nicholasville is running, at the present writing, with an average output of 30 tons a day. The barite is all ground to flour and shipped in 100 pound bags.

There are numerous other barite veins opened in Central Kentucky, but at the present date none of them are being worked. (See report on Barite in Central Kentucky, this volume.)

The Chinn Mineral Company, of Harrodsburg, Ky., is operating a calcite mine which is located on the Kentucky River just above Mundy's Landing, in Mercer County, and 14 miles west of Nicholasville. A full description of this mine is given on another page of this volume (see Barite report).

A crushing plant has been erected on the bank of the Kentucky River at the mouth of the mine where the calcite is first roasted to drive off the surplus water and then ground into a fine rock-flour. At present the plant is running at full capacity with an output of 25 tons a day. About two-thirds of the output is shipped

in 100 pound bags; the remainder in 500 pound barrels. The larger part of this is shipped by boat to the main distributing plant at Madison, Indiana, although occasional shipments are made by boat to High Bridge, where it is hoisted to the Queen & Crescent Railroad and shipped by rail.

FLUORSPAR DISTRICT OF WESTERN KENTUCKY.

In "Mineral Resources of the United States," Kentucky is credited in 1911 with a production of 12,403 short tons of fluorspar, valued at $96,574, an average price of $7.79 a ton, distributed as follows:

Gravel spar	8,128 short tons at an average of $ 6.12 a ton.
Lump spar	1,045 short tons at an average of $7.183 a ton.
Ground spar	3,230 short tons at an average of $12.07 a ton.

The principal part of the fluorspar mined in Kentucky comes from the Western district, Crittenden County being the largest producer.

In 1912 the production was probably a little larger than in 1911. Exact figures have not been obtained but will probably reach a total of 16,000 short tons. In 1913 the output promises to be much larger than ever before. There is a rapidly increasing demand for the product, prices have increased and the mines are being put in better shape and on a more substantial basis for work, with competent men in charge. In addition to this some of the mines spent a large part of 1912 in development work and are now ready to produce more than at any previous date. One company, which only produced 676 tons in 1912 has already put out 1,500 tons for the first three months of 1913 and other companies will show a similar increase. A great drawback to the mining industry in this section is the long wagon haul over bad roads. In the Illinois district the largest producing mines are located on the Ohio River with practically no haul, while on the Kentucky side (according to figures from Mineral Resources 1911), the cost for haul amounts to $1.50 to $3.00 a ton with a general average of $2.25 a ton or a tax of $1.25 a ton, taking the $2.25 average cost, over the $1.00 a ton cost over good roads—certainly a forcible argument in favor of improving the roads.

The following is a list of the operators now (June 1st) at work in Crittenden County:

Roberts Fluorspar and Lead Company operating the Keystone mine, 5½ miles west of Marion. They have one shaft 200 feet down and one 300 feet, with a vein of spar 12 feet wide.

Franklin Mining Company operating near the Keystone mine. They have a shaft 296 feet deep with cross cuts at the 150, 200 and 250 foot levels. The vein is 6 to 12 feet wide on the different levels.

J. E. Wright operating on the Franklin property near Levias.

Persons and Roberts operating on the Blue and Haynes land near the Mary Belle mine, 6 miles northwest of Marion. The shaft is 40 feet deep with a vein 3 to 4 feet wide.

Eclipse Mining Company, 5 miles northwest of Marion. This company has a shaft 271 feet deep. The vein began with fluorspar but at a depth of 130 feet had changed to sulphide of zinc with a small percentage of galena and this continued to the bottom of the shaft. During development work 500 tons of sulphide of zinc was produced in 63 days. The company has a mill which is separating the ore by the wet jig process. The mine is in charge of Mr. J. B. White and a large production of zinc is expected this year.

The mines near Mexico are being operated by the Kentucky Fluorspar Company. Their mill at Marion not only grinds their own production but buys and grinds a large amount of the spar produced in the district.

The American Fluorspar Mining Company is operating near the Yandell mine in the Mexico district. This company was one of the large producers in 1912 and will probably keep up its output in 1913.

Edward F. W. Kaiser is developing a lead and zinc prospect on the old Crittenden Springs property 5 miles from Marion. He has three shafts, one down 20 feet, one 70 feet and one 118 feet. He is finding both carbonate and sulphide of zinc without any fluorspar.

The Hoosier Mining Company, located 6 miles west of Marion has a shaft 130 feet deep. At a depth of 70 feet they got a vein 12 to 13 feet wide. This mine is still in process of development.

The Pigmy Mining Company is operating a mine near Mexico. The shaft is down 100 feet with two working levels, the first at a depth of 60 feet and the second at 100 feet. The mine has only been in operation about two years, but is one of the largest producers in the district. The fluorspar carries about one per cent of galena.

W. Murray Saunders operating the Asbridge mine near Mexico has two shafts, one 40 feet deep and one 200 feet. This mine was the largest producer in the district in 1912. The fluorspar carries about one-half of one per cent of galena.

Memphis Mine. The Memphis property, located 5 miles northwest of Marion, was recently purchased by a St. Louis Company, which is having the property thoroughly prospected by diamond drill.

The following are operating in Livingston County:

Persons and Masters have begun operations on the A. J. Pierce property 3 miles southeast of Salem. They have a vein of zinc carbonate. They are also producing lump fluorspar on the Woods property near the Pierce zinc prospect.

D. C. Roberts and Company are developing a sulphide of zinc property in the town of Carrsville on the Ohio River. The shaft was down 40 feet with a showing of zinc when high water flooded the mine. Prospecting has since begun back from the river on higher ground.

At this date no mines in Caldwell County are being operated.

According to advance figures from U. S. Mineral Resources for 1912 the production of zinc in Kentucky for 1912 was 1,243 tons, valued at $41,391, an increase of 776 tons over 1911. The production of galena was 151 tons, having an average lead content of 70.2 per cent valued at $9,540. The production of zinc for 1913 will probably be much greater than in 1912.

Numerous requests for information in regard to where ground limestone may be obtained are received at the office of the Survey, and on this account it is deemed advisable to give a list of places where it may be obtained. This list is as complete as could be made.

FIRMS IN KENTUCKY SELLING GROUND LIMESTONE.

Bowling Green White Stone Co.	Bowling Green
Cartwright & Brannum	Elkton
Clark County Construction Co.	Winchester
Conley Construction Co.	Somerset
Dickinson Bros.	Glasgow
J. P. Donovan	Georgetown
A. L. Harris	Glasgow
Hopkinsville Stone Co.	Hopkinsville
F. W. Katterjohn Construction Co.	Princeton
Kentucky River Stone & Sand Co.	Lawrenceburg
Kissler & Rigelwood	Bowling Green
B. D. Lake	Springfield
Louisville Cement Co.	Louisville
Planters Hardware Co.	Hopkinsville
W. J. Sparks	Mt. Vernon

H. A. Somers	Elizabethtown
Webster Stone Co.	Irvington, Ky.
Ivor Stone Co., Ivor, Ky.	Carntown, P. O.
Ches. Stone Co., Highland, Ky.	Olive Hill, P. O.
Atlas Stone Co., Highland, Ky.	Olive Hill, P. O.
Lawton Stone Co.	Lawton, Ky.

WATER POWER.

Section 4 of the Act of 1912, creating a new Geological Survey, provides for reports on the water powers of the State and these will be taken up from time to time as opportunity affords. Reliable estimates of cost and production of power, however, can only be based on long continued gage readings of the flow of the streams, and but few of these have been made in Kentucky.

To the casual observer it might seem that the numerous streams in the State would furnish opportunities for unlimited water power and it is a fact that small, intermittent powers are innumerable, almost every creek furnishing such opportunities. It is not so long ago that many of the smaller streams had dams of moderate height furnishing power for local use for at least a portion of the year, but conditions have changed, our forests have been destroyed, the rain fall is carried away in a series of floods and freshets followed by periods of practically no flow in the smaller streams and the intermittent water power can no longer compete with the cheap, all the year around power, furnished by steam or gasoline. The life of any water power now is a question of storage of flood water to tide over the periods of small flow and this means high dams on the larger streams and the investment of large amounts of capital.

Of the larger streams in the State but few are available for the construction of high dams owing partly to some of them being under Federal control, with a system of locks and dams provided for navigation purposes and partly to the heavy cost for damages which would ensue from the flooding of valuable property which would be covered by the reservoir above the dam. This latter cost may in cases prove so great as to form a very large percentage of the total cost and in some cases prohibitive. Of the larger streams the Green River has locks and dams from the mouth up to Lock No. 6 located one mile above Brownsville with slack water to Mammoth Cave on Green River, ten miles up Nolin River and up Big Barren River to Bowling Green, to which point boats run regularly. In addition to these the U. S. Government has made surveys for Lock No. 2 on Big Barren at Bowling Green and Lock No. 3 one mile below Drake's Creek and Lock No. 7 near Mammoth Cave on Green River.

On the Kentucky River, locks and dams give slack water up to Beattyville. On the Big Sandy there is slack water for some distance up both forks above Louisa and plans are under way for additional dams both on this river and the Kentucky. There is considerable power in the aggregate, developed at these dams but it is under Federal control. The lower Cumberland and Tennessee Rivers from the points where they enter the State from Tennessee would develop considerable power, but both are navigable streams under Federal control and any hydroelectric development would face excessive costs for overflow damages and would also have to be done with a view of providing uninterrupted navigation. Rough River, Tradewater River, and the upper poriton of the Barren River and of Nolin River all have opportunities for the development of comparatively small powers but no measurements of flow are available for these streams. Salt River presents numerous opportunities for the location of dams but stream measurements are lacking on this also and any developments would be at great cost for damages caused by overflow. On the Upper Kentucky waters the North Fork has numerous towns not far above the water level and the Louisville and Nashville Railroad Company has built its track along the banks to the head of the river at McRoberts, the two combining to effectually preclude any development of water power requiring a dam more than a few feet in height. On the Middle and South Forks sites for dams are still available but no stream measurements have been made. On the Upper Big Sandy there are towns and a railroad on the banks of both forks up to the State line. On the Upper Cumberland the same conditions prevail with coal mines in operation also not far above water level.

There are, however, some opportunities for the development of hydro-electric power in large amounts on some of the streams of the State the principal ones among them being Dix River, Green River between Mammoth Cave and the mouth of Casey Creek and Cumberland River from Burnside up to Williamsburg including its tributaries, the Big South Fork and Rockcastle and Laurel Rivers.

DIX RIVER.

Dix River rises in Rockcastle County and comes into the Kentucky River at High Bridge cutting for the last twenty-five miles of its course a deep gorge in the limestones forming the cliffs of the Kentucky River at High Bridge and draining an area of approximately 450 square miles. In the gorge the stream is confined between high cliffs on both sides from the mouth to above the Danville water works, presenting some magnificent scenery and forming an almost ideal location for a reservoir, the stream running on a solid limestone floor with almost vertical walls of the same dense hard limestone —the High Bridge limestones of the Geological Survey, the cliffs along the whole gorge rising at least 100 feet above the level of back water above the proposed dam. Very complete surveys and estimates of the cost of a dam and plant have been made by the Dix River Power Company of Richmond, Ky., along with stream flow measurements over a period of about three years, the latter under the supervision of the Kentucky Geological Survey. The following data have been kindly furnished by the Dix River Power Company.

Drainage area above the dam approximately, 450 square miles.

Location of proposed dam two miles by river above the mouth of Dix River.

Proposed heights of dam 175, 215 and 250 feet.

With a height of 175 feet for the dam slack water will extend up to King's mill at the Danville and Lexington pike crossing, giving a reservoir about 26 miles long increasing rapidly in depth from the head of slack water to the 175 feet at the dam, the fall of the stream being very rapid in the upper stretch.

With a height of 215 feet for the dam slack water will extend to the top of the upper dam of the Danville Water Works, a distance of about 29 miles and with a height of 250 feet, to near the iron bridge near Hedgeville on the Danville and Lancaster pike.

Rainfall, as taken from the records of the U. S. Weather Bureau for the last sixteen years, gives an average annual fall of 45.07 inches.

Stream measurements for run off were made by a gage placed on the bridge at Kennedy's Mill and daily (a portion of the time twice a day) readings of stream level were taken beginning July 1, 1910 and continued up to the present time and from these and the measured section of the stream the run off was calculated. The average monthly run off thus calculated was 918.6 cu. ft. per second. The average monthly run off per square mile of drainage area was 2.09 cubic feet per second.

The total average precipitation per square mile of drainage area equals 3.54 cubic feet per second. This gives the mean run off $= \frac{2.09}{3.54} =$ 59 per cent of the total precipitation. This large percentage of run off is due to the topography of the drainage area, much of which is very steep and hilly.

With a dam of 175 feet in height a spillway will be constructed to carry off surplus flood waters. An opportunity is afforded at the proposed site to construct this by a channel in the hill side which will carry all overflow to a discharge entirely beyond the face of the dam. This spillway will be provided with gates to maintain full head as long as there is any surplus of water. With a dam 250 feet high all flood water will be stored and none allowed to go through the spillway. Owing to the peculiar gorge like character of the territory to be filled by the reservoir the cross section of the reservoir will be practically the same width all the way, there will be no overflow on either side except where small streams come in from the sides and for the same reasons damages from overflow will be very small.

For the proposed 175 foot dam the length of the dam will be 242 feet at the bottom and 630 feet at the top. The elevation of the surface of the reservoir when full will be 684.5 feet A. T. The total draw down, or amount of storage available for power purposes, will be 48.67 feet. (Elevation of line of lowest draw down 635.83 A. T.) The line of mean draw down for this will be at 658.33 A. T. or 27.2 feet below the surface when the reservoir is full and at this line the area of the reservoir for the 175 foot dam will be 1,223 acres. With this available

draw down of 48.67 feet and mean area of 1,223 acres the calculated content of the reservoir above the lowest point of draw down is 2,523,052,916 cubic feet or 57,921 acre feet, an available draw down reservoir of remarkable size. With an average use of 600 cubic feet per second of water the proportion of use to storage becomes 1 to 4,205.000. For a dam 215 feet high the total draw down, or amount of the storage available for power, will be 64 feet instead of 48.67 and the total storage for use above the lowest draw down will be 3,667,752,000 cubic feet or 84,200 acre feet. For the 250 foot dam only approximate estimates have been made. These give for this height of dam an available storage for draw down of over 110,000 acre feet.

With the proposed dam a power house is planned which will be an integral part of the dam and so arranged as to be independent of back water from the Kentucky River, enabling the plant to be operated under any flood conditions.

Calculated available power is as follows:

Height of dam....	175 feet.	215 feet.	250 feet.
H. P. developed..............	28,000	34,000	40,000
H. P. steam auxiliary....	7,000	8,500	10,000
K. W. Hour output.........	91,980,000	111,690,000	131,400,000
(50% load factor).			

In this latitude trouble from ice will be practically eliminated and owing to the fact that the whole gorge is cut in solid limestone there should be very little trouble caused by sand passing through the turbines.

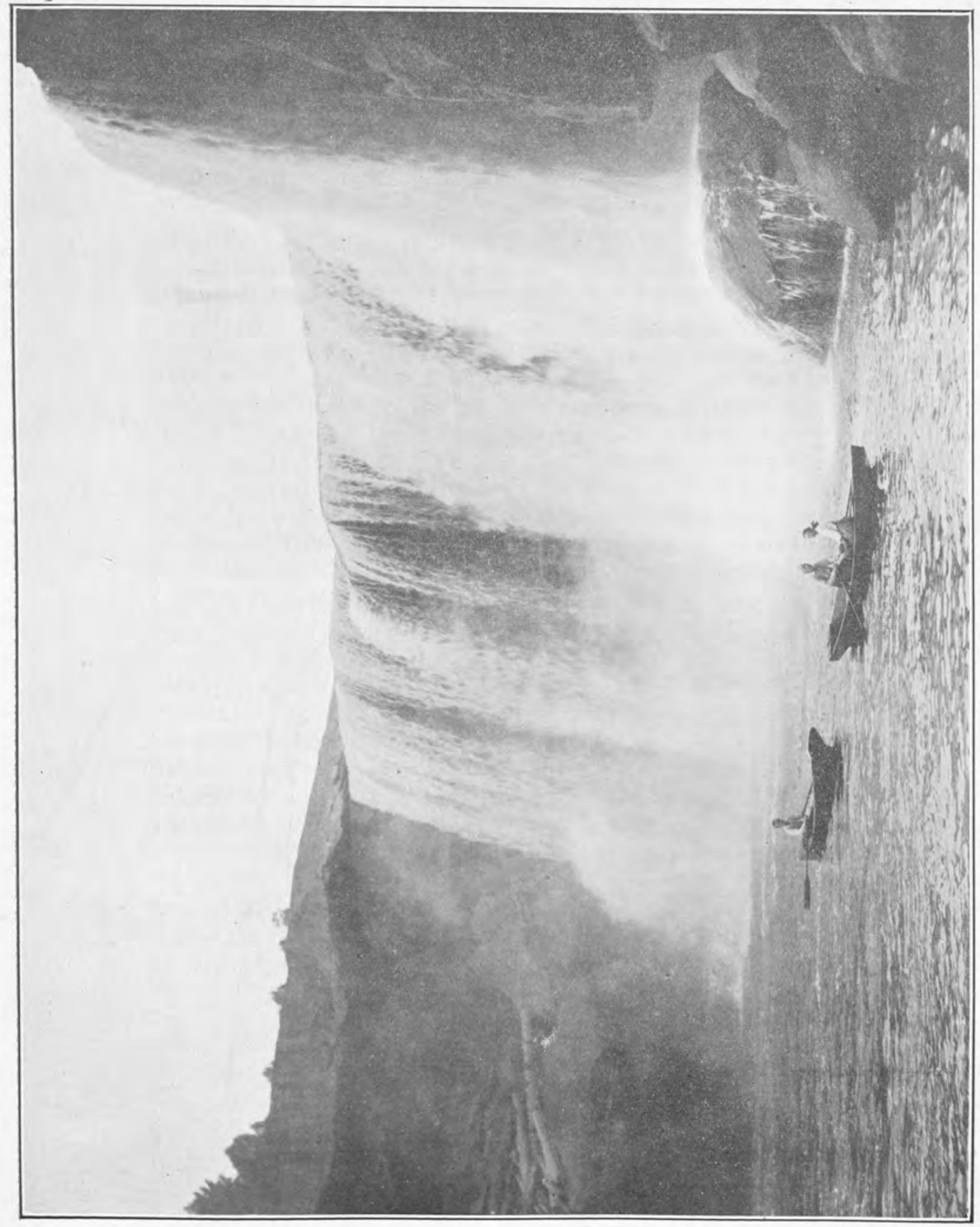
The market for power for this plant would be all of Central Kentucky with air line distance to Louisville 67 miles and to Cincinnati 90 miles. Transmission lines in Central Kentucky are already in existence as traction lines between Lexington and Paris, Georgetown, Nicholasville, Versailles and Frankfort and a connecting line between Frankfort and Shelbyville would give a continuous line from Nicholasville to Louisville.

CUMBERLAND RIVER.

Cumberland River rises in the extreme southeast corner of the State and flows in a general westerly direction through Bell, Knox, Whitley and Pulaski Counties then turning to the southwest crosses the State line in Monroe County into Tennessee. Its main tributaries are the Laurel River, Rockcastle River and Big South Fork, besides numerous large creeks. Its total drainage area above the State line is about 6,500 square miles. Above Cumberland Falls its drainage area is about 2,000 square miles and above Burnside about 3,300 square miles. In the stretch of river between Williamsburg and Barbourville there is not much fall. Above Barbourville the fall is more rapid but power could only be secured by a succession of low dams and these would have correspondingly small storage with loss of head during floods. Between Williamsburg and Burnside, however, and up the Big South Fork there is an enormous aggregate power going to waste.

Following are elevations at the Falls of Cumberland and on the main river:

Ledge at top of Falls	842.78	A. T.
Low water at head of rapids ½ mile above Falls	856.66	A. T.
Low water at a proposed site for power house 300 yards below Falls	788.66	A. T.
Low Water one mile below Falls	785.71	A. T.
Height of Falls	53.84	Feet
Additional height of rapids above	13.88	Feet
From the foot of the Falls to the mouth of Laurel River, distance 10 miles, total fall	85	Feet
From mouth of Laurel River to head of Smith's shoals, distance 24 miles, total fall	31	Feet
From head of Smith's shoals to foot of shoals, distance 9 miles, total fall	55	Feet
From foot of Smith's shoals to State Line in Monroe Ccuny distance 129 miles, total fall	95	Feet
From Williamsburg to head of rapids above Falls, distance about 30 miles, total fall	65	Feet
From head of rapids above Falls to site for a power house below the Falls, total fall	67.8	Feet
From Williamsburg to Burnside, total fall	320	Feet



Cumberland Falls.

Stream measurements have been kept over a long period of time and surveys made to locate dam sites. For the following data I am indebted to Mr. L. E. Bryant of Roberta, Tenn.

Height of proposed dam at head of rapids above Cumberland Falls, 83 feet.

This dam would give a storage basin over 30 miles long giving slack water to a point above Williamsburg. Two other dams located between the Falls and Burnside would develop for the three a total of 75,000 K. W.

The minimum flow at Burnside he gives as 850 second-feet and the maximum flood flow 100,000 second-feet. For the average flow he gives 2,500 second-feet. For the two lower dams the flow would be largely equalized by the discharge from the dam at the falls but with increased flows from Laurel and Rockcastle Rivers, Buck Creek and the smaller tributaries. Instead of the two additional dams, one dam 170 feet high at the foot of Smith's Shoals, would give back water up to the Falls.

For the Big South Fork, Mr. Bryant gives the total fall as 500 feet, drainage area 1,500 square miles, minimum flow 250 second-feet, maximum flow 30,000 second-feet, average flow 800 second-feet. To develop it would require eight dams averaging 60 feet each and the power developed would equal 50,000 K. W. The markets for power for the whole circuit would be Louisville, Cincinnati and Nashville and intermediate points. Rockcastle River would afford sites for additional dams to supply more power for the same circuit, but no stream measurements have been made.

In the stretch between Burnside and the State line there is a total fall of 95 feet in a distance of 124 miles as stated above. This portion of the river could not be utilized on account of Government control.

GREEN RIVER.

As mentioned above, Green River has locks and dams from the mouth up to Lock No. 6 one mile above Brownsville with slack water up to Mammoth Cave. Above that point, however, the river affords opportuni-

ties for power development on a larger scale. The following are elevations A. T. at different points up the river beginning at Mammoth Cave:

Low water one mile above Mammoth Cave	389
Low water at Dennison's Ferry (Hart Co. line)	398
Low water at mouth of Cub Run	401
Low water at Blue Springs	407
Low water under R. R. bridge at Munfordville	422
Low water at Rio	436
Low water at 300 Springs	442
Low water at mouth of Little Barren River	453
Low water at Well's Ferry (Green County)	487
Low water at Greensburg	516
Low water at Bluff Boom	531
Low water at Roachville	545
Low water at Atchley's Mill (Taylor Co. line)	548
Low water at neck below Lemon's Bend	549
Low water at neck above Lemon's Bend	574
Low water at Griffin's Springs	590
Low water at Plum Point (mouth of Casey Creek, Adair Co.)	634
The total fall in the river from Plum Point, Casey Creek to Mammoth Cave, is 245 feet.	
Elevation of lower end of town of Munfordville	539
Elevation of Court House at Munfordville	571
Elevation of depot at Greensburg	584

From the above levels it will be seen that a dam below Munfordville could be built about 140 feet high and not interfere with the railroad bridge and throw slack water up to the edge of the town of Munfordville. A dam of this height would give slack water to a point several miles above Greensburg. Damages for overflow would be very large but there would be a magnificent reservoir formed. A serious feature to be considered would be the probable leakage through the cavernous limestones of this vicinity and the possible flooding of Mammoth Cave thereby.

From the mouth of Little Barren to the mouth of Casey Creek the fall of the river is 181 feet and the objections noted above to a location below Munfordville would be avoided but a dam 180 feet high there would overflow Greensburg. Above Casey's Creek the fall is light and the valley widens out. It is likely that surveys made to locate points for water powers would give about four locations where dams of moderate height (50 ft.

to 75 ft.) could be built each having ample storage and a large stream flow.

At the neck of Lemon's Bend above Roachville a power could be developed by a tunnel through the hill, the river falling 25 feet going around the bend with a very narrow ridge at the neck of the bend. The drainage area of the river above Mammoth Cave is nearly 2,000 square miles. Above the mouth of Little Barren River it is about 1,600 square miles. The average rainfall per annum taken from the record for 15 years is 45.54 inches.

Gage readings have been kept at Lock No. 5 for a number of years and from these readings I have the following calculations of stream flow or run off furnished by Mr. T. L. Fitch, President of the Capital Gas and Electric Light Company, of Louisville.

Minimum flow	200 second feet.
Low monthly flow	400 second feet.
Normal high monthly flow	1,000 second feet.

Records are also kept at Locks No. 4 and No. 6.

These figures for run off would not be diminished very much at the mouth of Little Barren River as Green River has very few tributaries between Nolin and Little Barren, nearly all the flow coming from above the latter.

The use of water power through the development of electric transmission is increasing so rapidly as to have become already one of the great factors in the production of power. Of all the stationary power developed in the United States it is estimated that 20 per cent is now produced by water power with enough more economically available to practically supply all that is now used. The fact that power produced by this means is practically inexhaustible means the conservation of all other fuel. Coal, oil and gas once used cannot be replaced, but the modern hydro-electric plant, once it is built, is practically permanent and will continue to furnish its power as long as water runs. The supply of coal in Kentucky is large, and it will be many years before it is exhausted but the supply is being drawn upon more and more largely every year and it is of the greatest importance to the

future industrial development of the State and for the conservation of our supply of coal that these powers should be developed.

For the purposes of comparison a few notes from the successful recent development of a similar water power in Eastern Tennessee on the Ocooe River are here given. The Ocooe rises in Northern Georgia and joins the Hiawassee near Parksville, Tennessee where the river flows through a narrow gorge with a drainage area above it of 500 square miles. In the narrowest portion of this gorge a dam has been built over 800 feet wide and 125 feet high forming a reservoir eight miles long. The draw down is only about 20 feet and the greatest available head is 102 feet. It is planned to increase the power by additional future developments but from the present development alone power is successfully transmitted northeast to Knoxville, 85 miles, west to Chattanooga, 39 miles, south to Rome, Ga., 70 miles and northwest to Nashville, 150 miles.

As compared with these figures the proposed Dix River alone has drainage area 457 square miles, dam 175 feet to 250 feet high instead of 125 feet, reservoir 26 miles long, draw down of 48.67 feet instead of 20 feet and greatest available head for the 175 feet dam about 173 feet. When the total combined power from this development along with those of Cumberland River, Rockcastle River, Big South Fork and Green River (which could all be utilized in one combination) is compared with what has already been done on the Ocooe River in Tennessee, the enormous possibilities are at once apparent.

RAINFALL IN KENTUCKY—FROM U. S. WEATHER BUREAU FROM JULY, 1912, TO JUNE, 1913.

STATION	COUNTY	1912						1913				
		July	August	September	October	November	December	January	February	March	April	May
Alpha	Clinton	3.35	3.40	4.47	1.10	1.05	4.91	11.76	4.42	9.70	2.71	**2.57**
Anchorage	Jefferson	5.68	6.41	4.88	1.89	1.39	3.00	10.84	2.47	7.15	2.39	**1.43**
Bardstown	Nelson	5.47	3.50	4.16	1.32	1.43	4.43	13.99	2.92	6.18	3.40	**3.06**
Beattyville	Lee	5.72	5.20	3.10	1.32	1.36	5.44	10.24	3.78	9.70	3.04	**4.04**
Beaver Dam	Ohio	5.40	5.59	2.59	1.95	1.05	2.35	13.85	2.99	6.74	1.58	**0.87**
Berea	Madison	4.45	5.96	2.61	1.02	1.55	6.33	9.84	2.28	8.96	2.34	**3.40**
Blandville	Ballard	1.84	2.21	2.79	4.40	0.73	2.14	12.47	2.75	8.59	3.68	**0.65**
Bowling Green	Warren	5.83	4.83	2.54	1.32	0.32	4.89	12.76	4.19	8.27	1.18	**1.55**
Burnside	Pulaski	8.76	2.35	3.61	1.44	0.95	4.86	9.20	3.75	7.45	2.05	**2.53**
Calhoun	McLean	5.52	3.61	1.89	2.68	1.40	2.96	12.70	2.48	7.71	2.34	**1.64**
Catlettsburg	Boyd	8.28	5.10	1.86	1.24	0.94	3.64	7.56	2.12	5.22	2.84	**5.04**
Earlington	Hopkins	3.95	3.07	2.09	2.57	0.61	2.53	11.97	2.50	6.82	2.77	**0.70**
Eubank	Pulaski	6.34	4.98	4.95	0.59	1.66	5.45	11.42	2.66	6.65	2.33	**3.26**
Falmouth	Pendleton	4.09	3.95	3.23	1.58	1.09	3.29	9.91	1.87	6.07	3.69	**3.41**
Frankfort	Franklin	5.41	8.03	1.95	0.74	1.21	3.71	11.80	1.98	6.45	3.34	**3.36**
Franklin	Simpson	5.50	3.73	4.01	1.44	1.13	6.81	14.81	4.88	8.43	1.61	**1.08**
Greensburg	Green	6.49	4.77	2.68	0.52	2.30	5.13	12.32	3.65	8.11	2.52	**2.93**
High Bridge	Jessamine	7.06	4.52	2.03	0.54	1.19	3.83	10.51	2.70	6.23	2.66	**5.15**
Hopkinsville	Christian	7.61	5.07	1.20	1.17	1.28	3.00	14.53	4.37	6.17	2.52	**2.18**
Irvington	Breckinridge	5.47	4.73	2.73	2.34	1.42	3.57	14.33	2.80	8.01	1.88	**1.44**
Leitchfield	Grayson	4.79	4.13	3.03	1.70	0.57	3.78	13.26	3.40	6.16	1.90	**1.59**
Lexington	Fayette	4.70	3.23	2.09	0.51	1.02	3.66	10.35	2.61	6.04	2.41	**4.32**
Loretto	Marion	5.80	4.41	2.93	0.62	1.02	4.42	10.29	2.22	......	4.10	**4.57**
Louisville	Jefferson	4.68	5.06	3.03	2.43	0.65	2.52	9.91	2.09	7.70	2.11	**1.07**
Marion	Crittenden	2.24	......	3.27	2.57	1.67	3.50	13.27	3.74	6.84	......	......
Maysville	Mason	5.67	4.41	2.29	1.36	1.52	3.51	11.19	1.70	4.91	3.05	**5.18**
Middlesboro	Bell	5.25	5.41	2.41	0.72	1.86	5.98	10.61	3.84	8.34	2.77	**5.26**
Mt. Sterling	Montgomery	8.84	4.99	1.67	0.43	2.29	4.88	9.78	3.60	6.51	2.23	**5.85**
Owensboro	Daviess	6.62	5.96	3.05	2.52	1.12	3.01	10.89	3.05	8.32	2.68	**0.68**
Paducah	McCracken	4.76	1.50	1.76	3.00	1.24	2.12	14.68	2.88	8.81	3.43	**1.92**
Richmond	Madison	3.64	4.36	2.71	0.50	1.48	3.30	11.03	2.45	7.41	2.39	**5.27**
St. John	Hardin	7.43	5.51	2.69	1.39	1.24	3.75	12.79	3.56	7.66	2.25	**2.90**
Scott	Kenton	4.96	5.07	2.51	1.42	1.84	2.91	10.33	1.61	8.73	4.10	**2.48**
Shelby City	Boyle	6.80	4.62	3.26	0.32	1.62	5.07	10.89	2.77	7.59	2.56	**2.64**
Shelbyville	Shelby	4.05	5.15	3.05	1.41	1.09	4.69	13.36	2.97	7.99	4.04	**2.74**
Taylorsville	Spencer	4.14	5.99	2.37	1.27	1.01	3.07	12.95	2.42	6.90	2.82	**1.82**
Williamsburg	Whitley	7.87	4.16	3.57	0.70	1.19	4.98	9.25	4.19	6.22	4.32	**3.84**
Williamstown	Grant	2.38	6.56	2.75	1.62	1.26	2.51	9.75	1.74	6.80	3.54	**3.46**

THE COALS OF THE UPPER BIG SANDY VALLEY AND THE HEADWATERS OF THE NORTH FORK OF THE KENTUCKY RIVER.

BY

J. B. HOEING.

In view of the great development which has been going on for the last few years in the Upper Big Sandy Valley and the Elkhorn region on Elkhorn and Shelby Creeks and the head waters of the North Fork of the Kentucky River, it is deemed advisable to give, as fully as can be done at present, a connected statement in regard to the coals of that region mainly with the view of showing as far as possible the extent of the area in which the Elkhorn coal is recognizable as a workable vein and clearing up some of the confusion which seems to exist in regard to what are known as the "Upper" and "Lower" Elkhorn coals, but also giving at the same time such information as is now available in regard to other coal seams in the same territory.

Unfortunately there is a great lack of accurate topographical maps on which to base any detailed work. Under the arrangement by which co-operative topographical work is carried on jointly by the Kentucky Geological Survey and the U. S. Geological Survey, accurate contour maps are being issued, but this work has heretofore been done mainly in other sections of the State. Work along this line however has been fairly started in this section and will be carried to completion as rapidly as possible. Until these contour maps are available final, detailed work on the coals of the region under discussion will necessarily have to be postponed. Maps covering this territory, however, have been compiled this year and published herewith which are fairly accurate so far as the main features of the topography are concerned. The present discussion, while only along general lines, it is trusted will be accurate enough to cover the main features of the region as a whole; it is intended rather to meet present demands and form a framework, as it were, around which future more accurate and much more detailed work can be built, the writer realizing that much must necessarily be left unsaid and possibly some corrections made later on as opportunity is afforded for closer and more detailed work. No attempt beyond an occasional suggestion will be made to correlate the higher coals of the region although thick veins are known to exist above the veins now being worked. Commercially, owing to their relatively high positions in the ridges, these are not at present so important as the lower coals. Likewise all attempts at correlating the coals, shales and sandstones of this region with those on the southeast side of Pine Mountain will have to be deferred until later on.

Much of the data contained in this article has been obtained from work done by the different coal companies now operating in this field. These companies have turned over to the survey the results of their field work and copies of numerous private reports and field maps which have been corrected and correlated as far as possible. To these companies the thanks of the Survey are due as without their co-operation much time and far more expense than the State Survey could afford, would have been necessary to get together the data herewith presented.

GENERAL FEATURES.

In the deep sea waters of the Great Appalachian basin during a long period of subsidence, a series of limestones, the Greenbrier limestones, were deposited, followed unconformably in irregular alternate periods of subsidence and depression by the thick deposits of red shales, sandstones and limestones which constitute the Mauch Chunk series of West Virginia and Pennsylvania. These Mauch Chunk beds were subsequently deeply eroded in turn, the erosion in some cases entirely removing them and cutting down into the Greenbrier limestones below. (See records of drilled wells given on subsequent pages). On this eroded surface the sandstones, shales and coals of the Lower Pennsylvanian were deposited unconformably, the oldest deposits filling the deepest portion of the basin first and being succeeded in turn by the later deposits each overlapping the

lower one and extending farther to the northwest. The main divisions of the Pennsylvanian as given in the Pennsylvania reports are as follows:

XVI.—Dunkard or Permian.
XV. —Monongahela.
XIV.—Conemaugh or Barren.
XIII.—Alleghany or Lower Productive.
XII. —Pottsville.

In West Virginia, Prof. I. C. White divides the Pottsville (the lowest or oldest group of the Pennsylvanian) into three groups each delimited by a heavy sandstone as shown below:

Pottsville Series in West Virginia	Upper Pottsville or Kanawha Group.
	Middle Pottsville or New River Group.
	Lower Pottsville or Pocahontas Group.
Unconformity.	
Mauch Chunk Beds.	
Greenbrier Limestones.	

The Pocahontas Group, which includes the Pocahontas coals, is limited at the top by the Flat Top Mountain Sandstone. The New River Group, containing the New River coals, has a massive sandstone known as the Nuttall Sandstone as the top member, while the Upper or Kanawha Group has the Roaring Creek sandstone as the top member and carries the Kanawha coals beginning with the War Eagle coals and ending with the Stockton coal.

Prof. White further divides the Kanawha into two groups, the Upper and Lower Kanawha, and on page 271, Vol. 2 (A) of the West Virginia Reports gives the following generalized section of the Kanawha Group.

GENERALIZED SECTION, KANAWHA GROUP.

Upper Kanawha.

	Feet		Feet.
Roaring Creek Sandstone (Homewood)	50	to	100
Shales, sometimes holding coal beds	0	to	30
Kanawha Black Flint (Mercer)	0	to	10
Shales	5	to	25
Coal, Stockton, Lewiston, Belmont, etc.	4	to	12

	Feet		Feet.
Sandy shales or impure fire clays	2	to	10
Coalburg sandstone, often weathering into chimney rocks	50	to	80
Shales	5	to	10
Coalburg coal, multiple bedded	4	to	8
Sandy shales or impure fire clays	10	to	20
Upper Winifrede Sandstone	50	to	80
Winifrede coal, multiple bedded	4	to	12
Sandy shales and impure fire clays	5	to	15
Lower Winifrede Sandstone, base of Upper Kanawha	20	to	40

Lower Kanawha.

	Feet		Feet.
Chilton Sandstone	30	to	50
Chilton coal	2	to	6
Fire clay	3	to	5
Malden sandstone	200	to	300
Cedar Grove coal (appears to correlate with Thacker coal on Tug Fork)	2	to	8
Fire clay and sandy shales	5	to	10
Sandstone or sandy shales sometimes including a siliceous limestone	80	to	150
Peerless coal, Alma of Tug River, "gas" coal	2	to	4
Fire clay and shales	2	to	10
Sandstone and sandy shales	0	to	80
No. 2 gas coal, correlated with Warfield and Rawl of Tug river	2	to	10
Fire clay and sandy shales	2	to	10
Brownstown Sandstone	35	to	50
Powellton coal (Brownstown)	1	to	5
Shales and standstones sometimes including a sliceous limestone	60	to	100
Eagle coal, No. 1 gas	2	to	6
Shales and sandstones	20	to	50
Little Eagle coal	1	to	2
Shales and sandstones	40	to	50
Black slate	2	to	10
Eagle limestone, "Black Marble," etc.	1	to	2
Dark shales	5	to	10
Shales and sandstones	100	to	200
Upper War Eagle coal (Possibly same as Eagle)	2	to	6
Shales and sandstones	100	to	220
Middle War Eagle coal	2	to	6
Shales and sandstones	100	to	250
Lower War Eagle coal	2	to	4
Shales and sandstones	40	to	50
Nuttall Sandstone—top of Middle Pottsville.			

The lower coals (all below the Alleghany Group) of the Eastern Kentucky coal field are mainly within this Kanawha or Upper Pottsville Group, the Pocahontas and New River Groups of West Virginia rapidly becoming thinner and disappearing to the northwest as they approach the Kentucky-West Virginia line, to be followed by a similar thinning of the Upper Pottsville or Kanawha series toward the northwestern edge of the coal field in northeastern Kentucky. Probably none of the members of the Pocahontas Group reach the Big Sandy at all and of the New River Group, with the possible exceptions of the lowest sandstone which comes up near the West Virginia line and a portion of the lowest sandstones of the section in the upturned measures along the Pine Mountain fault, none come to the surface in this part of Kentucky and with the above exceptions, they are only represented by some of the lower sandstones and shales and thin coals shown in some of the deep wells drilled in the Upper Big Sandy Valley and rapidly thin out and disappear entirely, to the north and northwest.

From this it will be evident that the correlation of any of the Big Sandy River coals with those of the New River or Pocahontas Groups, as has often been attempted, is futile. All of the lower coals above drainage in this region are comprised within the Kanawha Group which is limited, as explained above by the Roaring Creek sandstone at the top and the Nuttall sandstone (the top member of the New River Group) at the base. The lowest sandstone exposed on the Big Sandy River, with the above mentioned exception of those in the face of Pine Mountain, is the one which comes to the surface near Elkhorn City and it is this sandstone which Prof. White has provisionally correlated with the Nuttall sandstone or top member of the New River Group. This is also one of the four great sandstones distinguished by the drillers when drilling the deep wells of Pike and Martin Counties, probably, judging by the depth given in the records and assuming Prof. White's identification of the sandstone at Elkhorn City as the Nuttall sandstone to be correct, is the "Beaver" sand of the drillers.

If this be true the remainder of the section between the Beaver sand and the Mauch Chunk as shown in the following well records will represent what is left of the Pottsville below the Kanawha Group. The distance down from the top of the Beaver sand to the base of the Pottsville is given with each record to show the increasing thickness of that portion of the Pottsville below the Kanawha to the southeast.

The following records of drilled wells will illustrate the changes in the lower part of the Pennsylvanian in going from northwest to southeast and also the variable section, due to unconformity and erosion, in the Mauch Chunk and Greenbrier Limestone:

No. 1—Well at Central City near Huntington, W. Va.—(I. C. White).

	Thickness	Depth.
Soil	26	26
Shale, sand and lime	94	120
Lime	7	127
Slate and fire clay	98	225
Sand (Upper Mahoning)	25	250
Slate	50	300
Sand (Lower Mahoning) gas	30	330
Black slate	10	340
Gray sand	60	400
Black slate	10	410
Gray sand	85	495
White and blue slate	25	520
Sand and lime	20	540
Slate	20	560
Black slate	175	735
Gray sand	25	760
Black slate	105	865
Sand (gas and salt water) base of Pottsville	30	895
Black sand	10	905
Black slate	30	935
Lime	5	940
Black slate	30	970
Mountain lime	150	1,120
Slate	28	1,148
"Big Injun" sand (salt water)	177	1,325
Black shale and slate	370	1,695
Lime and hard sand	10	1,705
Brown slate	25	1,730
Berea sand (oil and gas)	25	1,755
Black slate	10	1,765

	Thickness	Depth.
Hard gray sand	5	1,770
Lime	5	1,775
Gray sand	10	1,785
Lime	3	1,788
Black sand	2	1,790
Bastard lime	4	1,794
Black shale	20	1,814
Fine black sand	97	1,911
Shale and slate (black, blue and white) Devonian	574	2,485
Bastard lime (gas)	15	2,500
Shale	250	2,750
Gray sand	10	2,760
Corniferous limestone	10	2,770

In this well, according to Dr. White's correlations, the total thickness from above the Upper Mahoning sandstone down through the Alleghany and Pottsville is only 895 feet. The 30 foot sandstone at 865 to 895 probably represents what is known as the Beaver sand in the Pike County wells, the remainder of the Pottsville being cut out.

No. 2—Morgan County Well.

	Thickness	Depth.
Soil	15	15
Shale	10	25
Sand (pebbly)	293	318
Dark shale and sand	12	330
Dark shale	10	340
Shaly sand	5	345
Sand (pebbly)	65	410
Coal	1	411
Dark shale—Base of Pottsville	42	453
Limestone	15	468
Limy shale—Mountain limestone	5	473
Limestone	52	525
Sand and shale	235	760
Limy shale	5	765
Red sand	1	766
Sandy shale	154	920
Hard, fine sand	5	925
Shale	5	930
Fine sand	2	932
Coarse sand	8	940
Dark shale	33	973

	Thickness.	Depth.
Sand	2	975
Dark shale	37	1,012
Shale and sand	16	1,028
Very black shale	7	1,035
Sand—Berea Grit	24	1,059
Dark shale and sand	28	1,087
Black shale—Devonian	283	1,370
Blue shale	30	1,400
Sandy lime.—Morgan county oil sand at 1,408	50	1,450
Lime	65	1,515
Lime and sand.—Caney oil sand	15	1,530
Lime	87	1,617
Sand	10	1,627
Sandy lime	25	1,652
Red shale	133	1,785
Blue shale	79	1,864
Hard lime	5	1,869
Blue shale	22	1,891
Gray lime	9	1,900
Red shale	6	1,906
Blue shale and lime	12	1,918
Red shale	4	1,922
Blue shale	20	1,942
Gray lime	25	1,967
Sand	7	1,974
Shale	4	1,978
Sandy lime	7	1,985
Lime and shale	4	1,989
Blue limy shale	32	2,021

This well started just below the No. 1 coal (old notation) and shows a total thickness down to the base of the Pottsville of 453 feet. The Mauch Chunk does not reach this far to the west.

No. 3—Well on Tom's Creek—Johnson County.

	Thickness.	Depth.
Soil } Pottsville	19	19
Black slate } Pottsville	186	205
White sand } Pottsville	399	604
White lime.—Greenbrier	156	760
Blue sand	40	800
Black slate	269	1,069
Gray sand	75	1,144
Gray slate and shells	61	1,205

	Thickness.	Depth.
Black shale	75	1,280
White slate } Devonian	68	1,348
Brown shale } Devonian	327	1,675
White slate } Devonian	125	1,800
White line	132	1,932

The well started just below the Van Lear coal and shows a thickness of 604 feet to the base of the Pottsville in place of the 453 of the last record, records No. 2 and No. 3 having started at about the same point in the vertical section. Only one heavy sandstone is shown in the Pottsville and there is as yet no appearance of the Mauch Chunk beds. The thick sandstone at the base of the Pottsville probably represents the Beaver and Horton sands of the wells to the southeast. The total thickness from the top of the Beaver Sand to the base of the Pottsville is 399 feet.

No. 4—Well on Middle Creek—Floyd County.

	Thickness	Depth.	
Soil	22	22	
Light slate	28	50	
Gray sand	20	70	
Black slate	30	100	
White sand	70	170	
Black slate	8	178	
Gray sand	82	260	
Black slate	65	325	
White sand	58	383	
Light slate	17	400	
Gray sand	28	428	
Dark slate	22	450	
Gray sand	18	468	
Black slate	78	546	
White sand	10	556	
Black slate	8	564	
Dark slate	35	599	
White sand	16	615	
Dark slate	49	664	
White sand (salt water)	142	806	Beaver Sand.
Black slate	5	811	
Dark sand	25	836	
White sand (salt water)	34	870	Horton Sand.
Black slate	17	887	
Black sand	8	895	

	Thickness.	Depth.	
Black slate	25	920	
Gray sand (oil, gas and salt water)	234	1,155	Pike and Salt sands. Base of Pottsville.
Black slate	16	1,171	
Limestone	201	1,372	Greenbrier
Red shale	38	1,410	
Black slate	85	1,495	
White slate and shells	100	1,595	
Dark slate	95	1,690	
White slate and shells	60	1,750	
Brown slate	96	1,846	Devonian.
White slate	12	1,858	
Brown slate	268	2,126	
Black slate	15	2,141	

This record starts just below the Van Lear coal at about the same point in the section as records No. 2 and No. 3, and gives 1.155 feet to base of Pottsville and also shows the separate divisions of the lower part coming in, viz.: the Beaver, Horton, Pike and Salt Sands (the last two together) of the drillers. The limestone shows 201 feet thick with no Mauch Chunk over it. The total thickness from the top of the Beaver Sand to the base of the Pottsville is 491 feet.

No. 5—Well Near Prestonsburg.

	Thickness	Depth.	
Soil	61	61	
White sand	5	66	
Light slate	34	100	
Gray sand	4	104	
Light slate	36	140	
Gray sand	50	190	
Black slate	5	195	
Gray sand	65	260	
Light slate	121	381	
White sand	175	556	Beaver sand.
Coal	4	560	
Gray sand	15	575	
Dark slate	15	590	
White sand	114	704	Horton sand.
Black slate	8	712	
Dark sand	12	724	

	Thickness.	Depth.	
White sand (salt water)	15	739	Pike sand.
Very dark sand	25	764	
Black slate	25	789	
White sand (salt water)	62	851	Salt sand. Base of Pottsville.
Black lime	25	876	
White lime	39	915	

The record starts near the Van Lear coal and shows the four Pottsville sands with base of Pottsville at 851. The thickness of the section from ths top of the Beaver sand to the base of the Pottsville is 470 feet.

No. 6.—Well on Beaver Creek Below Salt Lick Creek.

	Thickness	Depth.	
Soil	22	22	
Slate	18	40	
Coal	4.5	44	
Black slate	51	95	
Coal	4.5	99	
White sand	28	127	
Black slate	28	155	
Gray sand	15	170	
Light slate	17	187	
Coal	3.5	190	
Light slate	20	210	
Sand	3	213	
Light slate	85	298	
Light sand	22	320	
Light slate	5	325	
Light sand	22	347	
Slate	183	530	
Dark sand	5	535	
Black slate	45	580	
White sand	124	704	Beaver sand.
Light slate	10	714	
White sand	129	843	Horton sand.
Light slate	5	848	
White sand	67	915	Pike sand.
Coal	3.5	918	
Sand	35.5	953	
Dark slate	5	958	
Gray sand	19	977	
Black slate	87	1,064	
Sand	49	1,113	Salt sand.
Black slate	3	1,116	

No. 9.—Burning Well Across the River From Warfield.

	Thickness	Depth.	
Soil	26	26	
Light slate	46	72	
White sand	44	116	
Coal	5	121	
Light slate	80	201	
White sand	18	219	
Black slate	20	239	
White sand	20	259	
Light slate	57	316	
Black slate	50	366	
Light slate	75	441	
White sand	130	571	Beaver sand.
Light slate	15	586	
White sand	46	632	Horton sand.
White slate	20	652	
White sand	112	764	Pike sand. Base of Pottsville.
Shelly slate	55	819	
Red shale	30	849	
Light slate	5	854	
Red shale	25	879	
Light slate	15	894	
Hard sand	18	912	
Red shale	10	922	
White sand	24	946	Mauch Chunk.
Red shale	4	950	
Light slate	22	972	
Lime	4	976	
Slate	10	986	
Red shale	2	988	
Shelly slate	20	1,008	
Sand	30	1,038	
Limestone	162	1,200	Greenbrier.
Slate and sand shells	138	1,338	Big Injun sand.

Record started just below the Warfield coal and shows another coal 116 feet down and the Beaver, Horton and Pike sand. The Salt sand is cut out and the base of the Pottsville is at 764 and the section shortened at the bottom of the Pottsville. The Mauch Chunk and Greenbrier are shown in full thickness. From the top of the Beaver sand to the base of the Pottsville is only 323 feet.

No. 10.—Well on Caney Fork of John's Creek.

	Thickness	Depth	
Soil	42	42	
Slate	30	72	
Gray sand	32	104	
Slate	216	320	
Gray sand	35	355	
Slate	66	421	
Sand	57	478	
Slate	13	491	
Lime	8	499	
Sand	9	508	
Lime	5	513	
Sand	8	521	
Slate	20	541	
Sand	22	563	
Slate	12	575	
Sand	65	640	Beaver sand.
Slate	15	655	
White sand	230	885	Horton sand.
Slate	30	915	
Sand	421	1,336	Pike and salt sands.
Red rock	18	1,354	
Slate	5	1,359	
Sand	77	1,436	Mauch Chunk.
Red shale	8	1,444	
Red shale and slate	56	1,500	
Limestone	240	1,740	Greenbrier.
Slate	55	1,795	
Sand	80	1,875	Big Injun.
Slate	260	2,135	

Record started below the Van Lear coal and shows base of Pottsville at 1,336 and the Mauch Chunk and Greenbrier both well developed. Distance from top of Beaver sand to base of Pottsville 761 feet.

No. 11.—Well on Big Creek, Pike County.

	Thickness	Depth
Soil	24	24
Slate	10	34
Gray sand	12	46
Dark slate	8	54
Gray sand	35	89
Slate	10	99

Gray sand	21	120	
Dark slate	4	124	
Sand	15	139	
Dark slate	46	185	
Limy sand	15	200	
Gray sand	55	255	
Slate	80	335	
Coal	4	339	
Sand	42	381	
Slate	64	445	
Lime	10	455	
Slate	30	485	
Black sand	10	495	
Slate	15	510	
Sand	75	585	
Slate	15	600	
White sand	355	955	Beaver sand.
Slate	27	982	
Gray sand	83	1,065	Horton sand.
White sand	47	1,112	
Coal	3	1,115	
White sand (salt water)	134	1,249	Pike sand.
Coal	3	1,252	
Sand	12	1,264	
Slate	24	1,288	
White sand	152	1,440	Salt sand.
Black slate	24	1,464	
White sand (salt water)	61	1,525	
Limestone	215	1,740	Greenbrier.
Dark sand	25	1,765	
Slate	15	1,780	

This well is the farthest to the southeast and shows the thickening in the lower part of the Pottsville section. The base of the Pottsville is shown at 1,440. The Mauch Chunk is practically cut out, although shown in full thickness in the last record. The thickness of the Pottsville below the top of the Beaver sand is 840 feet, the greatest of the series of records.

STRUCTURE.

The structure in this region is in the main simple but modified to a great extent by several distinct features. The country may be considered as a great table land sloping more or less rapidly to the north and north-

west from the crest of Pine Mountain but deeply eroded, with high ridges and narrow valleys and still further modified by other folds and uplifts in addition to the great Pine Mountain fault.

PINE MOUNTAIN.

This great barrier which extends in an unbroken line from the water gap at Pineville in Bell County northeast to the Breaks of Sandy in Pike County has been too often described to need more than a brief mention of its principal features. Originally an anticlinal fold, it broke near the line of the present crest of the mountain and was lifted on the southeast side with a vertical displacement of nearly 2,000 feet, exposing on the northwest slope for the greater portion of its length rocks from the Silurian up to the Pottsville sandstones which form the present crest. These lower rocks are exposed to within a few miles of the Breaks of Sandy but from that point to the Breaks the displacement is not so great, the section at the Breaks showing only the Pottsville sandstones (with possibly a few thin coals) of the base of the Kanawha Group and the upper part of the New River Group. From the Breaks to the northeast the fault soon diasppears and the mountain becomes a fold with its axis dropping to the northeast. In the region under discussion Elkhorn creek runs parallel and close to the foot of the mountain from the main head of the Kentucky River at Payne's Gap and Pound Gap to the Big Sandy River near the Breaks, cutting a deep valley between the Pine Mountain and the Coal Measure rocks just to the northwest. These coal measure rocks which include a total thickness in the highest portion (the Flatwoods area) of over 2,000 feet, are dipping rapidly to the northwest on what was before the break the northwest flank of the old Pine Mountain anticlinal fold. This dip together with the corresponding thinning of the measures themselves, as shown above, brings the Elkhorn coal down from its highest elevation of 1,720 feet A. T. just above the mouth of Marshall Branch of Elkhorn creek to about 800 feet A. T. at the foot of the anticlinal slope.

The base of this rapid dip is approximately on a line drawn from above Williamson on the Tug Fork and roughly parallel to the crest of Pine Mountain, to near the mouth of Steele's creek of Right Beaver and crossing Levisa Fork below Stone Coal Creek. Conversely the more rapid rise of the measures toward Pine Mountain begins approximately at this line.

The main northwest slope, however, is only general and is modified by local changes and to a greater extent by the fold next to be described.

The D'Invilliers Anticline.

This is an anticlinal fold first described by D'Invilliers in a report on the Elkhorn coal field made some years ago and drawn by him on a map accompanying that report. As given by him and determined by contours run on coal openings, the fold ran from Shelby Gap with a curving axis in a generally northeast direction to Russell Fork of Big Sandy River a short distance above where Russell Fork joins Levisa Fork. The elevations given on his map are not correct, but it is assumed that the direction and shape of the anticline is about as given. He shows a long uninterrupted slope from the axis of the fold to the northwest and a decided syncline or basin on the southeast between the anticline and Pine Mountain.

More recent developments show that the axis instead of curving sharply in to Shelby Gap, as he shows it, extends in a nearly straight line southwest to a summit on Marshall Branch of Elkhorn and probably extends in the other direction further to the northwest as indicated on the accompanying map of that region.

Warfield Anticline.

At Kermit, which is a station on the Norfolk and Western Railroad, just opposite Warfield, Ky., is a well marked anticline known in West Virginia as the Warfield anticline. The direction of the axis of the anticline is about S. 60° W. The crest crosses Tug Fork just above Kermit and brings the Warfield coal above high water mark there. The measures dip sharply to the northwest and southeast from Kermit, the Warfield coal going below drainage again a short distance below Kermit and going under up the river near the mouth of

Wolf Creek, which comes into the river from the Kentucky side. Just above where the coal goes under near Wolf Creek a fault brings it up again but it rapidly disappears with the fall in the measures up Tug Fork. This anticline and fault crossing into Kentucky forms what is locally known as "The Breaks" (this is not the same locality, however, as the Breaks of Sandy), and it is along this fold that the numerous gas wells which are now supplying Central Kentucky and the region down the Big Sandy and Ohio Rivers with natural gas have been drilled. Prof. Crandall calls the fold at Paintsville on the Levisa Fork the continuation of the Warfield anticline. This, however, seems to be an error. The Paintsville fold is a part of the Paint Creek uplift to be described further on, while the Warfield anticline continues in the direction of Prestonsburg, flattening down, however, and crossing Levisa Fork with its crest at the mouth of Middle Creek. The arch can be plainly seen dipping in both directions along the Chesapeake & Ohio Railroad from the mouth of Middle Creek.

West of Levisa Fork the anticline has not been definitely traced.

The Paint Creek Uplift.

In a report issued some years ago by the Kentucky Geological Survey, Prof. Crandall described what he calls the "great Conglomerate uplift" in the western portion of Johnson County by which the Conglomerate sandstone, as it was known at that time, was brought sharply above drainage on the waters of Paint and Big Blaine Creeks, but Prof. Crandall evidently did not appreciate its full significance. Owing to its prominence on Paint Creek this will be known hereafter in these reports as the Paint Creek Uplift. Full details in regard to this uplift remain to be worked out, but it seems to have been an old fold, or rather escarpment, in early Pottsville times with a steep slope on the east side and a much more gradual one on the west and extending from near the head of Kentucky River a little west of north to the great bend in Paint Creek near the mouth of Little Paint and probably still further north. The dikes in Elliott County are directly on the line of this old fold, as is an old axis which is known to exist in Carter and Greenup Counties, but any possible connection with these remains to be proved. Against the eastern slope of this fold the lower Pottsville measures were laid down unconformably the higher and later measures going across the top. On the eastern slope the waters of the Big Sandy cut down deeply while on the much more gradually sloping western flank the Licking River waters were held at a much higher elevation, the valleys being today several hundred feet higher than the opposite valleys on the Big Sandy side. Later movements have further folded the rocks along this axis producing an anticline along the divide between the Licking and Big Sandy which culminates in an immense dome on Paint Creek and the headwaters of Blaine, where the lower Kanawha standstones are brought 200 feet above the surface. From this dome the measures dip rapidly in all directions and it is the eastern flank of this dome which causes the rapid dip up and down the Levisa Fork from Paintsville. To the southeast from Paintsville the transverse axis of this dome also continues to dip toward Tug Fork merging gradually into the Warfield anticline.

Between the Warfield anticline, with the rocks dipping to the southeast on its southeastern flank and the line mentioned above as the foot of the old Pine Mountain anticline where the measures begin to rise sharply toward Pine Mountain, there is a reversal of dip and the rocks lie in a wide shallow synclinal fold broken by very small local folds. This syncline is also approximately parallel to the crest of Pine Mountain.

The main features of structure along the two forks of Big Sandy River are then as follows:

On Levisa Fork a sharp dip from Paintsville down stream, a more moderate dip up stream and a rather rapid dip across toward Tug Fork, all three being caused by the eastern limb of the Paint Creek uplift. Going down stream the Van Lear coal (which is about 120 feet above the river at Paintsville) goes under the river just below Offutt. Going up stream the same coal goes below the railroad just above Mary Luck mine above Auxier, while the S. E. dip takes it under going up Buffalo Creek. Between the Mary Luck mine and the mouth of Abbott Creek there is a syncline with a reversal of dip and the coal comes up to within 15 feet of the railroad at the mouth of Abbott rising rapidly from that point with the Warfield anticline to the mouth of Middle Creek where it again reverses with the eastern flank of the anticline and goes below the railroad again at the mouth of Bull Creek. From this point the coal rises and falls in small local folds going below the railroad again near the mouth of Prater Creek in the synclinal trough which extends across from Tug Fork, rising again above the railroad near the Betsy Layne mine and continuing to rise gradually to the foot of the sharper rise near the Steel Coal Company mines. From this point the measures rise sharply as described above toward the crest of the old Pine Mountain fold but with a reversal of dip in the D'Invillier syncline near Marrowbone Creek. At the State line, near the Breaks, the Van Lear coal is high in the hills and the lowest exposed Pottsville sandstones (with the exception of those in the face of Pine Mountain) come to the surface.

On Tug Fork the Warfield anticline crosses at Kermit, as already described, and the Warfield coal goes under the river near the mouth of Wolf Creek. From this point the rocks are in a wide shallow trough with small local folds to or near Borderland. The measures then rise gradually and the Freeburn (Warfield?) coal comes above the river at the mouth of Turkey Creek and to railroad level at Sycamore. Above the latter point the rapid rise up the river sets in with a still more rapid rise up the main creeks bringing up the lower measures as on Levisa Fork with the Freeburn coal high in the ridges.

On the waters of the upper part of the North Fork of Kentucky River the measures rise rather rapidly toward the head of the rivers, the Fire clay coal which is about 250 feet above the river at the mouth of Rockhouse Creek rising to nearly the level of the gap where the road from McRoberts to Jenkins crosses the divide between North Fork waters and Elkhorn Creek.

Nomenclature.

Under the old system adopted by the Geological Survey the coals were described numerically beginning with No. 1, which was the first coal above the so-called

Conglomerate and the formations below were all included in what was called the Conglomerate Measures. This system is continued in use to a great extent in the Big Sandy Valley today and is the source of great confusion in the correlation of the different seams. Prof. Crandall, for instance, identified the main coal at Paintsville as the No. 1 of the Geological Survey. If, however, as the lower coals come up above drainage going up the river and also become workable, as they do, and the lowest one there is called No. 1 as is sometimes done, it is evident that the ascending numbers will apply to different coals in different sections. The continuity of different coal beds over a wide area is often supposed but is not borne out by the facts. The seams increase and decrease in thickness, new seams come in, others disappear, even in local basins, and the best that can be attempted in name designations is to approximately correlate the general coal horizons giving such local names as are available and correlating these as closely as possible with coals at approximately the same horizon in other basins. It is extremely doubtful if the coal at Paintsville, Miller's Creek, etc., called No. 1 by Professor Crandall, really represents the seam known as No. 1 on the western border of the coal field. It is true that on the northwestern and western edges of the coal field the old No. 1 is a coal at a very persistent horizon and is rather easily correlated, but it has gone under drainage in the western part of Breathitt County on the Kentucky River and everywhere to the west of Big Sandy River drainage and at no point can it be positively carried through to the waters of Big Sandy or to where it should be above drainage again on the head waters of the Kentucky River. In addition to this, as mentioned above, lower coals are coming in both on the Big Sandy and the Upper Kentucky. There are two above drainage and below the so-called No. 1 at Paintsville and the number increases going up Big Sandy. A numerical notation will no longer be followed in these reports and for this coal which Crandall calls No. 1, and which is so prominent in the local basin on the waters of Greasy, Buffalo, Paint, Miller's and John's Creeks, instead of No. 1, the designation "Van Lear" coal from the locality at Van Lear on Miller's Creek, where it probably has its

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best development, will be used and for other coals local names, correlating them in different basins as nearly as may be.

THE WARFIELD COAL.

This coal is brought up, as described above, by the Warfield anticline at Warfield and Kermit on Tug Fork of Big Sandy. It has been correlated by Professor Crandall with the Van Lear coal on the Levisa Fork and the Vulcan-Freeburn seam further up Tug Fork. This coal, however, is rather difficult to correlate with any other definitely, as it goes under drainage rapidly in every direction and does not come up again for some distance. It is quite likely that Professor Crandall's correlation with the Van Lear and Freeburn is correct, although numerous records of drilled wells in that section report a thick coal below the Warfield which might correspond to the Van Lear, which is known to be dipping to the east where it goes under drainage on the head of Buffalo Creek. Prof. White also correlates the Warfield coal with the Freeburn of Tug Fork and with the No. 2 Gas of West Virginia. If it really is the No. 2 Gas is a question to be determined by the West Virginia Survey; what is of more importance on the Kentucky side is what Kentucky coal it correlates with. A suggestion may be made later on as to its correlation with the No. 2 Gas, but for this report it will simply be called the "Warfield" coal with a provisional correlation with the Van Lear on the west and the Freeburn on the south.

THE VULCAN-FREEBURN COAL.

On Tug Fork at the mouth of Turkey Creek a coal comes above drainage which, as explained above, has been correlated with the Warfield and Van Lear. It rises rapidly up Tug Fork after it comes above drainage and is worked at Vulcan and other places under the names Vulcan, Freeburn, Majestic, etc. In this report it will be referred to as the Freeburn seam and correlated with the Van Lear coal of Johnson County. The Johnson County basin and the Tug Fork are rather widely separated, but this horizon is a well marked one, the coal is found at other points between and there is is not much doubt about their relation. The name "Van Lear," however, will be applied locally to the Levisa Fork district and "Freeburn" to the Tug Fork. In a former report on the coals of the Big Sandy, Prof. Crandall identifies this Van Lear-Freeburn seam with the Syck coal at Pikeville. In a later report on the coals of the Tug Fork, however, he makes it a higher coal than the latter and correlates it with the "Lower" Elkhorn which, as will be shown later, is rather indefinite, there being several different coal seams in this region which have been referred to as "Lower" Elkhorn. Other writers have correlated this same coal simply as "Elkhorn." It's true relation to the Elkhorn coal will be shown later on.

Upper Coals on Tug Fork.

Above the Freeburn coal on Tug Fork are a series of coals which have been given the names Alma, Lower Thacker, Upper Thacker and Winifrede in ascending order on the West Virginia side. For the present these names will continue to be used for the same coals on the Kentucky side in the Tug Fork region, correlating them wherever possible with local names in the sections to the west and southwest.

The Fire Clay or Hyden Coal.

This is one of the most persistent and well-marked horizons found in Eastern Kentucky and can be identified by its peculiar flint clay parting over a very large area. Known there as the Deane coal, it is found on the Upper Cumberland waters, and on the Kentucky river (where it is also called the Hyden) it is found from where it comes above drainage in the western edge of Perry County, rising gradually above the stream to about 250 feet above at the mouth of Rockhouse and 400 feet above the Elkhorn coal at the head of the river. It is above drainage on the head waters of Licking River and is found over the ridge on Beaver Creek and also across Levisa Fork on Stone Coal creek, but has not as yet been definitely traced across on to Tug Fork or down the river to Johnson County. The Fire Clay coal and its rider (there close together) form the "Flatwoods" coal at the head of Marrowbone Creek in Pike County.

The name Hyden or Fire Clay will be retained for this seam on Levisa Fork.

For the coals above the Fire Clay or Hyden coal, the names Haddix, Hazard, Flag and Hindman, as proposed by Mr. J. M. Hodge, will continue to be used for those coal seams on the drainage of the Kentucky River and corresponding correlations will be carried across to equivalent seams on the Big Sandy River wherever possible.

The "Elkhorn" Coal.

In his first report on the coking coal region at the heads of Kentucky River and Elkhorn and Shelby Creeks (Report on the Pound Gap Region, Kentucky Geological Survey), Prof. Crandall describes the main coking coal of that section as the "Elkhorn" coal and places it in the series from 70 to 115 feet above the Sand Lick coal of the Upper Kentucky River and correlates the latter coal (Sand Lick) with the No. 1 coal of the Geological Survey. Later he and Mr. J. M. Hodge correlated this "Elkhorn" coal with the old No. 3 of the Kentucky Geological Survey Reports. In a still later report (Bulletin No. 4—Kentucky Geological Survey), Professor Crandall in his sections on Big Sandy River, speaks of the "Elkhorn" coal and the "Lower" Elkhorn coal rather indiscriminately. In the same report when treating of the coals on Marrowbone Creek he mentions "the Elkhorn seam proper, the "Lower" Elkhorn of this district, and gives an "Upper" Elkhorn about 200 feet above it and says the latter is also a coking coal. Again, when writing on the coals on the waters of Shelby, Mud and Beaver creeks in this same report, he speaks of the "Elkhorn" coal and the "Upper" and "Lower" Elkhorns, and on the section devoted to the heads of the North Fork of Kentucky River and Elkhorn and Shelby Creeks in the same reports, he calls the main coking coal of that region (the Jenkins-McRoberts coal) the "Lower" Elkhorn and describes a coal about 140 feet above it as "probably" the Upper Elkhorn. From this he would seem to either correlate the main coking coal at the head of Elkhorn, which he there calls the "Lower" Elkhorn, with the lower coal worked on Marrowbone Creek, which he also calls Lower Elkhorn, or else he has two sets of Upper and Lower Elkhorns, one at the head of Elkhorn and one on Marrowbone. His reports are very hazy in regard to the actual correlation of these coals and it is practically impossible to determine from them just what he does mean and he is especially indefinite in regard to what he calls "Upper" Elkhorn, but is positive that the Jenkins-McRoberts coking coal is Lower Elkhorn. In his last report (coals of the Tug Fork Region, Kentucky Geological Survey, 1909), Prof. Crandall correlates the Warfield, the Paintsville (Van Lear) and the Freeburn with the "Lower" Elkhorn and the Upper Elkhorn with the old No. 5 of the Geological Survey, and with the Broas and Thacker seams.

In a report on the Coal Resources of the Russell Fork Basin by Ralph W. Stone, U. S. Geological Survey, 1908, Mr. Stone describes the two Marrowbone Creek coals as the Upper and Lower Elkhorn respectively, and says they are 160 to 180 feet apart, and, tracing them up Elkhorn Creek, makes his Lower Elkhorn go under drainage just above the mouth of Marshall's Branch, and calls the thick coking coal at Jenkins, which he correlates with the upper coal on Marrowbone, Upper Elkhorn, although Professor Crandall always calls it in that section either "Elkhorn" or "Lower" Elkhorn, and gives a higher coal there as the Upper Elkhorn.

In all other reports issued by the Geological Survey the attempt is made to correlate Crandall's Lower Elkhorn, the thick coal at the head of Elkhorn Creek, with the old No. 3 coal, although it really is a lower coal than that seam. In numerous private reports on the Upper Big Sandy Region, including the coking coal region, the term "Elkhorn" is applied to several thick coals with a vertical range of 300 to 400 feet. In this and following reports the two coals on Marrowbone will be called Lower and Upper Marrowbone, and there will be no attempt at a distinction between Upper and Lower Elkhorn. There really appears to be no Upper Elkhorn as distinguished from Lower Elkhorn and the thick coking coal now being worked at Jenkins and McRoberts

and its extension in other sections will be known simply as the Elkhorn coal. On the North Fork of Kentucky River a coal comes above drainage about the mouth of Smoots Creek and rises up the river with the rapid rise in the measures mentioned above. This coal is well exposed on Sand Lick Creek below Whitesburg and to it Prof. Crandall gave the name Sand Lick coal, but called it 70 to 115 feet below the Elkhorn coal. Later Mr. J. M. Hodge gave a coal which is well developed along Rockhouse Creek the name "Rockhouse" coal which is the same seam as the Sand Lick coal. As seen on Sand Lick Creek, this coal is split in two benches by a thick parting of shale and has a thin coal about 30 feet above it and another about the same distance below it. The two benches are still wide apart at Whitesburg, where the coal is about 140 feet above the river and has been worked for local use. As the coal rises going up the river the two benches come closer together until at the mouth of Colly Creek and of Shop Branch the parting is only about 12 inches thick. This rapidly thins out going up the river and at the mouth of Webb Branch—the next branch of North Fork above Shop Branch, it has nearly disappeared and the coal is nearly 4 feet thick. On the head of Colly Creek the parting is still about 12 inches in thickness, but going across from Colly on to Thornton and Millstone it disappears and the coal also thickens down the latter two creeks becoming a solid vein of over 5 feet in thickness at the mouth of these creeks. Followed up the river, this seam becomes the Elkhorn coking coal of the McRoberts-Jenkins district. Above and below this coal at Whitesburg and other points is a thinner coal and still lower another coal. This latter is in the river bed at Whitesburg under a massive sandstone and has been worked for local use. These coals rise with the Elkhorn coal up the river and are found at the proper interval below the latter, but the lowest one is under drainage at McRoberts and Jenkins. The relation of these coals to the Elkhorn coal is quite an important one for correlation as will be seen later on.

On the waters of Levisa Fork, in Johnson County, are found three coals, the lower one of the three being the Van Lear coal. The next above is a thinner coal which is well exposed along the railroad in the syncline from above Prater's Creek to below Mud Creek, and will be called the Ivel coal from the station of that name where it is well developed. Above this again is a thicker coal which on Tom's Creek and Greasy Creek is quite prominent. The interval between the lower and upper of these three coals generally varies from 120 to 160 feet, always with the thinner coal between them. The lowest one of the three is the Van Lear coal; the other two under the old nomenclature by which the Van Lear was called No. 1, would be No. 1-A and No. 2.

These three coals are persistent all over the Big Sandy Valley, from Greasy Creek up, and are also found on the North Fork of Kentucky River, where the lower one (Van Lear) corresponds with the lowest of the coals at Whitesburg (the one in the river under the massive sandstone), and the upper one of the three becomes the Elkhorn coal. With some variations in thickness and the intervals between them they can be followed over on to Tug Fork where the lower one of the three becomes the Freeburn seam and the upper one seems to correspond with the Alma of that section. The Elkhorn coal then is the thick coal at Jenkins and McRoberts, the Rockhouse or Sand Lick coal of North Fork and the Alma coal of the Tug Fork section, while the Van Lear coal is the old No. 1 or Wheeler or Miller's Creek coal of Johnson County, provisionally the Warfield, the Vulcan-Freeburn seam, the Keyser coal of Levisa Fork and the lowest coal at Whitesburg.

THE MARROWBONE CREEK COALS.

On Marrowbone Creek are two coals which Crandall and Stone in his report (U. S. Geological Survey) called Upper and Lower Elkhorn, and which Stone endeavors to correlate the lower one with a coal going under Elkhorn Creek at Marshall Branch and the upper one with the Jenkins coking coal. On his map he gives the elevation of the lower one as about 1,350 feet above sea at the head of Cassel's Fork and the upper one 180 to 200 feet above that. These elevations are not correct, being considerably greater than they should be. It is possible that he was misled by these elevations in his correlation of these two coals with the two at the head

of Elkhorn Creek, but at any rate, his correlation is not correct and the two Marrowbone coals are both lower coals than the Elkhorn, and should, therefore, not be called "Elkhorn" at all. Following his correlation these coals in their eastward extension across to Tug Fork have also been called Upper and Lower Elkhorn with the result of having two sets of Upper and Lower Elkhorns, viz., these two and the Jenkins coal which is above these two and which Crandall called Lower Elkhorn and a somewhat mythical still higher coal, which he called Upper Elkhorn. Between these two fields on Upper Shelby Creek are two coals which Crandall called Upper and Lower Elkhorn, which he did not definitely connect in any other way with the other field. It is quite likely that the lower one of these was the Upper Marrowbone coal and the upper one the Elkhorn coal.

On Levisa Fork a coal comes up above drainage some where near the mouth of Stone Coal Creek and rises rapidly above the river becoming locally workable in places. This coal is about 180 to 200 feet below the Van Lear coal and on Little Chloe Creek, near Pikeville, is known as the Syck coal. Further up Levisa Fork it becomes in places quite a prominent seam being known as the Jim Dotson or Fed's Creek coal. This coal is the Lower Marrowbone coal and the Upper Marrowbone coal is the Van Lear or Freeburn coal. On Marrowbone Creek the Elkhorn coal would came very high in the hills probably about 140 feet above the Upper Marrowbone or Freeburn coal. This interval increases toward Tug Fork where the two coals are 165 feet apart instead of about 140 feet as on Kentucky River.

The correct correlation of these coals then is:

Elkhorn Coal—(Thick coal on the heads of Elkhorn creek, of North Fork, of Shelby creek and of Beaver creeks.)

Interval 120 to 165 feet.

Upper Marrowbone Coal—(The Van Lear, Freeburn, Vulcan, Warfield seam)

Interval 160 to 180 feet.

Lower Marrowbone Coal—(Syck, Jim Dotson or Fed's Creek coal.)

These coals are all three coking coals and all valuable seams, and, as with all other coals, each of more prominence and value in local basins.

On Greasy Creek and its branches a coal is found about 140 feet above the Van Lear. It is opened in the point of the hill at the mouth of Old House Branch of Greasy at an elevation of 140 feet above the mouth of the branch, the Van Lear coal being just at drainage at the mouth. The section there is:

Coal	21″
Shale and bone	2 to 4″
Coal	17″
Cannel coal	4″

Other openings up the creek show a similar bed section. This is the seam which is the upper one of the three coals mentioned previously of which the Van Lear is the lowest. Between the two but at somewhat varying intervals is found a thinner coal, the middle one of the three, which runs from 24 to 36 inches in thickness and is about at the horizon of the Powellton coal of Tug Fork and West Virginia. The Peach Orchard coal has not been opened at many points on this creek, but several openings at an elevation of about 200 feet above the Van Lear coal and with generally a thinner coal below probably represent this bed. One of these old openings is on the Marion Pack land and another at what is known as the Phoenix entry.

At the first the section is:

Coal	24″
Slate	3″
Coal	20″

and at the other—

Coal	18″
Slate	3″
Coal	24″
Slate	½″
Coal	4″

At an elevation of about 240 feet above the Van Lear coal is found the Two Mile cannel coal now operated by the Sandy River Cannel Coal Company at the head of The Right Fork of Two Mile. The coal is transported over a narrow gauge railroad to the Chesapeake & Ohio Railroad at Offutt. The mine is about 40 feet below the

low gap where the wagon road crosses from Two Mile on to Buffalo. As mined here the vein averages 40 to 46 inches, showing a 20 to 24 inch block of fine cannel overlaid by about the same thickness of soft coal. An analysis of the cannel coal by the Kentucky Geological Survey gives:

Water	0.75
Combustible matter	58.69
Fixed carbon	39.64
Ash	5.10

On the next workable coal above, the Broas coal, the old openings seem to have all fallen in and the vein could not be seen. It is reported to be a good coal about four feet thick. At the heads of the main forks of Greasy the "big vein" of this section, the old "F" coal of the Broas region on Rockcastle, has been opened with its usual character and thickness, but too high in the ridges to be of commercial importance. Prof. Crandall also reported a 40 inch coal as about 60 feet below this seam, but was a little doubtful as to its correlation.

TOM'S CREEK—JOHNSON COUNTY.

On this creek the vertical section of the rocks is about the same as the lower part of the section across the river on Greasy Creek, the three coals, the Van Lear and the next two above, being well developed and opened at a great many places. The measures rise up the creek with the Paint Creek dome and the ridges do not, therefore, carry as much of the upper part of the section as on Greasy Creek. The Van Lear coal is the one underlying the largest portion of the territory lying as it does near drainage and rising with the creek from the mouth to near the head. At the mouth of the creek it is opened along the river bank below high water mark and dipping rapidly down the river, going under near River Station, as mentioned above. As opened here it is of excellent quality, but not up to the average thickness. Up the main creek and its branches it is opened at a great many places showing a rapid improvement in thickness of the vein going up the creek, but apparently thinning down again on the head waters. It shows from 40 to 48 inches in thickness of good clean coal without a parting in fairly large areas between the head and the mouth of the creek particularly on Rush Branch and Road Fork.

Following are some of the openings:

Mouth of Tom's Creek	30"
James Vanhoose below mouth of Road Fork	42"
Harry Vanhoose	36"
Abraham Gibbs on Road Fork	42"
George Daniels on Baker Branch	30"
Susan Meadows on Whippoorwill Branch	32"
William Hampton	34"
Isaac Dixon on Rush Branch	43"
Dogwood Fork of Sycamore Fork	36"
One half mile above Sycamore Fork	32"
Head of Tom's Creek	29"

The Ivel coal, the coal between the Van Lear and the third coal in the section noted on Greasy Creek, is present also on Tom's Creek, with an increased thickness and a somewhat greater interval between. This is in places a good workable coal and may be easily mistaken for the Van Lear coal. In its best development as opened, it is found on the head of Rush Fork and the main head of Tom's creek, although further prospecting may show it to be of good thickness in other places. Above this and about 160 feet above the Van Lear coal instead of 140 feet as on Greasy Creek, is found the third coal with about the same bed section as on Greasy Creek. One mile from Sitka on the Rush Branch road this coal is opened in the point of the hill about 160 feet above an opening on the Van Lear coal, with the bloom of the middle coal showing between the two. The bed section is:

Coal	21"
Bone and shale	2"
Coal	21"

In the divide at the head of Sycamore Fork of Tom's Creek the full section from below the Van Lear

coal to the heavy sandstone above the Two Mile cannel coal, can be seen on the road crossing at the gap.

The section is:

Massive S. S.	
Coal.	
Interval about 40 feet.	
Coal (opened at level of gap)	Interval 50 feet.
Thin coal	
Coal with parting	
Thin coal	Interval 160 feet.
Ivel coal	
Thin coal	
Van Lear coal	
Creek bed.	

The coal opened at the level of the gap is apparently at the horizon of the Two Mile cannel coal. The massive standstone above it caps the hills which are not high enough to carry the upper coals.

BUFFALO CREEK, JOHNSON COUNTY.

With the exception of the Van Lear coal and some openings on the Two Mile cannel coal on the Buffalo side of the ridge, but little is known of the coals on Buffalo Creek. The Van Lear coal is opened all the way up the creek from the mouth to a short distance above the mouth of Stone Coal Branch, going under drainage about a quarter of a mile below where the road from Two Mile strikes the main creek. It is also opened along all the side branches below this point. The rapid fall of the creek together with the gradual rise along the axis of the Paint Creek dome brings this coal about 50 feet above high water at the mouth of the creek, its elevation there being greater than on Tom's and Greasy Creeks owing to the rise of the strata up the river.

Elevations taken from actual levels show the coal rising from all directions to the summit of a small dome on Road Fork of Bob's Branch. In thickness the seam varies very considerably; measured at different points it is as follows:

Along the lower part of the creek	30 to 36"
On Right Fork at foot of Miller's creek hill	48"
At schoolhouse on Main creek	36"

At Sam Preston's	30 to 38"
At David Wells	48"
At Wards'	36"

At other places, particularly up the creek where it goes under drainage it is squeezed down by the overlying sandstone and is very thin and practically worthless.

Elevations, above tide, of some of the openings on the Van Lear coal on Buffalo are as follows:

At mouth of Buffalo	663 feet
One fourth mile up Buffalo	652 feet
Mouth of Bob's Branch	678 feet
Mouth of Sam Preston's Branch	669 feet
Mouth of Deadfall	659 feet
Mouth of Stone Coal Branch	640 feet
Three fourths of a mile up Bob's Branch	670 feet
Mouth of Road Fork of Bob's Branch	688 feet
Three fourths of a mile up Road Fork	691 feet
On river opposite head of Road Fork	665 feet

The intervals between the coals in the Upper part of the vertical section on Buffalo Creek appear to be somewhat greater than on Greasy Creek, agreeing with the thickening of the section to the southeast as shown later.

THE PAINTSVILLE COAL.

At Paintsville the Van Lear coal is brought up by the Paint Creek dome to about 120 feet above low water in the river, dipping both up and down the river from the axis which latter crosses the river near the Acrogen mine just below Paintsville. The coal is mined by the North East Coal Company at three mines, the Acrogen, on the river front below the mouth of Muddy Branch, and on the right and left forks of Muddy Branch. The coal has its usual character and thickness running on an average nearly four feet, sometimes cut down in the mine to about 30 inches. The company has modern plants and a large output of excellent steam and domestic coal.

MILLER'S CREEK—JOHNSON COUNTY.

The splint and block coal of the Paintsville region is seen at its best development, both as to thickness and

workable area, on this creek and at the mouth of John's Creek, and forms the basis of the large development and production of the Consolidation Coal Company at the mouth of Miller's Creek. The company has bridged the Big Sandy River and built the mining town of Van Lear on the east side of the river, and put in a first-class, modern mining plant. As mentioned before, owing to its prominence in this locality, this coal will hereafter in these reports be called the Van Lear coal and is the same coal as worked on Greasy Creek, at Paintsville and at Auxier, at the mouth of John's Creek. The elevation of the coal at the mouth of Miller's Creek is 675 feet A. T.; it is dipping gradually up the creek going under drainage about three miles above the mouth at an elevation of about 635 feet, showing an easterly dip of about 15 feet to the mile. Numerous openings along the creek show it to be a good clean coal, free from partings and from 48 to 60 inches thick.

Following are analyses of this coal made by different chemists and at different times:

	Semet-Solvay Co.	McCreath.	Wuth.
Water	3.75	2.412	1.29
Volatile matter	37.90	38.436	35.95
Carbon	56.10	56.713	58.41
Ash	2.25	1.830	3.27
Sulphur	0.57	0.557	0.58

A very complete test of the run of mine of this coal was made by Justus Collins and a copy furnished the Survey through the courtesy of Mr. J. C. C. Mayo. The test is as follows:

Analyses.

Sample	No. 1	No. 2	No. 3
Air drying loss	4.50	4.20	2.20
Moisture	6.95	6.52	5.12
Volatile matter	35.03	34.42	36.49
Fixed carbon	55.99	56.80	55.63
Ash	2.03	2.26	2.76
Sulphur	0.48	0.45	0.57

Ultimate Analysis.

Hydrogen	5.47
Carbon	77.20
Nitrogen	1.45
Oxygen	12.55

B. T. U. 13,687

Gas Analysis.

Coal	Per cent.	Gas	Per cent.
Moisture	4.49	Carbon Dioxide (CO_2)	7.7
Volatile matter	36.82	Carbon Monoxide (CO)	23.6
Fixed carbon	55.23	Hydrogen (H_2)	16.6
Ash	3.41	Methane (CH_4)	2.9
Sulphur	0.51	Nitrogen (N_2)	49.2

Boiler Test No. 1.

Duration of test....10.02 hours
Average diameter of lump coal.... 1.14 inches
Kind of grate....plain
B. T. U. per lb. dry coal....14445
Per cent of rated H. P. of boiler....89.4
Efficiency....67.39
Water evaporated per lb. of coal.... 7.91

Equivalent Water Evaporated:
Per pound of coal as fired.... 9.50
Per pound of dry coal.... 9.96
Per pound combustible....10.42

Furnace temperature ....2412° F.

Equivalent lbs. of coal used per I. H. P. hour at steam engine:
Dry....2.84
As fired....2.98

Equivalent lbs. of coal used for E. H. P. hour developed at switchboard:
Dry....3.51
As fired....3.68

Dry coal burned per square foot of grate surface per hour....16.03

Analyses of Coal.

Proximate		Ultimate	
Moisture	4.69	Carbon	81.18
Volatile matter	35.63	Hydrogen	5.16
Fixed carbon	56.56	Oxygen	8.41
Ash	3.12	Nitrogen	1.52
Sulphur	0.44	Sulphur	0.46
		Ash	3.27

Equivalent pounds of water evaporated per square foot of water heating surface per hour.... 3.19

Boiler Test No. 2.

Duration of test....10.02 hours
Average diameter of lump coal.... 1.12 inches
Kind of grate....plain

B. T. U. per pound dry coal....14512.
Per cent. of rated H. P. of boiler....87.6
Efficiency....66.81
Water evaporated per pound of coal as fired.... 7.83

Equivalent Water Evaporated:
Per pound of coal as fired.... 9.37
Per pound dry coal.... 9.86
Per pound combustible....10.33

Furnace temperature 2426° F.

Equivalent pounds of coal used per I. H. P. hour at steam engine:
Dry....2.87
As fired....3.02

Equivalent pounds of coal used per E. H. P. hour developed at switchboard:
Dry....3.54
As fired....3.73

Dry coal burned per square foot of grate surface per hour 15.86 lbs.

Analyses of Coal.

Proximate.		Ultimate.	
Moisture	5.01	Carbon	81.53
Volatile matter	36.23	Hydrogen	5.19
Fixed carbon	56.09	Oxygen	8.43
Ash	2.67	Nitrogen	1.55
Sulphur	0.48	Sulphur	0.51
		Ash	2.81

Equivalent pounds of water evaporated per square foot of water heating surface per hour.... 3.12

Coking Test No. 1.

Duration of test....56 hours
Kind of coal....raw—large lump

Analyses.

	Coal	Coke
Moisture	521	2.81
Volatile matter	36.82	1.27
Fixed carbon	55.62	91.93
Ash	2.35	3.99
Sulphur	0.51	0.40

Amount of coal charged	12,000 pounds
Amount of coke produced	6,780 pounds
Amount of breeze produced	587 pounds
Percentage of coke produced	56.50
Percentage of breeze produced	4.89
Total percentage	61.39

Color of coke—Light gray and silvery with ½ inch black butts.

Coking Test No. 2.

Duration of test	55 hours
Kind of coal	raw, large lump

Analyses.

	Coal	Coke
Moisture	5.42	1.64
Volatile matter	36.82	1.69
Fixed carbon	55.30	92.26
Ash	2.46	4.41
Sulphur	0.48	0.37
Amount of coal charged	12,000 pounds	
Amount of coke produced	6,659 pounds	
Amount of breeze produced	447 pounds	
Percentage of coke produced	55.49	
Percentage of breeze produced	3.73	
Total percentage	59.22	

Color—Light gray and silvery with ½ inch black butts.

On Miller's Creek no openings were noted on the two coals above the Van Lear but the next higher coal has been opened at a few places. Bed section at two of these are:

No. 1		No. 2	
		Slate:	
Coal	24″	Coal	21″
Slate	3″	Slate	5″
Coal	24″	Coal	27″
Slate	4″	Slate	2″
Coal	12″	Coal	14″
		Fire clay.	

An analysis of the latter gave:

Moisture	2.60
Volatile matter	36.90
Fixed carbon	45.70
Ash	13.70
Sulphur	1.09

Prof. Crandall identified this seam as the old No. 3 or Peach Orchard bed. A section on the same coal on Scaffold Lick Fork, of Rockcastle Creek (where it is known as the ten foot coal), is given for comparison.

	Inches.
Coal	1
Shale	2
Coal	18
Shale	3
Coal	12
Shale	4
Coal	1
Shale	12
Coal	17
Clay	1
Coal	13
Clay	4
Coal	3
Shale	4
Coal	6
Shale	1
Clay	24

From 80 to 120 feet above this vein is the Broas or "E" coal, locally known as the Toppin's coal and found in all the ridges about the head of Miller's, Buffalo, Daniels and Rockcastle Creeks, a fine block coal with a thickness varying from 52 to 85 inches and probably averaging about five feet. Prof. Crandall has given a full list of openings on this coal in his report on Big

Sandy coals, but should have included a bone parting in most of them. The openings have now all fallen in.

From 160 to 190 feet above the Broas coal is the place of the Richardson or "F" coal, a very thick coal, but so high in the ridges as to be of no commercial importance at present.

JENNIES CREEK, JOHNSON COUNTY.

On Jennies Creek a great many openings have been made recently and the three coals mentioned on Greasy Creek and Tom's Creek are well exposed, the Van Lear coal, the lowest one of the three, being the most prominent. The measures are rising up the creek. The sections as measured by Mr. W. H. Cunningham, are as follows—all openings given are on the Van Lear coal except where otherwise stated:

1. Mouth of Lick Fork—
   Coal .. ..32"
2. On right, one-fourth mile up Lick Fork—
   S. S.
   Shale
   Coal .. ..36"
   Elevation 700. (80 feet above creek).
3. Lick Fork at mouth of Road Fork—
   S. S.
   Shale .. ..12"
   S. S. ....6"
   Shale .. ..12" (20 feet above creek).
   Coal .. ..22"
4. Lick Fork, on right above Webb Branch—
   S. S.
   Shale .. ..40"
   Coal .. ..29"
   Clay.
5. Lick Fork, on left ¼ mile above last—
   S. S.
   Shale .. ..36"
   Coal .. ..29"
   Clay .. ..10"
   S. S.
6. Lick Fork, just above last—
   S. S.
   Shale .. ..44"
   Coal ....31"

7. Lick Fork, ¼ mile above last—
   S. S.
   Shale .. ..55"
   Coal .. ..32"
8. Lick Fork opposite last—
   Shale
   Coal .. ..29"
   Clay.
9. Lick Fork, on left, 1 mile above last—
   S. S.
   Shale ....10 feet
   Coal .. ..29"
10. Lick Fork, on left, opposite Ad. Hall Branch—
    S. S.
    Shale .. ..30"
    Coal .. ..30"
11. Lick Fork, on left, ½ mile above Hall Branch—
    S. S.
    Shale .... 6 feet
    Coal .. ..28"
12. Lick Fork, on left, ¼ mile above last—
    Shale
    Coal .. ..12"
    Slate .. .. 3"
    Coal .. .. 3"
    Blue slate ....18"
    Coal .. .. 6"
    Blue slate ....½"
    Coal .. ..15"
    Blue slate.
13. Middle Fork, on right, ¼ mile above mouth—
    S. S.
    Shale .. ..48"
    Coal .. ..30"
    Fire clay.
    Elevation 700 (80 feet above creek).
14. Middle Fork, on right, ½ mile up—
    S. S.
    Shale
    Coal .. ..36"
    Fire clay.
    Elevation 700. (57 feet above creek).

15. Middle Fork, on left, opposite last—
S. S.
Shale
Coal .. ..30" to 36"
Fire clay.
Elevation 700. (60 feet above creek).

16. Middle Fork, on right, ¾ mile up—
S. S.
Shale .. ..48"
Coal .. ..30"
Fire clay.
Elevation 705. (55 feet above creek).

17. Middle Fork, on right, one mile up—
S. S.
Shale.
Coal .. ..30"
Fire clay.
Elevation 710. (50 feet above creek).

18. Middle Fork, up Kelsey Branch—
S. S.
Shale .. ..8 feet.
Coal .. ..35"
Fire clay.
Elevation 720. (45 feet above creek).

19. Middle Fork, on left, 1½ miles above Kelsey—
S. S.
Shale .. ..54"
Coal .. ..36"
Fire clay.
Elevation 740. (30 feet above creek).

20. Middle Fork, on left, ¼ mile above last—
S. S.
Shale .. ..60"
Coal .. ..40"
Fire clay.
Elevation 740. (25 feet above creek).

21. Middle Fork, on left, ½ mile above last—
Slate .. ..48"
Coal .. ..21"
Bone .. ..1"
Coal .. ..20"
S. S.
Elevation 730. (8 feet above creek).

22. Middle Fork, on Left, 3/8 mile above last—
S. S.
Shale .. ..36"
Coal .. ..35"
Fire clay.
Elevation 735. (at drainage).

23. Middle Fork, on left, ¼ mile above last—
S. S.
Sandy shale.
Slate .. .. 6"
Coal .. ..30"
Fire clay.
Elevation 765. (25 feet above creek).

24. Jennies Creek opposite Line Branch—
S. S.
Shale
Coal .. ..30"
Fire clay.
Elevation 720. (105 feet above creek).

25. Line Branch, ½ mile up—
S. S.
Shale .. ..26"
Coal .. ..34" to 36"
Slate.

26. Jennies Creek below mouth of Twin Branch—
S. S.
Shale .. ..48"
Coal .. ..34"

27. Jennies Creek, on right, 1¼ miles above Denver—
S. S.
Shale .. ..12"
Coal .. ..36"
Fire clay.
Elevation 750. (112 feet above creek).

28. Jennies Creek, on right, 1¼ miles above Denver—
S. S.
Coal .. ..34"
Fire clay.
Elevation 760. (122 feet above creek).

29. Jennies Creek at mouth of Asa Creek—
S. S.
Shale
Coal .. ..37"
Fire clay.
Elevation 770. (133 feet above creek).

30. Asa Creek, 1 mile up—
S. S.
Shale
Coal .. ..31"
Fire clay.
Elevation 765. (100 feet above creek).

31. Asa creek, 1½ miles up—
S. S.
Shale
Coal .. ..41"
Slate.
Elevation 840. (100 feet above creek).

32. Schoolhouse Branch of Asa Creek—
S. S.
Shale .. ..48"
Coal .. ..36"

33. Head of Wolf Pen Branch of Asa Creek—
S. S.
Slate .. ..60"
Coal .. ..35"
Slate.

34. One-fourth mile up Right Fork of Asa Creek—
S. S.
Coal ....38"
Fire clay.
Elevation 840. (100 feet above creek).

35. One-half mile up Right Fork of Asa Creek—
S. S.
Coal .. ..38"
Fire clay.
Elevation 840. (80 feet above creek).

36. One-half mile up Greasy Creek—
S. S.
Shale
Coal .. ..40"

37. One and a half miles up Greasy Creek—
S. S.
Shale .. ..24"
Coal .. ..33"

38. Jennies Creek at mouth of Mill Branch—
S. S.
Coal .. ..26"
Fire clay.
Elevation 790.

39. Jennies Creek at mouth of Swamp Branch—
S. S.
Coal .. ..36"
Slate.

40. Jennies Creek above Swamp Branch—
S. S.
Coal .. ..24"
Slate.
Elevation 870. (First coal above Van Lear coal).

41. Jennies Creek at mouth of Green Rock Branch—
S. S.
Shale .. .. 6"
Coal .. ..48"
Slate.
Elevation 830. (143 feet above creek).

42. Green Rock Branch below mouth of Right Fork—
S. S.
Shale .. .. 4"
Coal .. ..34"
Slate.
Elevation 840. (90 feet above creek).

43. Green Rock Branch above last—
S. S.
Coal .. ..30"
Slate.

44. Long Fork of Jennies Creek, 1½ miles up—
S. S.
Shale .... 6 feet
Coal .. ..15"
Shale .. .. 2"
Coal .. ..19"
Interval ....40 feet
S. S.
Coal .. ..27"
Interval ....20 feet
Van Lear Coal..........36"

45. Long Fork, on left, two miles up—
Slate.
Coal .. ..22"
Slate .. .. 1"
Coal .. ..10"
Elevation 860.

46. Long Fork, on right, two miles up—
S. S. and Shale.
Coal .. ..30"
Fire clay.
Elevation 860. (60 feet above creek).

47. One-half mile up Brushy Fork of Long Fork:
Shale
Coal .. ..15"
Slate .. .. 2"
Coal .. ..17"
Shale.

48. Jennies Creek, ½ mile above Long Fork—
Shale.
Coal .. ..30"
Clay.
Elevation 845. (125 feet above creek).

49. Jennies Creek, ¾ mile above Long Fork—
Shale
Coal .. ..11"
Parting ....½"
Coal .. ..14"
Parting .. ..½"
Coal .. ..16"
Fire clay.
Elevation 845. (120 feet above creek).

50. Jennies Creek, opposite last—
S. S.
Slate and Shale........26"
Coal .. ..33"
Clay.
Elevation 845. (115 feet above creek).

51. Jennies Creek, ¼ mile above last—
S. S.
Slate and Shale......28"
Coal .. ..28"
Clay.
Elevation 845.

52. At lower end of Narrows, on left—
Slate and Shale
Coal .. ..36"
Slate.
Elevation 840. (25 feet above creek).

53. At lower end of Narrows, on right—
Slate and Shale
Coal .. ..30"
Slate.
Elevation 840. (15 feet above creek).

54. In Narrows—
S. S.
Coal .. ..18"
Shale.
Elevation 860.

A railroad is now under construction from Stafford on the Chesapeake & Ohio Railroad up the main fork of Jennies Creek to the mouth of Green Rock Branch.

LITTLE PAINT CREEK, FLOYD COUNTY.

On Little Paint the Van Lear coal has thinned down and is not of much value. The southeast dip from Paintsville brings it low in the hills and there is not much change in dip going up the main creek. On the Right Fork, however, the measures rise about with the creek to its head against Lick Fork of Jennies Creek. Following are bed sections of openings on the Van Lear coal:

Bear Hollow, at mouth of Mile Branch—
Shale
S. S. ....36"
Coal .. ..24"
Clay.

Mile Branch, three-fourths of a mile above mouth—
Shale
Coal ....28"
Slate.

Bear Hollow, above mouth of Long Branch:
Shale
Black slate ....14"
Coal .. ..18"
Clay.

Bear Hollow, one and a half miles above mouth—

Shale	
Coal	8″
Bone	3″
Coal	4″
Shale	

(Below this opening the coal measured 30 inches and just above it, 34 inches).

Bear Hollow, two miles above mouth—

S. S.	
Slate	5″
Coal	22 to 30″

Bear Hollow, one-fourth mile above last—

S. S.	
Slate	8″
Coal	27″
Shale.	

Little Paint, below Hager Branch—

Shale.	
Coal	36″
Clay.	

Little Paint, at mouth of Right Fork—

Shale	
Coal	14″
Slate	2″
Coal	12″

Head of Right Fork—

Shale.	
Slate and coal	1½″
Coal	24″

The second coal above the Paintsville coal is a much better coal and is present on Little Paint in its full thickness, but has not been opened to a great extent. One opening below the mouth of Right Fork is reported as 51 inches and another near the mouth of the creek, 42 inches to 48 inches with a slate parting. Still above this coal the cannel coal corresponding to the old East Point cannel is reported at several places, but was not seen opened. It is reported as 54 inches thick, part splint coal, in the divide between Little Paint and Lick Fork and about the same in the divide between Little Paint and Abbott Creek.

ABBOTT CREEK, JOHNSON COUNTY.

The Van Lear coal, dipping up the river from the Paint Creek dome, goes under the railroad just above the Mary Luck mine, the measures lying in a syncline between the Paint Creek dome and the Warfield anticline. There is a reversal of dip between the Mary Luck mine and the Cliff Coal Company's mine, the measures gradually rising again toward the axis of the anticline at the mouth of Middle Creek. Below the Cliff mine the Van Lear coal is opened close to the river 40 inches thick with a 3 inch parting near the center. At the Cliff mine it is worked by a slope and at Cliff Station at the mouth of Abbott, it is still about 15 feet below the railroad, but rises rapidly from there to its highest point just below the mouth of Middle Creek, a rise of about 100 feet in a little over a mile. Abbott Creek, runs nearly parallel to the strike of the anticline, but the axis of the latter is rising gradually to the southwest from Levisa Fork to the Licking River divide and the rocks on Abbott Creek rise to a corresponding degree, the thin coals in the black slate under the Van Lear coal coming to the surface below Bonanza and rising from there toward the head of the creek. Around the mouth of Abbott, the Van Lear coal is opened for local use at a number of points ranging from 36 inches up to as much as 50 inches. The next coal above it is also shown in outcrop about 60 feet up, but the second coal above, which is well developed a mile above on Middle Creek, was not seen and appears to be either nearly or entirely cut out by a heavy sandstone which appears locally just where the coal should be found.

The following section was taken in the hill between Abbott Creek and Little Paint:

Top of second massive sandstone	625
Top of massive S. S.	525
Coal bloom	510
Coal bloom at level of gap	450
Coal bloom	435
Coal bloom	400
Iron ore	385
Coal bloom	330

Old coal opening	300
(Interval mostly sandstone.)	
Coal bloom	65
Van Lear coal	0

The space between the bloom at 65 feet and the old opening at 300 is apparently entirely taken up by sandstone.

Between the mouth of the creek and Bonanza few openings were to be seen. On both forks, about Bonanza, the two thin coals in black slate below the Van Lear coal become rather prominent and are worked to some extent for local use.

An opening on one showed—

Slate.	
Coal	6″
Slate	1″
Coal	13″
Slate	

and on the other—

Slate.	
Coal	15″
Slate	8″
Coal	12″
Slate.	

On the upper portion of Abbotts Creek the second coal above the Van Lear coal has been opened at a number of places. The following sections are on that coal except where otherwise stated:

Mouth of Right Fork of Conley Branch of Bee Branch; First coal above the Van Lear coal—

Shale		
Coal	24″	Elevation 860.
Clay.		

Farther up Right Fork of Conley Branch, four openings:

No. 1.

Shale	
Coal	15″
Shale and coal	1″
Coal	18″
Elevation 880.	

No. 2.

S. S.	
Shale	12″
Coal	40″
Slate.	

No. 3.

Coal	13″
Parting	1″
Coal	26″
Clay.	

No. 4.

S. S.	
Shale	18″
Coal	15″
Slate	1.5″
Coal	23.5″
Slate.	
Elevation 910.	

On Bee Branch, half way above mouth—

S. S.		
Shale	4″	
Coal	12″	Elevation 890.
Slate	1″	
Coal	25″	
Fire clay.		

On Bee Branch, just above last—

Shale	
Coal	11″
Slate	1″
Coal	12″
Shale	2″
Coal	10″

On Right Fork of Abbott, near head—Van Lear coal—

Shale		
Coal	18″	
Fire clay	4″	
Coal	14″	Elevation 800.
Fire clay.		

MIDDLE CREEK, FLOYD COUNTY.

Just below the mouth of Middle Creek the crest of the Warfield Anticline crosses Levisa Fork and the Van Lear coal is brought up nearly 100 feet above low water in the river. The coal is mined by the Middle Creek Coal Co., The Beaver Pond Coal Co., the Prestonsburg Coal Co. and the Colonial Coal Co., on Middle Creek just above the mouth, on the river front and on Town Branch and Kelse Hollow. The creek runs almost with the strike of the anticline and there is not much dip, the rocks rising slowly up the creek. About the mouth of the creek the coal shows with its usual variations in thickness from about 30 inches to 50 inches and dipping up and down the river on the two flanks of the anticline. At the mouth of the creek the Elkhorn coal has been opened about 3 1-2 feet thick with two partings. Recently it has been opened by the Colonial showing a local thickness of about 6 feet with two thin partings.

Following are bed sections of openings on the Van Lear coal farther up the creek:

One-half mile up Middle Creek—

Shale
Coal .. 29"
Shale .. 2"
Coal 23"
Clay.

One mile up Middle Creek—

S. S.
Slate .. 6"
Coal .. 44"
Slate .. 6"
S. S.

One and a half miles up Middle Creek—

S. S.
Slate .. 10"
Coal .. 40"
Slate .. 6"
S. S.

On Harris Branch, just back of last—

S. S.
Slate .. 6"
Coal .. 29"
Slate 2"
Coal .. 21"

Above this the Van Lear coal gets thinner and is also thinner on Right Fork of Middle creek.

Spurlock Fork.

2½ miles up Spurlock Fork—Van Lear coal—

Slate
Coal .. 52"
Slate.

At mouth of Buckeye Creek—

Coal .. 18.5"
Slate .. 2.5"
Coal .. 27.5"

One-fourth of a mile up Buckeye—

Coal .. 9"
Slate .. 4"
Coal .. 31"

Three-fourths of a mile up Buckeye—

S. S.
Shale .. 24"
Coal .. 45"

On Middle Creek above Buckeye Creek—

Coal .. 16"
Slate .. 1"
Coal .. 31"

Caney Fork.

At mouth of Caney—Van Lear coal—

Coal .. 43"

One-fourth of a mile up Caney—Van Lear coal—

Coal .. 19"
Slate .. 2"
Coal .. 23"

At mouth of left hand branch, one-half of a mile up Caney—Elkhorn coal—

Shale
Coal .. 24"
Slate .. 12"
Coal .. 36"

On same branch—Elkhorn coal—

No. 1.		No. 2.	
Coal ..	27"	Slate	
Slate ..	10"	Coal ..	22"
Coal ..	33"	Slate ..	30"
		Coal ..	27"

On Stevens land, one-half mile farther up Caney—Elkhorn coal—

Coal .. 22"
Slate .. 10 to 20"
Coal .. 32"

Across Caney from last on Owsley land—Van Lear coal—

Shale
Coal .. 48"
Slate.

Analysis.

Moisture	3.94
Volatile matter	35.32
Fixed carbon	54.62
Ash	6.12
Sulphur	0.62
Phosphorus	0.004

B. T. U. 12,753

On A. G. Hamilton land—Van Lear coal—

S. S.
Coal .. 11″
Slate .. 3″
Coal .. 26″
Slate.
Elkhorn coal—
Slate
Coal .. 15.5 ″
Slate .. 0.5 ″
Coal 1.5″
Slate .. 7 ″
Coal .. 12 ″
Slate.

At mouth of Alum Lick—Van Lear coal—

Shale
Coal .. 8″
Slate .. 3″
Coal .. 31″

Mouth of Cloverfield Branch of Caney—Van Lear coal—

Shale
Coal .. 44″

At head of Caney Creek—Van Lear coal—

Coal .. 12 ″
Slate .. 1.5″
Coal . 31″

Middle Creek, one-fourth mile above Caney—

Coal .. 38″

Middle Creek three-fourths of a mile above Caney—Van Lear coal—

S. S.
Shale 8 feet
Coal .. 18″
Shale .. 2″
Coal .. 30″

Middle Creek, at mouth of Lick Fork—Van Lear coal—

Coal .. 46″

One-fourth mile up Lick Fork—Van Lear coal—

Coal .. 46″

One-half mile up Lick Fork—Van Lear coal—

Coal .. 48″

Middle Creek at mouth of Open Fork—Van Lear coal—

Coal .. 41″

Analysis.

Moisture	3.40
Volatile matter	36.70
Fixed carbon	55.30
Ash	4.60
Sulphur	0.61

Middle Creek above mouth of Open Fork—Van Lear coal—

Coal .. 32″

Head of Middle Creek—Van Lear coal—

Coal .. 31″

The above openings are all on the Van Lear coal, except where otherwise stated, and show a good area on Middle Creek from the mouth of Buckeye to Open Fork, the coal thinning down again above that.

Four miles up Middle Creek on the Friend Branch is an opening on the East Point Cannel seam—

S. S.
Shale 36″
Soft coal 24″
Cannel coal 16″
Slate

And on the Fitch Branch through the hill from the last, an opening on the same vein—

Slate.
Soft coal 12″
Splint coal 18″
Cannel coal 12″
Shale.

Opposite the head of Lick Fork, on the Licking River side, is an opening on the Fire Clay coal—

S. S.
Slate .. 4″
Shale .. 6″
Coal .. 21″
Shale .. 3″
Coal .. 4″
Shale .. 3″
Flint clay 3″
Coal .. 15″

About twenty feet below this is another coal and about 120 feet above it a thick coal which may be the Hazard coal.

Prof. Crandall reports a seam carrying 80 inches of coal in the high hills at the head of the creek and gives it as 780 feet above the Van Lear coal. This may be either the Flag or the Hindman coal.

Right Fork of Middle Creek.

On Right Fork all the lower coals are thin.

Right Fork, one-half mile below State Road Fork—Van Lear coal—
Shale.
Coal ....34″
Fire clay.
Elevation 840. (50 feet above creek).

Up a branch on left just above last—Van Lear coal—
Coal ....32″

At mouth of Left Fork of State Road Fork—Van Lear coal—
Slate and shale
Coal ....34″
Fire clay.
Elevation 850. (30 feet above creek).

One-half mile up Left Fork of State Road Fork—Van Lear coal—
Black slate
Coal ....30″
Fire clay.
Elevation 850. (10 feet above creek).

Three-fourths of a mile below head of State Road Fork—Elkhorn coal—
Coal ....32″

Head of State Road Fork—Elkhorn coal—
S. S.
Slate ....30″
Coal ....30″ Elevation 960

One mile up a branch on right, one-half mile above State Road Fork —Elkhorn coal—
Slate.
Coal ....36″
Elevation 1020. (180 feet above creek).

At head of same branch—Elkhorn coal—
S. S.
Slate ....48″
Coal ....9″
Shale ....2″
Coal ....28″
Slate
Elevation 1030. (170 feet above creek).

At head of Allen Branch—First coal above Van Lear—
Coal ....24″

On Left Fork, three-fourths of a mile below Ivyton—Elkhorn coal—
Coal ....32″
Elevation 1030. (170 feet above creek).

On Left Fork, one-fourth of a mile below Ivyton—Elkhorn coal—
S. S.
Slate and shale.
Coal ....33″
Slate.
Elevation 1030.

BULL CREEK, FLOYD COUNTY.

At the mouth of Bull Creek the dip down the southeast flank of the arch, the crest of which crosses at Prestonsburg, has brought the Van Lear coal down to a little below the level of the railroad. The coal shows of good thickness at some points but is very variable in bed section, getting up to five feet at a few points and cutting down to less than two in other places. On this creek a parting in the Van Lear coal, which begins to appear in some of the openings on Abbott and Middle creeks has become much more prominent and continues for a long distance up Levisa Fork.

The following are some of the openings on Bull Creek:

Bull Creek, near mouth—
Coal ....38″

Hopkins opening, 1-2 mile from mouth of creek—
Slate
Coal ....6″
Slate ....9″
Coal ....41″
Slate.

Lewis Dotson openings—one mile from mouth of creek—
Coal ....11″
Slate ....3″
Coal ....25″
and
Coal ....4″
Slate ....1″
Coal ....38″

T. D. Calhoun opening—
Coal ....46″

J. Wills' opening—1¾ miles from mouth of creek—

Coal	21″
Slate	6″
Coal	31″

On Right Fork of Bull Creek, James Banks' opening—one-half mile from Prestonsburg—

S. S.
Coal .... 63″
S. S.

Just west of last, Jas. Conley opening—

S. S.
Coal .... 55″
S. S.

The above openings are all on the Van Lear coal. The measures rise slowly up the creek and the second coal above the Van Lear is opened in three places at about 140 feet above it with following bed sections:

Coal	12″	Coal	12″	Coal	10″
Slate	2″	Slate	1″	Slate	4″
Coal	24″	Coal	43″	Coal	42″

This is the coal which to the southeast becomes the Elkhorn seam. Higher coals are known to exist in the ridges toward the head of the creek but the openings have fallen in and the coals have not been definitely correlated.

BEAVER CREEK.

At the mouth of Beaver there is a coal about 30 inches thick showing over a heavy sandstone and above the railroad . This coal shows along the railroad at Alonzo, Beaver Creek, Dwale and Prestonsburg at an interval of 30 to 40 feet below the Van Lear coal and owing to its prominence between the mouth of Beaver and Dwale may be called the Dwale coal. Going up Beaver it is near drainage until below the mouth of Wilson Creek; above that it rises with the increasing dip. This coal, farther up Beaver Creek, gets to be of a workable thickness in places and has sometimes been taken as the Van Lear coal which it occasionally exceeds in thickness. Toward the head of Left Beaver the interval between this Dwale coal and the Van Lear coal diminishes very rapidly and the two seams come almost together.

The Van Lear coal at the mouth of Beaver is thin and split, but begins to show about its normal thickness on Buck's Branch and Stephens Branch. The Ivel coal, above the Van Lear, has been opened in but few places. It is about 30 to 40 feet above the Van Lear and seems to have an average thickness of about 30 inches. The Elkhorn coal, with an interval of about 130 feet above the Van Lear, is, as shown in the following sections, not as prominent or as thick as the Van Lear coal on the lower part of the creek, but assumes its normal thickness toward the head of the creek but is there high in the hills. Above the Elkhorn is a thin coal about 38 to 40 inches thick and above that, other thicker coals which have not, as yet, been correlated. On the lower part of the creek the dip is moderate but below the mouth of Steele's and Frazier Creeks a rapid rise to the southeast sets in which brings the Van Lear coal 200 feet above the creek on Frazier creek. A railroad to develop the coals of this section is now under construction from the mouth of Beaver to the mouth of Steele's Creek. The following bed sections show the general character of the coals on this creek.

Bucks Branch.

In point of hill below mouth of Buck's Branch—Van Lear coal—

Slate
Coal .... 6″
Slate .... 10″
Coal .... 26″

On first right hand branch of Buck's Branch—Van Lear coal—

Coal .... 5.5″
Clay .... 11 ″
Coal .... 37 ″
Clay.

On J. P. Mayo land on Buck's Branch, three openings—Van Lear coal—

(1)		(2)		(3)	
Slate		Slate		Slate	
Coal	42″	Coal	39.5″	Coal	44″
Clay.		Clay.		Clay	

On W. S. Flannery land on Right Fork of Buck's Branch—Elkhorn coal—

Slate.	
Coal	26″
Slate	3″
Coal	12″
Slate	18″
Coal	28″

On Left Fork of Buck's Branch—Elkhorn coal—

Coal	39″
Slate	25″
Coal	38″

Analyses of Buck's Branch Coals.

	J. P. Mayo, No. 1. (Van Lear)	J. P. Mayo, No. 2 (Van Lear)
Moisture	6.96	2.64
Volatile matter	35.02	37.76
Fixed carbon	53.38	55.70
Ash	4.64	3.90
Sulphur	0.79	0.85

Right Beaver.

On right and half way between mouth of Left Beaver and mouth of Stephen's Branch—Van Lear coal—

Coal	9″
Slate	14″
Coal	43″

On left and below mouth of Stephens Branch, two openings—Van Lear coal—

(1)		(2)	
Coal	8″	Shale	6″
Shale	14″	Coal	6″
Coal	40″	Shale	10″
Slate		Coal	41″
Elevation 703.		Slate.	

Stephens Branch.

On A. L. Allen's land—Van Lear coal—

Coal	3 ″
Slate	0.5″
Coal	29 ″
Coal and shale	4 ″
Slate.	

On D. Kennedy's land—Van Lear coal—

Shale	
Coal	8″
Slate	1″
Coal	16″
Slate	3″
Coal	42″

Analysis.

Moisture	3.12
Volatile matter	36.14
Fixed carbon	52.90
Ash	7.84
Sulphur	1.01

On J. Click land, 2 openings—Van Lear coal—

(1)		(2)	
Slate		Slate	
Coal	10 ″	Coal	15″
Slate	1 ″	Slate	4″
Laminated coal	2.5″	Coal	41″
Coal	33 ″		
Slate	1.5″		
Coal	1 ″		
Slate	0.5″		
Coal	1 ″		
Slate.			

At head of Stephens Branch—Elkhorn coal—

Coal	42″
Slate	5″
Coal	18″

On S. H. Allen land, on Right Beaver above Stephens Branch—

Van Lear coal—		Elkhorn Coal—	
S. S.		Coal	23″
Slate	2″	Slate	18″
Coal	16″	Coal	8″
Slate	1″	Slate	12″
Coal	17″	Coal	36″
Slate.		Slate	

On Right Beaver opposite John's Branch—Dwale coal—

S. S.	
Coal	29″

On J. J. Ratliff land, on John's Branch—Elkhorn coal—

Shale	
Coal	40"
Clay	13"
Slate	1"
Coal	9"

Analysis.

Moisture	2.96
Volatile matter	36.16
Fixed carbon	56.66
Ash	4.22
Sulphur	0.70

On Right Beaver above John's Branch—Van Lear coal—

Slate	
Coal	17"
Clay	12"
Coal	38"

Analysis.

Moisture	3.54
Volatile matter	34.96
Fixed carbon	55.64
Ash	5.86
Sulphur	0.95

On May Branch—

Elkhorn coal—

Slate.	
Coal	11"
Slate	5"
Coal	40"
Slate	48"
Coal	10"
Clay.	

Van Lear coal—

Slate	
Coal	8.5"
Slate	7 "
Coal	38 "
Slate.	

Analyses.

	Elkhorn	Van Lear
Moisture	3.02	2.36
Volatile matter	36.84	36.46
Fixed carbon	56.72	55.58
Ash	3.42	5.60
Sulphur	1.04	0.76

Above mouth of May Branch—Dwale coal—

Coal	34"
Slate	8"
Coal	10"

Turkey Creek.

On left about three miles up—Dwale coal—
Coal 40 inches.

On the A. Hays land above last—

Dwale coal—

Slate	
Coal	45"
Slate.	

Van Lear coal—

Slate	
Coal	2"
Slate	2"
Coal	9"
Bone	1"
Coal	36"

Elkhorn coal—

Slate	
Coal	2"
Slate	59"
Coal	34"
Slate.	

Analyses.

	Dwale Coal	Van Lear Coal
Moisture	2.58	2.44
Volatile matter	35.10	38.74
Fixed carbon	55.84	52.24
Ash	6.48	6.58
Sulphur	0.92	1.99

On J. Webb land farther up on Turkey Creek—

Dwale coal—

Shale	
Coal	10"
Slate	2"
Coal	35"

Van Lear coal—

Slate	
Coal	23 "
Clay	¾"
Coal	24 "
Slate.	

On P. L. Saulsbury land—Van Lear coal—

Shale	
Coal	46"

On land of Turner heirs—Coal above Elkhorn coal—

Shale	
Cannel coal	33"

Goose Creek.

At the Forks of Goose Creek three openings on the Dwale coal—

(1)		(2)		(3)	
Coal	36″	Coal	46″	Coal	50″

On Wilson Creek—on F. T. May land—

Van Lear coal—		Elkhorn coal—	
Slate		Slate	
Coal	15″	Coal	4″
Clay	6″	Slate	2″
Coal	20″	Coal	33″
Bone	4″	Slate.	
Clay	3″		
Coal	3″		

On Right Beaver above Wilson Creek, on J. N. Allen land—

Van Lear coal—		Coal above Elkhorn—	
S. S.		S. S.	
Slate	6 ″	Coal	31.5″
Coal	4.5″	Clay	0.5″
Slate	7.5″	Coal	1 ″
Coal	34 ″	Clay	
Clay	1 ″		
Coal	1 ″		

Analysis.

Van Lear Coal.

Moisture	3.10
Volatile matter	35.74
Fixed carbon	54.88
Ash	6.28
Sulphur	0.94

On Right Beaver on Osborn land—Van Lear coal—

Coal 39″

On Right Beaver at Gearhart's—Elkhorn coal—

Shale	
Coal	6″
Shale	7″
Coal	30″

On Right Beaver on J. Allen land below mouth of Brush Creek—

Van Lear coal—		Elkhorn coal—	
Slate		S. S.	
Coal	42″	Slate	8″
Bone	2″	Coal	2″
Slate.		Slate	8″
		Coal	35″
		Slate.	

On Right Beaver above mouth of Brush Creek—Van Lear coal—

S. S.	
Slate	3 to 12″
Coal	26″
Clay and Coal	5″
Coal	28″
Clay.	

On left side of Right Beaver above Brush Creek—Dwale coal—

S. S.	
Coal	43″
Slate.	

On left of Right Beaver at Gearhart's—Van Lear coal—

Slate.	
Coal	18″
Clay	2″
Coal	23″
Clay.	

On Right Beaver below mouth of Salt Lick Creek—Van Lear coal—

Coal	13″
Shale	2″
Coal	25″

On B. M. Allen land on Salt Lick—Second coal above Elkhorn coal—

S. S.	
Coal	12″
Bone	1″
Coal	28″
Clay	2.5″
Coal	18″

On left of Right Beaver below mouth of Rock Fork—Van Lear coal—

S. S.	
Coal	45″
Slate.	

Analysis.

Moisture	2.58
Volatile matter	35.10
Fixed carbon	55.84
Ash	6.48
Sulphur	0.92

On Branch opposite Rock Fork—Dwale coal—

Coal .. 44″
Slate.

Rock Fork.

On R. Webb land—Van Lear coal—

S. S.
Coal .. 48″
Slate.

Analysis.

Moisture	3.54
Volatile matter	35.14
Fixed carbon	56.88
Ash	4.44
Sulphur	0.95
Phosphorus	0.013

B. T. U. 13,726

On R. Webb land—Van Lear coal—

S. S.
Coal .. 39″
Cannel coal 17″
Clay.

On B. Howard land two openings on Van Lear Coal—

(1)		(2)	
Cannel coal	10″	S. S.	
Coal	29″	Coal	36″
Cannel coal	14″	Cannel coal	12″
		Clay	8″
		Coal	8″

Analysis (No. 2)

Moisture	2.84
Volatile matter	37.78
Fixed carbon	55.20
Ash	4.18
Sulphur	0.73
Phosphorus	0.0514

B. T. U. 13,821

Above mouth of Rock Fork—Van Lear coal—

Coal 35″
Cannel coal 19″

Stone Coal Branch.

At mouth—Van Lear coal—

S. S.
Shale .. 5″
Coal .. 44″
Cannel coal 10″
Slate.

On left, just above mouth—Dwale coal—

Coal .. 6″
Slate .. 1″
Coal .. 37″

On G. Allen land—Van Lear coal—

S. S.
Coal .. 4″
Cannel coal 10″
Coal .. 34″

On A. Hays land, above Stone Coal Branch—Van Lear coal—

Shale .. 8″
Coal .. 34″
Cannel coal 17″
Slate.

Analysis.

Moisture	3.80
Volatile matter	34.42
Fixed carbon	58.04
Ash	3.74
Sulphur	0.76
Phosphorus	0.014

B. T. U. 13,561

Opposite mouth of Jones Fork—Van Lear coal—

S. S.
Shale .. 15″
Coal .. 49″
Slate.

Jones Fork.

On W. H. Triplett land—Van Lear coal—

Shale
Coal .. 45″
Clay.

Analysis.

Moisture	3.44
Volatile matter	35.08
Fixed carbon	57.26
Ash	4.22
Sulphur	0.76
Phosphorus	0.014

B. T. U. 13,629

On S. Webb land—Van Lear coal—

S. S.	
Shale	24″
Coal	46″
Laminated coal	4.5″
Clay.	

Analysis.

Moisture	2.12
Volatile matter	35.96
Fixed carbon	57.48
Ash	4.44
Sulphur	0.61
Phosphorus	0.22

B. T. U. 13,826

Second coal above Elkhorn coal—

S. S.	
Coal	20.5″
Clay	0.5″
Coal	4 ″
Bone	2 ″
Coal	22 ″
Slate.	

Analysis.

Moisture	8.10
Volatile matter	30.76
Fixed carbon	44.88
Ash	16.26
Sulphur	1.10
Phosphorus	0.0126

B. T. U. 9,925

On third Right Hand Branch—Van Lear coal—

Coal	5″
Slate	2″
Coal	48″
Slate	18″
Coal	12″

On J. W. Baldridge land—Van Lear coal—

S. S.	
Coal	44 ″
Laminated coal	5.5″
Clay	11.5″
Coal	10 ″
Slate.	

Analysis.

Moisture	2.86
Volatile matter	34.66
Fixed carbon	56.20
Ash	6.28
Sulphur	0.81
Phosphorus	0.0164

B. T. U. 13,434

On P. Triplett's land—Van Lear coal—

Slate	
Coal	22″
Slate	6 to 12″
Coal	31″
Bone	5″
Coal and slate	15″
Coal	14″
Slate.	

Coal above Elkhorn coal—

Coal	37″

On B. Smith's land—Van Lear coal—

Slate	
Coal	35.5″
Clay	4.5″
Coal	4.5″
Clay	7 ″
Coal	4 ″
Clay	2 ″
Coal	23.5″
Clay.	

On W. May land on Ball Branch—Elkhorn coal—

S. S.	
Coal	33″
Slate	4″
Coal	2″

Coal above Elkhorn coal—

Slate.
Coal ....35"
Slate ....11"
Coal ....12"

On C. Stengel land above Dismal Branch—Coal above Elkhorn coal—

S. S.
Clay .... 3 "
Coal ....13.5"
Slate .... 1 "
Coal ....21.5"
Slate.

Analysis.

Moisture	2.26
Volatile matter	37.86
Fixed carbon	55.08
Ash	4.80
Sulphur	0.80
Phosphorus	0.004

B. T. U. 13,651

On Raynor land above Dismal Branch—Second coal above Elkhorn coal—

Shale
Coal ....49"

On Terry Branch of Jones' Fork—Second coal above Elkhorn coal—

Slate
Clay .... 3"
Coal ....11.5"
Slate .... 1.5"
Coal ....33 "
Slate.

Analysis.

Moisture	2.80
Volatile matter	38.04
Fixed carbon	55.36
Ash	3.80
Sulphur	2.95
Phosphorus	0.0026

B. T. U. 13,827.

On W. Wicker land above Jones' Fork—Van Lear coal—

S. S.
Coal ....54"
Slate ....14"
Coal .... 6"

On J. Martin land—Van Lear coal—

Shale
Coal ....54"
Slate.

Steele's Creek.

At mouth of Steele's Creek on D. D. Martin land—Van Lear coal—

Shale
Coal ....49"
Slate and coal ....15"
Coal ....10"

On B. Osborne land—Van Lear coal—

(1)

S. S.
Coal ....53"

(2)

Fire clay.
Coal ....18"
Slate and bone ....3"
Coal ....26"
Laminated coal ....24"
Slate.

Mill Creek.

On M. Martin land—Elkhorn coal—

(1)

S. S.
Coal ....18"
Clay .... 2"
Coal ....30"
Clay.

(2)

Shale.
Coal ....51"
Slate .... 1"
Coal ....10"
Slate .... 9"
Coal ....10"

Analysis No. 1.

Moisture	1.86
Volatile matter	35.24
Fixed carbon	53.82
Ash	9.08
Sulphur	0.76
Phosphorus	0.0154

B. T. U. 13,134

On left of Right Beaver above Mill Branch—Elkhorn coal—

S. S.
Slate .... 1"
Coal ....12"
Clay .... 3"
Coal 27.5
Clay.

On left below mouth of Caney Fork—Elkhorn coal—

S. S.	
Shale	12″
Coal	29″
Clay	5″
Coal	4″

Analysis.

Moisture	2.94
Volatile matter	36.54
Fixed carbon	56.02
Ash	4.50
Sulphur	0.74
Phosphorus	0.016

B. T. U. 13,651.

Caney Fork.

On G. Sloan land—Elkhorn coal—

Clay	0.5″
Coal	37″
Clay	4″
Coal	8.5″

Analysis.

Moisture	2.22
Volatile matter	37.12
Fixed carbon	57.06
Ash	3.60
Sulphur	1.04
Phosphorus	0.0048

B. T. U. 13,915

On next right branch above last—

Van Lear coal—

Coal	30″

Elkhorn coal—

Shale	
Slate	6″
Coal	37″
Clay	4″
Coal	4″
Clay.	

Analysis (Elkhorn.)

Moisture	2.06
Volatile matter	35.20
Fixed carbon	58.54
Ash	4.20
Sulphur	0.71
Phosphorus	0.006

B. T. U. 13,860

On Big Branch, one half mile up—Elkhorn coal—

S. S.	
Coal	36″
Clay	5″
Coal	5″
Clay	

Analysis.

Moisture	1.86
Volatile matter	36.90
Fixed carbon	58.18
Ash	3.06
Sulphur	1.34
Phosphorus	0.0054

On Big Branch, one mile up—Elkhorn coal—

Clay.	
Coal	39″
Clay	2″
Coal	4″
Clay.	

Analysis.

Moisture	2.62
Volatile matter	36.26
Fixed carbon	58.54
Ash	2.58
Sulphur	1.06
Phosphorus	0.0062

On Caney below mouth of Thornberry Branch—Elkhorn coal—

Clay.	
Coal	37″
Clay	4″
Coal	3″
Clay.	

On Right Fork of Thornberry Branch of Caney—Van Lear Coal—

Shale.
Coal .. 41″
Clay

Analysis.

Moisture	3.42
Volatile matter	36.20
Fixed carbon	58.36
Ash	2.02
Sulphur	0.88
Phosphorus	0.005

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On Huff Branch—Elkhorn coal—

Slate.
Coal .. 40″
Slate .. 1″
Coal .. 20″
Slate.

Analysis.

Moisture	2.04
Volatile matter	36.44
Fixed carbon	56.86
Ash	4.66
Sulphur	1.25
Phosphorus	0.004

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On W. S. Sloan place above Pounding Mill Branch—

Van Lear coal—
Coal .. 20″
Slate .. 2″
Coal .. 21″

Elkhorn coal—
S. S.
Coal .. 42″
Clay .. 1 to 2″
Coal .. ″

Analysis.—Elkhorn.

Moisture	2.10
Volatile matter	36.78
Fixed carbon	56.38
Ash	4.74
Sulphur	1.03
Phosphorus	0.0066

Arnold's Fork.

On left above mouth of Little Doty Creek—Elkhorn coal—

Coal .. 36″
Slate .. 24″
Coal 24″

Saulsbury Branch.

On left, one-half mile up—

Dwale coal—
Shale
Coal .. 24″
Clay.

Van Lear coal—
Shale
Coal 30″
Clay.

Elkhorn coal—
Slate
Coal 36″
Clay.

On D. Martin land, below Sly Branch—Van Lear coal—

Shale
Coal 39″

Analysis.

Moisture	4.56
Volatile matter	33.38
Fixed carbon	60.38
Ash	1.68
Sulphur	0.55

Sly Branch.

On Sly Branch—
Van Lear coal—
Coal .. 52″

Elkhorn coal—
Coal .. 30″
Slate .. 5″
Coal .. 25″

On D. Martin place farther up Sly Branch—Van Lear coal—

(1)
Slate
Coal .. 41″
Clay.

(2)
S. S.
Slate .. 24″
Coal .. 35″
Clay.

Oldhouse Branch.

On Oldhouse Branch—Van Lear coal—

S. S.
Shale .. 24″
Coal .. 45″
Clay .. 1″
Coal .. 3 to 5″

Analysis.

Moisture	3.06
Volatile matter	34.18
Fixed carbon	58.88
Ash	3.88
Sulphur	0.95

Slate Branch.

On J. Hall's land on Slate Branch—Elkhorn coal—

Slate	
Coal	6"
Slate	15"
Coal	23"
Slate	2"
Coal	41"

Arnold's Branch.

On Right Fork of Dry Creek of Arnold's Branch—Elkhorn coal—

(1)

Shale	6"
Coal	44"
Clay	3"
Coal	6"
Clay.	

(2)

S. S.	
Coal	54"
Clay	3.5"
Coal	10"
Slate.	

(3)

S. S.	
Coal	50"
Slate	2"
Coal	5"

(4)

S. S.	
Clay	12"
Coal	4"
Clay	3"
Coal	52"
Clay	3"
Coal	9.5"
Clay.	

Above mouth of Dry Creek—

(1)

Dwale coal—
Coal .... 40"

Van Lear coal—
Coal .... 48"

(2)

Dwale coal—
Coal .... 50"

On G. W. Cook land, on left of Arnold Fork, one mile above Dry Creek—Dwale coal—

Clay	2"
Coal	11"
Clay	0.5"
Coal	12"
Clay	3"
Coal	21"
Clay.	

On right of Arnold's Fork opposite last—

(1)

Dwale coal—
Coal .... 36"

(2)

Dwale coal—
Coal .... 48"
Van Lear coal—
Coal .... 42"
Elkhorn coal—
Coal .... 38"

(3)

Dwale coal—
Coal .... 30"

Below mouth of Mullins Branch—Dwale coal—

Shale.	
Coal	31"
Clay	1 to 3"
Coal	6"
Clay	3"
Coal	5.5"

Mullin's Branch.

On Bates land on Mullin's Branch—Elkhorn coal—

Shale.	
Coal	23"
Shale	2"
Coal	16"
Bone	2"
Coal	10"

Johnson Fork.

On Johnson Fork—Elkhorn coal—

S. S.	
Coal	5"
Slate	36"
Coal	35"
Laminated coal	3"
Coal	29"
Clay	3"
Coal	9"
Slate.	

Analysis.

Moisture	1.52
Volatile matter	34.84
Fixed carbon	56.20
Ash	7.44
Sulphur	1.28
Phosphorus	0.005

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On James King Branch—Elkhorn coal—

S. S.

Shale and coal	5″
Clay	6″
Coal	21″
Laminated coal	2″
Coal	35″
Slate	11″
Coal	4″

Analysis.

Moisture	1.92
Volatile matter	34.78
Fixed carbon	60.52
Ash	2.78
Sulphur	0.75
Phosphorus	0.0048

Puncheon Camp Branch.

On Hall land on Puncheon Camp Branch—Elkhorn coal—

Shale.

Coal	32″
Slate	2″
Coal	9″
Slate	5″
Coal	18″

On Triplett land on Puncheon Camp—Elkhorn coal—

Shale.

Coal	25″
Slate	4″
Coal	12″
Slate	7″
Coal	16″

Opposite mouth of Puncheon Camp—Elkhorn coal—

Slate.

Coal	71″
Slate	3″
Coal	8″
Laminated coal	4″
Coal	19″

Shale.

Analysis.

Moisture	1.72
Volatile matter	35.92
Fixed carbon	58.56
Ash	3.80
Sulphur	0.64
Phosphorus	0.0046

Arkansas Branch.

Arkansas Branch—two openings on the Van Lear coal—

(1)		(2)	
Slate		Coal	9″
Coal	8″	Slate	5″
Slate	6″	Coal	6″
Coal	26″	Slate	3″
		Coal	21″

Left Beaver.

On right, one-half mile above mouth—Dwale coal—

Shale.

Coal	13.5″
Slate	2.5″
Coal	20″

Clay.

Analysis.

Moisture	2.90
Volatile matter	35.16
Fixed carbon	55.28
Ash	6.66
Sulphur	1.10

First right hand branch above mouth—A. J. Davidson land—

Dwale coal—		Van Lear coal—	
S. S.		Shale	
Coal	12″	Coal	12 ″
Slate	12″	Slate	2.5″
Coal	10″	Coal	33.5″
Slate.		Clay.	

Analysis.

Van Lear.

Moisture	3.72
Volatile matter	34.10
Fixed carbon	59.16
Ash	3.02
Sulphur	0.64
Phosphorus	0.0068

On left side of Right Beaver on J. Spurlock land—

Dwale coal—
Coal ... 38″

Van Lear coal—
Coal ... 47″

On second branch on right above mouth—

Dwale coal—
S. S.
Coal ... 28″
Clay.

Van Lear coal—
Coal ... 11″
Clay ... 2″
Coal ... 26″

On left and below mouth of Spurlock Fork—

Dwale coal—
S. S.
Coal ... 27″

Van Lear coal—
Shale
Coal ... 38″

Spurlock Fork.

At mouth of Butler Fork—Van Lear coal—
S. S.
Coal ... 46″

At mouth of Gunstock Fork—Dwale coal—
Coal ... 28″
Slate ... 2″
Coal ... 6″

On left Fork of Gunstock Fork—Dwale coal—
Cannel Coal ... 32″

Near head of Gunstock Fork on Spurlock land—Dwale coal—
S. S.
Coal ... 8″
Slate ... 2″
Coal ... 25″

Shop Branch.

On Shop Branch—Dwale coal—

(1)	(2)	(3)
Cannel coal ... 41″	Coal ... 42″	Coal ... 27″
		Slate ... 13″
		Coal ... 7″

On First Branch on left above Shop Branch—Dwale coal—
Coal ... 26″
Bone ... 2″
Coal ... 9″

On Right and above last on J. Salisbury land—Dwale coal—
Shale.
Coal ... 11″
Slate and coal ... 2″
Coal ... 20″
Clay.

Analysis.

Moisture	8.28
Volatile matter	32.88
Fixed carbon	53.76
Ash	5.08
Sulphur	0.51
Phosphorus	0.0078

Van Lear Coal—
Shale.
Coal ... 16″
Bone ... 2″
Coal ... 23.5
Clay.

Analysis.

Moisture	3.54
Volatile matter	35.04
Fixed carbon	58.16
Ash	3.26
Sulphur	1.13
Phosphorus	0.0076

Elkhorn coal—
Coal ... 20″
Clay ... 13″
Coal ... 7″
Clay ... 5″
Coal ... 31″

Hunter Branch.

On Hunter Branch—Dwale coal—

Coal	25"
Bone	2"
Coal	11"

Stone Coal Branch.

On Stone Coal Branch—Dwale coal—

Coal	39"

On left of Left Beaver and above Stone Coal Branch—Van Lear coal—

Shale.	
Coal	42"
Clay.	

Analysis.

Moisture	3.54
Volatile matter	34.14
Fixed carbon	58.62
Ash	3.70
Sulphur	0.56

On Turner's Branch on P. Turner land—

Dwale coal—		Van Lear coal—	
Slate		Shale	
Coal	48"	Coal	46"
		Slate.	

Simpson Martin Branch.

On Simpson Martin Branch—Dwale coal—

Coal	42

On H. Stewart land above mouth of Simpson Martin Branch—
Dwale coal—

Shale	
Coal	4"
Slate	21"
Coal	47"
Clay.	

Analysis.

Moisture	2.40
Volatile matter	35.92
Fixed carbon	58.92
Ash	2.76
Sulphur	0.59

Van Lear coal—

(1)		(2)	
S. S.		Shale	
Coal	42"	Coal	12"
		Bone	1"
		Coal	24"
		Cannel coal	14"

Analysis (No. 1.)

Moisture	2.20
Volatile matter	35.18
Fixed carbon	57.92
Ash	4.70
Sulphur	0.56

Elkhorn coal—

Coal	26"
Slate	33"
Coal	30"

Opposite mouth of Sizemore Branch—Van Lear coal—

S. S.	
Coal	40"
Slate.	

Analysis.

Moisture	2.22
Volatile matter	33.96
Fixed carbon	58.56
Ash	5.26
Sulphur	0.73

Sizemore Branch.

On D. Gibson land—Dwale coal—

Shale.	
Bone	3"
Coal	43"

Analysis.

Moisture	3.22
Volatile matter	34.40
Fixed carbon	59.14
Ash	2.64
Sulphur	0.68

Van Lear coal—
S. S.
Slate .... 4″
Coal .... 43″
Fire clay.

Analysis.

Moisture	2.54
Volatile matter	33.74
Fixed carbon	58.08
Ash	5.70
Sulphur	0.62

On J. Turner land—

Van Lear coal—
S. S.
Shale .... 6 ″
Coal .... 2 ″
Slate .... 1.5″
Coal .... 45 ″

Elkhorn coal—
S. S.
Coal .... 22″
Slate .... 9″
Coal .... 12″

Doty Branch.

On R. Strumbo land—

Dwale coal—
Shale
Coal .... 41″

Van Lear coal—
Shale
Coal .... 43″

On J. Turner land—Van Lear coal—

(1)
Shale
Coal .... 45″

(2)
S. S.
Slate .... 8″
Coal .... 46″
Slate.

Frazier Creek.

At mouth of Frazier Creek—

Dwale coal—
Shale
Coal .... 6″
Clay .... 4″
Coal .... 36″

Van Lear coal—
S. S.
Coal .... 41″
Slate.

Analysis.

Moisture	2.32
Volatile matter	34.32
Fixed carbon	58.14
Ash	5.22
Sulphur	1.15

Opposite mouth of Middle Branch of Frazier—Van Lear coal—
S. S.
Coal .... 2.5″
Slate .... 4″
Coal .... 44″
Slate.

Analysis.

Moisture	2.18
Volatile matter	36.58
Fixed carbon	55.04
Ash	6.20
Sulphur	1.09

Bill Hall Branch.

At mouth of Bill Hall Branch—

Dwale coal—
Shale
Coal .... 36″
Clay.

Van Lear coal—
S. S.
Coal .... 1.5″
Slate .... 1.5″
Coal .... 46 ″
Clay.

Analyses.

	Dwale Coal.	Van Lear Coal.
Moisture	2.64	2.00
Volatile matter	33.60	36.48
Fixed carbon	60.26	54.98
Ash	3.50	6.54
Sulphur	0.67	1.59

Further up Bill Hall Branch—

Dwale coal—
Shale
Coal .... 35″
Clay.

Van Lear coal—
S. S.
Coal .... 40″
Clay.

On Frazier Creek above Hall Branch, on E. Hall land—Van Lear coal—

S. S.	
Coal	2"
Slate	4"
Coal	44"
Slate.	

Analysis.

Moisture	1.80
Volatile matter	38.20
Fixed carbon	53.50
Ash	6.50
Sulphur	2.40

Frazier Creek.

On land of O. Hall below Mill Branch—

Dwale coal—

Coal	54"

Van Lear coal—

Shale	15"
S. S.	
Coal	40"
Clay.	

Elkhorn coal—

Slate	
Coal	2 "
Slate	17"
Coal	57"
Slate.	

On O. Hall land on Mill Branch of Frazier—Van Lear coal—

S. S.	
Coal	46"
Slate.	

Analysis.

Moisture	1.66
Volatile matter	37.56
Fixed carbon	53.10
Ash	7.68
Sulphur	2.35

On W. S. Hall land on Mill Branch—Dwale coal—

S. S.	
Coal	37"
Slate.	

On S. Bentley land on Mill Branch—Dwale coal—

S. S.	
Coal	27"

On J. Johnson land on Ned's Branch of Frazier—

Dwale coal—

S. S.	
Coal	18 "
Slate	0.5"
Coal	20 "

Van Lear coal—

S. S.	
Coal	6.5"
Slate and coal	4 "
Coal	41 "
Clay.	

Elkhorn coal—

S. S.	
Clay	1.5"
Coal	19 "
Slate	5 "
Coal	16 "
Clay	1 to 5 "
Coal	11 "
Clay	9 "
Coal	27 "
Clay.	

Analyses.

	Dwale Coal.	Van Lear Coal.
Moisture	1.96	1.44
Volatile matter	37.24	35.86
Fixed carbon	56.26	53.28
Ash	4.54	9.42
Sulphur	0.66	1.77
Phosphorus	0.005	
B. T. U. 13,986		

At W. Hall's on Ned's Branch—

Dwale coal—

Shale	
Coal	7"
Slate	3"
Coal	41"

Van Lear coal—

Slate	
Coal	19"
Slate	3"
Coal	29"

At head of Ned's Branch—Van Lear coal—

Coal	20"
Shale	3"
Coal	30"
Shale	10"
Coal	31"

At head of Frazier Creek—Elkhorn coal—

Coal	18"
Shale	60"
Coal	64"

On right of Left Beaver, one mile above mouth of Frazier Creek—
Van Lear coal—

Coal	40″
Slate	39″
Coal	22″

On left of Left Beaver opposite last—Dwale coal—

(1)		(2)	
Coal	32″	Coal	44″
(3)		(4)	
Coal	46″	Coal	28″

Spewing Camp Branch.

At mouth of Spewing Camp Branch—Van Lear coal—

S. S.	
Coal	3″
Slate	6″
Coal	40″

Analysis.

Moisture	1.62
Volatile matter	37.12
Fixed carbon	54.98
Ash	6.28
Sulphur	0.98

On R. C. Elliott land on Spewing Camp Branch—Dwale coal—

(1)		(2)	
S. S.		S. S.	
Coal	41″	Coal	31″
Clay.		Shale.	

Van Lear coal—

S. S.	
Coal	2″
Slate	2.5″
Coal	8
Bone	4.5″
Coal	33.5″
Clay.	

Analyses.

	Dwale Coal. (1)	Van-Lear Coal.
Moisture	2.40	2.12
Volatile matter	35.42	35.74
Fixed carbon	59.30	56.68
Ash	2.88	5.46
Sulphur	0.64	1.00

On same land farther up Spewing Camp Branch—Van Lear coal—

(1)		(2)		(3)	
Shale		Shale		Shale	
Coal	2.5″	Coal	2 ″	Coal	2 ″
Clay	2.5″	Clay	0.5″	Clay	2 ″
Coal	58 ″	Coal	39 ″	Coal	40 ″
Clay.		Clay.		Clay.	

Analyses.

	(2)	(3)
Moisture	1.44	1.46
Volatile matter	38.04	39.14
Fixed carbon	54.36	52.92
Ash	6.16	6.48
Sulphur	2.05	2.15
Phosphorus		0.003
B. T. U.		13,771

On left of Left Beaver, one mile above Spewing Camp Branch—

(1)		(2)	
Dwale coal—		Coal	6″
Coal	40″	Slate	1″
		Coal	39″

Van Lear Coal—

S. S.	
Slate	4″
Coal	24″
Bone	2″
Coal	37″

On R. Moore land above last—Van Lear coal—

S. S.	
Coal	45″
Slate.	

On Nuzum's Branch of Left Beaver—

Dwale coal—		Elkhorn coal—	
Coal	24″	S. S.	
Slate	2″	Coal	2″
Coal	18″	Slate	2″
		Coal	26″
		Slate	2″
		Coal	32″

On Jenkins Branch of Left Beaver—

Dwale coal—		Elkhorn coal—	
Coal	30″	Coal	40 ″
		Slate	2.5″
		Coal	10 ″

Clear Creek.

On first left hand branch of Clear Creek—Dwale coal—

(1)		(2)	
Coal	30″	Coal	42″

On J. C. Reynolds land on Clear Creek—Coal above Elkhorn coal—

Shale.	
Coal	33″
Slate.	

On S. Hanson land—Van Lear coal—

S. S.	
Coal	12″
Slate	60″
Coal	54″

On J. Osborne land—Van Lear coal—

S. S.	
Coal	4″
Shale	48″
Coal	52″
Clay.	

On R. Reynolds land—

Dwale coal—		Van Lear coal—	
		S. S.	
Coal	2″	Coal	3 ″
Slate	1″	Slate	4 ″
Coal	28″	Coal	14.5″
		Slate	1 ″
		Coal	5 ″
		Slate	1 ″
		Coal	39.5″

Analysis. (Van Lear)

Moisture	1.48
Volatile matter	37.40
Fixed carbon	57.32
Ash	3.80
Sulphur	0.66
Phosphorus	0.003

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On Reynolds Branch—

Van Lear coal—		Elkhorn coal—	
S. S.		Coal	18″
Slate	8″	Shale	60″
Coal	18″	Coal	64″
Slate	1″		
Coal	44″		
Clay.			

On H. Sloan land—Van Lear coal—

S. S.	
Coal	13″
Slate	1″
Coal	44″

Left Beaver, one-half mile above Clear Creek—Van Lear coal—

Coal	17″
Slate	7″
Coal	41″

Riley Branch of Left Beaver.

On J. Newman land—Van Lear coal—

S. S.	
Coal	52″
Clay.	

Analysis.

Moisture	1.32
Volatile matter	37.08
Fixed carbon	56.94
Ash	4.66
Sulphur	1.17

On H. Newman land—Van Lear coal—

S. S.	
Shale	18″
Slate	15″
Coal	52″
Slate.	

Analysis.

Moisture	1.72
Volatile matter	34.66
Fixed carbon	57.32
Ash	6.30
Sulphur	0.73

On J. W. Jones land—Van Lear coal—

S. S.
Shale ....12"
Coal ....10"
Slate .... 0.5"
Coal ....40"
Slate.

Analysis.

Moisture	1.60
Volatile matter	34.80
Fixed carbon	59.46
Ash	4.14
Sulphur	0.18

Jack's Creek.

One mile above mouth—Dwale coal—

Shale.
Coal .... 5"
Slate ....11"
Coal ....15"

At head of first right hand branch of Jack's Creek—Van Lear coal—

S. S.
Shale ....10"
Coal ....48"
Clay.

Analysis.

Moisture	1.84
Volatile matter	34.94
Fixed carbon	58.86
Ash	4.36
Sulphur	1.14
Phosphorus	0.0038

On R. J. Mullin land—Van Lear coal—

S. S.
Slate ....12 to 36"
Coal ....53"
Clay.

Analysis.

Moisture	1.90
Volatile matter	34.86
Fixed carbon	61.20
Ash	2.04
Sulphur	0.64
Phosphorus	0.0042

On Honey Cut Branch—Van Lear coal—

S. S.
Shale.
Coal ....59"
Slate .... 5"
Coal .... 7"

Near head of Jack's Creek—Van Lear coal—

S. S.
Coal ....52"
Clay.

Analysis.

Moisture	1.80
Volatile matter	36.78
Fixed carbon	59.30
Ash	2.12
Sulphur	0.72

On left of Left Beaver above Riley Branch—Van Lear coal—

S. S.
Shale .... 5"
Clay ....3 to 8"
Coal .... 4"
Laminated coal .... 4"
Coal ....46"

Analysis.

Moisture	1.64
Volatile matter	33.84
Fixed carbon	55.70
Ash	8.82
Sulphur	0.73
Phosphorus	0.01

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On Right of Left Beaver below Otter Creek—Van Lear coal—

S. S.	
Shale	36"
Coal	45.5"
Clay.	

Analysis.

Moisture	2.38
Volatile matter	34.16
Fixed carbon	61.92
Ash	1.54
Sulphur	0.55

Otter Creek.

On J. Hall land—Van Lear coal—

Slate.	
Slate and coal	1"
Coal	48"
Slate.	

Analysis.

Moisture	1.72
Volatile matter	34.94
Fixed carbon	61.02
Ash	2.32
Sulphur	0.65
Phosphorus	0.005

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On J. M. Anderson land—Van Lear coal—

S. S.	
Slate	4"
Coal	51"
Clay.	

Analysis.

Moisture	1.74
Volatile matter	35.88
Fixed carbon	58.90
Ash	3.48
Sulphur	0.82

On left of Left Beaver, on K. Johnson land above Otter Creek—Van Lear coal—

S. S.	
Shale	36"
Clay	3"
Coal	52"

On right of Left Beaver opposite last—Van Lear coal—

S. S.	
Shale	8"
Coal	3"
Slate	6"
Coal	48"

On T. J. Little land on right of Left Beaver—Dwale coal—

S. S.	
Clay	1"
Coal	41.5"
Shale.	

Analysis.

Moisture	2.22
Volatile matter	33.52
Fixed carbon	62.70
Ash	1.56
Sulphur	0.64

On left of Left Beaver opposite last—Van Lear coal—

S. S.	
Shale and coal	4"
Laminated coal	12"
Coal	42"

Abner Branch.

On left, half way up—Van Lear coal—

Draw slate.	
Coal and slate	10"
Coal	43"

Analysis.

Moisture	1.36
Volatile matter	34.52
Fixed carbon	54.98
Ash	9.14
Sulphur	0.73

At head of Abner Branch—Van Lear coal—

Draw slate.
Coal ....44"
Clay.

Analysis.

Moisture	1.36
Volatile matter	35.54
Fixed carbon	58.64
Ash	4.46
Sulphur	0.76

At mouth of Mill Branch—Dwale coal—

S. S.
Clay .... 3"
Coal ....36"
Clay.

Analysis.

Moisture	3.22
Volatile matter	34.60
Fixed carbon	60.12
Ash	2.06
Sulphur	0.69

On Caleb Fork—

Dwale coal—		Van Lear coal—	
Slate		Coal	40"
Coal	36"	Slate.	

On right of Left Beaver one-half mile above Caleb Fork—
Dwale coal—

Shale.
Coal ....28"
Clay .... 4"
Coal .... 7"

On left of Left Beaver opposite last—Van Lear coal—

S. S.
Slate .... 6"
Coal ....41"
Clay.

Analysis.

Moisture	1.60
Volatile matter	36.84
Fixed carbon	60.16
Ash	1.40
Sulphur	0.57

On left of Left Beaver one mile above Caleb Fork—Van Lear coal—

S. S.
Slate .... 2"
Coal ....48"

Analysis.

Moisture	1.62
Volatile matter	36.24
Fixed carbon	60.46
Ash	1.68
Sulphur	0.65

BETSY LAYNE BRANCH, FLOYD COUNTY.

At the mouth of Betsy Layne Branch the Van Lear coal is down to the railroad, dipping down the river to the syncline mentioned previously, and the thin coal which lies about 20 feet above the Van Lear at Beaver Creek has thickened and come close down to the Van Lear forming locally a double vein with a few feet of shale between the two benches. Old openings gave,

Van Lear Coal—

On right above mouth—		On left above mouth—	
Coal	36"	Coal	39"
Shale	72"	Shale	60"
Coal	40"	Coal	40"

One half mile up the branch—Van Lear Coal—

Coal ....43"
Shale ....60"
Coal ....40"

200 yards farther up the branch—Van Lear Coal—

Coal ....42"
Shale ....42"
S. S. ....12"
Coal ....48"

One and a quarter miles up—Van Lear Coal—

Coal	39″
Slate	42″
S. S.	10″
Coal	46″

About 350 feet above the Van Lear coal are old openings on a thick coal not yet identified. These were:

(1)

Coal	6″
Slate	1″
Coal	34″
Bone	2″
Coal	20″

(2)

Coal	18 ″
Bone	1.5″
Coal	27 ″

(3)

Coal	18″
Bone	2″
Coal	32″

(4)

Coal	12″
Bone	2″
Coal	48″

Just below the mouth of Betsy Layne Branch at the old Layne opening the Van Lear was worked with the following section:

Van Lear Coal—

Coal	24″
Shale	24″
S. S.	22″
Coal	18″
Slate	6″
Coal	23″

On the river front in this section the Ivel coal is locally considerably split up by thin partings of slate and shale as shown in the cliff below Betsy Layne. These partings do not continue for any distance, the coal showing in its normal condition again at Ivel.

PRATER CREEK, FLOYD COUNTY.

One mile up, on right—Dwale Coal—

Slate.	
Coal	34″

One and a half miles up, on left—Van Lear Coal—

Shale.	
Coal	7″
Slate	9″
Coal	33″

Two miles up, on left—Van Lear Coal—

Shale.	
Coal	24″
Slate	2″
Coal	10″

Two and a half miles up, on left—Dwale Coal—

Splint	18″
Clay	5″
Cannel coal	24″

MUD CREEK, FLOYD COUNTY.

From the mouth of Beaver Creek the measures dip up the river to a syncline near Ivel then rise again to the mouth of Mud Creek, the Van Lear coal going below drainage in the syncline and coming up again just below the Betsy Layne mine. At the mouth of Beaver the Van Lear is thin and has another thin vein about 20 feet above it. Where the Van Lear comes again above drainage both veins have thickened up and are closer together. At the point of the hill on the railroad one-fourth of a mile below the mouth of Mud, they are only about five feet apart and are exposed in the railroad cut all the way to Mud Creek, with a varying interval between increasing to about 10 feet at the end of the cut just north of the mouth of Mud Creek and showing only four or five feet at points around up the creek. At Harold the Van Lear coal is about 40 feet above the railroad, but the opening had fallen in and could not be measured.

The Van Lear, along the railroad, has a very thin parting which gets thicker at some points up the creek and at some disappears entirely. Following are some of the bed sections of openings on Mud Creek:

Little Mud.

On Big Branch—Van Lear Coal —

Coal	11"
Slate	1"
Coal	38"

On head of Morgan Fork—Van Lear Coal—

Shale.	
Coal	46"

Hatcher's Bank above schoolhouse—Van Lear Coal—

Coal	27"
Shale	26"
Coal	42"

At head of Parson's Branch—Van Lear Coal--

S. S.	
Coal	49"
Clay.	

On Branham's Creek, one mile up—Van Lear Coal—

S. S.	
Coal	59"
Clay.	

Analysis.

Moisture	2.24
Volatile matter	28.94
Fixed carbon	54.98
Ash	3.84
Sulphur	0.67

At head of Frazier Branch—Van Lear Coal—

S. S.	
Clay	8"
Coal	2"
Clay	4"
Coal	51"
S. S.	

Analysis.

Moisture	2.00
Volatile matter	38.30
Fixed carbon	54.74
Ash	4.96
Sulphur	1.57

On Hamilton Branch—Van Lear Coal—

Slate.	
Coal	3"
Shale	5"
Coal	52"

On Howell Branch—Van Lear Coal—

Coal	5"
Coal and shale	27"
S. S.	24"
Coal	25"
Slate	7"
Coal	30"

At head of Mud—Van Lear Coal—

(1)		(2)	
S. S.		S. S.	
Coal	31"	Coal	24"
Shale	5"	Shale	4"
Coal	31"	Coal	29"
Clay.			

(3)		(4)	
S. S.		Coal	27"
Coal	26"	Shale	48"
Shale	2"	Coal	28"
Coal	20"	Shale	7"
Clay.		Coal	30"

Some of these openings show the full thickness of the double vein; others show only the lower bench.

Going up Mud Creek the measures rise at a moderate rate until near the mouth of Branham, the line marking the foot of the sudden increase in dip from which the rocks rise rapidly to the southeast toward Pine Mountain crossing Mud Creek somewhere near the mouth of Branham. This line is approximately parallel to the direction of Pine Mountain, and from it the rise is rapid to the head of the creek.

Above the mouth of Mud Creek as explained previously, the Van Lear coal is rising faster and is the coal worked at the old Hamlak mines, the Steel Coal Company mines and the Keyser mine at the mouth of Cabin Branch. On Stone Coal Branch across the river from Keyser it was formerly opened at an elevation of nearly 200 feet above the river. Lower coals are rising above the river with the increased northwest dip, one coming above the railroad about a quarter of a mile below Keyser. At Keyser the Dwale coal is reported as about 30 inches thick about 40 feet below the Van Lear coal with an 18-inch coal about 15 to 20 feet above the Van Lear and the Elkhorn, with a somewhat increased interval, showing as a thick coal about 150 feet above the Van Lear. On Stone Coal Branch the Van Lear coal is nearly 200 feet above the river with a bed section as follows:

Van Lear Coal—

Shale	
Coal and slate	6″
Coal	27″
Slate	1″
Coal	12″

About one hundred and fifty feet above it is the Elkhorn coal with a thick parting which extends over on to Joe's Branch of Coon Creek. The section here is:

Elkhorn Coal—

Slate	
Coal	31″
Shale	52″
Coal	31″

At the head of Stone Coal Branch the Fire Clay coal is opened at several places about 250 feet above the Elkhorn coal as follows:

Fire Clay Coal—

(1)		(2)	
S. S.		S. S.	
Slate	4″	Coal	26″
Coal	23″	Flint clay	3″
Flint clay	4″	Coal	14″
Coal	13″	Slate.	
Slate.			

On Ratcliff, Ferguson, Lower and Upper Chloe, the principal coal worked is the Van Lear with an elevation of about 300 feet above the river on Ferguson and

rising up the river. The Elkhorn has been opened at places but is very high in the hills. The Ivel under the Elkhorn, and the Dwale coal under the Van Lear are both present but seldom opened. On Ratcliff Branch an old opening on the Van Lear gave:

Coal	14″
Slate	1″
Coal	16″
Shale	19″
Coal	45″

showing the double character of the vein as on Mud Creek. On Ferguson two openings on the Van Lear coal gave:

(1)		(2)	
Coal	10 ″	Coal	14 ″
Slate	3.5″	Slate	3 ″
Coal	15 ″	Coal	7 ″
Shale	7 ″	Shale	11.5″
Coal	50 ″	Coal	47 ″

with the Ivel coal above them showing 36 inches thick. An old opening on the Elkhorn coal at the head of the creek had fallen in and could not be measured, but Prof. Crandall gives a measurement on the west side of the river and one mile above Pikeville as:

Coal	6″
Shale	20″
Coal	14″
Shale	3″
Coal	17″
Shale	1.5″
Coal	17″

and one mile below Pikeville as:

Coal	11.5″
Shale	7.5″
Coal	33″

with a rise of about 25 feet from the latter to the former. The rise from Stone Coal Creek to Pikeville is about 100 feet. At Pikeville the following section shows:

Gray shale with thin coal at top.
Sandstone
Gray shale ....10 ft.
Thin coal
Gray shale .... 2 ft.
Sandstone .. .. 1 ft.
Gray shale .... 2 ft.
Thin coal
Gray shale .... 5 ft.
Massive sandstone ....15 ft.
Dark shale and slate....................50 ft.
River bed.

This entire section dips under the river going down stream and the thin coal at the top of the section comes down to the railroad below Keyser.

On Lower Chloe the Syck coal is above drainage and has been worked for local use with a thickness of 36 inches to 40 inches.

On Harold's Branch an old opening on the Van Lear Coal gave—

Coal .. ..21"
Shale .. ..17"
Coal .. ..44"

and on Upper Chloe the same coal—

Coal .. ..15 "
S. S. .... 4 "
Coal .. ..26 "
Slate .. .. 1.5"
Coal .. ..28 "

Going up the river the upper bench of the Van Lear coal is not so prominent.

At the Kewanee mine, five miles above Pikeville three coals are opened, the upper one, which is the one worked, 530 feet above the river, the next one about 50 feet below and the third about 20 feet below that. This upper coal has not been definitely correlated. It would seem to be too high for the Van Lear but not high enough for the Elkhorn. It is most probably the Van Lear.

SHELBY CREEK, PIKE COUNTY.

At the mouth of Shelby the rapid southeast rise in the rocks has brought the lower coals high in the hills, the Van Lear coal being close to the top of the ridge. Going up the creek the stream runs about on the strike and there is not much dip. The lower coals are comparatively thin and the Elkhorn does not show of much importance until brought in by the increasing height of the hills up the creek.

On the Bear Fork of Robinson Creek, Prof. Crandall gives, Elkhorn Coal—

Coal .. .. 3"
Shale .. ..20"
Coal .. ..27"
Shale .. .. 9"
Coal .. ..25"

At the same locality he gives a thin coal about 70 feet above the Elkhorn with the following section—

Coal .. .. 3"
Shale .. .. 8"
Coal .. ..32"

This is probably the same coal as the one noted previously as above the Elkhorn on Beaver Creek. At the same locality Prof. Crandall also gives two cannel coal horizons as 300 and 450 feet respectively above the Elkhorn coal.

Farther up Robinson Creek, at the mouth of Open Fork—Elkhorn Coal—

Slate
Coal .. ..28"
Shale .. .. 3"
Coal .. ..29"

At Newsom's Store—Elkhorn Coal—

S. S.
Coal .. ..15"
Shale .. ..13"
Coal .. ..29"

At head of Robinson Creek—Elkhorn Coal—

S. S.
Coal .. ..33"
Shale .. ..12"
Coal .. ..23"

Long Fork of Shelby.

On Indian Creek, one half mile up—Elkhorn Coal—

Shale	
Coal	45″
Clay	3″
Coal	5″
Clay	14″
Coal	23″
Clay.	

On the head waters of Shelby the Elkhorn is opened at a number of points and the following measurements of bed sections were taken:

At head of Marshall's Branch—Elkhorn Coal—

Shale	
Coal	6″
Shale	1″
Coal	19″
Shale	3″
Coal	32″
Shale	1″
Coal	16″

On Right Fork of Long Fork—Elkhorn Coal—

Shale	
Coal	44″
Shale	18″
Coal	18″
Shale	7″
Coal	2″
Bone	0.5″
Coal	10″

On Yont's Fork of Right Fork of Long Fork—Elkhorn Coal—

Shale	
Coal	45″
Shale	7″
Coal	25″

Mout hof Beaver Fork of Right Fork—Elkhorn Coal—

Shale	
Coal	46″
Slate	22″
Coal	18″
Slate	5″
Coal	13″

One half mile up Beaver Fork—Elkhorn Coal—

Coal	48″
Slate	2″
Coal	36″

Left Fork of Long Fork.

On Petty's Fork—Elkhorn Coal—

(1)		(2)	
Coal	41″	Coal	36″
Shale	10″	Shale	15″
Coal	28″	Coal	26″

(3)		(4)	
Coal	30″	Coal	34″
Shale	7″	Shale	9″
Coal	28″	Coal	29″

(5)		(6)	
Coal	38″	Coal	46″
Shale	7″	Shale	10″
Coal	43″	Coal	28″

Between Petty's Fork and Joel Fork of Left Fork of Long Fork—Elkhorn Coal—

(1)		(2)	
Coal	38″	Coal	39″
Shale	9″	Shale	12″
Coal	25″	Coal	33″

(3)		(4)	
Coal	40″	Coal	39″
Shale	14″	Shale	1″
Coal	22″	Coal	29″

(5)	
Coal	38″
Shale	8″
Coal	26″

Left Fork of Long Fork.

On Joel Fork—Elkhorn Coal—

(1)		(2)		(3)	
Coal	43″	Coal	41″	Coal	44″
Shale	8″	Shale	5″	Shale	4″
Coal	32″	Coal	26″	Coal	28″

On Nat's Fork—Elkhorn Coal—

(1)		(2)		(3)	
Coal	34″	Coal	44″	Coal	46″
Shale	8″	Shale	2″	Shale	4″
Coal	32″	Coal	26″	Coal	27″

Between Nat's Fork and Buck Lick Fork—Elkhorn Coal—

(1)		(2)	
Coal	44″	Coal	45″
Shale	2″	Shale	2″
Coal	32″	Coal	28″

On Buck Lick Fork—Elkhorn Coal—

(1)		(2)	
Coal	45″	Coal	14″
Shale	2″	Shale	1″
Coal	30″	Coal	34″

(3)		(4)	
Coal	46″	Coal	43″
Shale	2″	Shale	4″
Coal	33″	Coal	36″

Beef Hide Creek.

On Lick Fork, one mile up—Elkhorn Coal—

Slate	
Coal	29″
Shale	11″
Coal	26″

On Lick Fork at head—Elkhorn Coal—

Slate	
Coal	30″
Shale	12″
Coal	18″

Below Booker's Branch—Elkhorn Coal—

(1)		(2)	
Coal	20″	Coal	34″
Shale	5″	Shale	15″
Coal	40″	Coal	33″

On Booker's Branch—Elkhorn Coal—

(1)		(2)		(3)	
Coal	36″	Coal	12″	Coal	39″
Shale	6″	Shale	2″	Shale	12″
Coal	41″	Coal	48″	Coal	27″

(4)		(5)		(6)	
Coal	29″	Coal	32″	Coal	36″
Shale	9″	Shale	12″	Shale	12″
Coal	31″	Coal	33″	Coal	43″

On John's Fork—Elkhorn Coal—

(1)		(2)		(3)	
Coal	39″	Coal	36″	Coal	47″
Shale	4″	Shale	5″	Shale	6″
Coal	43″	Coal	38″	Coal	38″

On Gray's Branch of John's Fork—Elkhorn Coal—

(1)		(2)	
Coal	33″	Coal	39″
Shale	4″	Shale	6″
Coal	42″	Coal	39″

On head of Road Fork of John's Fork—Elkhorn Coal—

(1)		(2)	
Coal	39″	Coal	39″
Shale	1″	Shale	4″
Coal	28″	Coal	20″

On Andy Wright Branch of Beef Hide—Elkhorn Coal—

(1)		(2)	
Coal	29″	Coal	41″
Shale	2″	Shale	1″
Coal	30″	Coal	48″

On Straight Fork—Elkhorn Coal—

Coal	38″
Shale	2″
Coal	24″

On Ike's Fork—Elkhorn Coal—

Coal	39″
Shale	9″
Coal	32″

Dorton Creek.

On Dorton Creek three openings on the Elkhorn give thickness from 56 to 60 inches.

Owl Branch—Elkhorn Coal—

Slate	
Coal	52"
Shale	1"
Coal	4"

The coal rises from an elevation of 1,396 A. T. on the head of Left Fork of Long Fork of Shelby to about 1,620 at the head of Gray's Branch of John's Fork of Beef Hide.

Analyses.

Elkhorn Coal on Marshall Branch, Right Fork of Long Fork and Yonts Fork of Long Fork—

Moisture	1.87	1.81	2.54
Volatile matter	35.69	37.39	35.54
Fixed carbon	57.89	56.74	60.21
Ash	4.55	4.06	1.71
Sulphur	0.92	0.73	0.56
Phosphorus	0.002	0.002	

Sycamore Fork of Long Fork, Middle Fork of Beef Hide and Wright Fork of Beef Hide—

Moisture	2.50	1.57	1.61
Volatile matter	35.30	36.59	35.48
Fixed carbon	60.38	59.14	59.74
Ash	1.82	2.80	3.17
Sulphur	0.48	0.52	0.52
Phosphorus	0.000	0.002	0.002

ELKHORN CREEK.

On the heads of Elkhorn and Shelby Creeks and the head waters of the North Fork of Kentucky River, the Elkhorn coal has its extreme development both in thickness and character as a coking coal. The Consolidated Coal Company has opened the coal and thoroughly proved it all over this territory and made it the basis

of the recent great developments in that section. The mining town of Jenkins at the head of Elkhorn is the terminus of the branch of the Baltimore and Ohio railroad which runs from the Chesapeake and Ohio at the mouth of Shelby Creek, and the town of McRoberts on the Kentucky River side is the terminus of the extension of the Lexington and Eastern Railroad (now L. & N.) recently built up the North Fork from Jackson. These towns already have a large population, with modern improvements and a large output of coal, but are only the beginning of what will probably be done in that section. Seven mining operations have been started on the Elkhorn side and five on the Kentucky River side. A detailed map of this section is published herewith which shows all locations from Whitesburg on the Kentucky River down to Russel and Levisa Forks of the Big Sandy. As at present developed, the main body of the Elkhorn coal (as a thick coal) is included roughly within the following boundaries: Beginning at the mouth of Thornton Creek on North Fork of Kentucky River (where it is about five feet thick) and taking in Thornton and all of the North Fork above Thornton, the head of Rockhouse above Camp Branch, the heads of Beaver, Long Fork of Shelby, Beef Hide and the head waters of Elkhorn Creek to the southern edge of the Flatwoods district. Of its features under the Flatwood area not so much is known but where it outcrops on the north side of this area it has thinned down considerably and is high in the ridges which are themselves considerably lower. Locally, in the high hills between Russell Fork and Levisa Fork, of Big Sandy, it thickens again and is a good seam but only present in detached areas near the tops of the ridges. On the Tug Fork side it seems to correlate with the seam locally known as the Alma, a most excellent coal where workable, but one which splits and becomes unworkable down Tug Fork about the same distance down as its corresponding split on the Levisa Fork and Kentucky River waters. Openings on this coal have already been given on the headwaters of Shelby Creek. (See Shelby Creek.) Following are openings on Elkhorn Creek:

Mine No. 201—Elevation 1,574—

Slaty shale.	
Coal	40″
Clay	12″
Coal	49″
Clay.	

Mine No. 202—Elevation 1,597—

Slaty shale.	
Coal	43″
Clay	10″
Coal	46″
Clay.	

Mine No. 203—Elevation 1,615—

Slaty shale.	
Coal	38″
Clay	6.5″
Coal	53.5″
Clay.	

Mine No. 204—Elevation 1,598—

Slaty shale.	
Coal	47″
Clay	6″
Coal	45.5″
Clay.	

Mine No. 205—Elevation 1,589—

Slaty shale.	
Coal	54″
Clay	10″
Coal	43″
Clay.	

Mine No. 206—Elevation 1,583—

Slaty shale.	
Coal	41.5″
Clay	6″
Coal	50″
Clay.	

Mine No. 207—Elevation 1,630—

Slaty shale.	
Coal	41.5″
Clay	3.5″
Coal	49″
Clay.	

Additional Openings.

Head of Left Fork of Marchall's Branch—Elevation 1,624—

Coal	31″
Parting	14″
Coal	30″

Head of Left Fork of Marshall's Branch—Elevation 1,624—

Coal	14″
Slate	4″
Coal	32″
Clay	9″
Coal	36″

On McPeak's Branch—

Slate.	
Coal	34″
Clay	15″
Coal	43″
Slate	3″
Coal	16″

Above mouth of Cane Branch—Elevation 1,583—

Coal	44″
Clay	9″
Coal	48″

Mouth of Little Elkhorn—Elevation 1,578—

Coal	44″
Clay	14″
Coal	44″

On Main Elkhorn above Mine 206—Elevation 1,608—

Coal	44″
Clay	11″
Coal	40″

On Main Elkhorn above Mine 207—Elevation 1,614—

Coal	44″
Clay	8″
Coal	44″

Bore Hole "A" on Main Elkhorn—Elevation 1,565—

Coal	44″
Clay	2″
Coal	42″

Bore Hole "B" on Main Elkhorn—Elevation 1,553—

Coal	40″
Clay	1″
Coal	44″

Bore Hole No. 7 on Main Elkhorn—Elevation 1,551—

Coal	37″
Clay	4″
Coal	20″

In Potter's Gap—Elevation 1,621—

Coal	36″
Clay	30″
Coal	41″

Sam Wright opening—Marshall Branch—

Coal	13″
Slate	1″
Coal	30″
Shale	8″
Coal	51″

Analysis.

Moisture	1.24
Volatile matter	35.60
Fixed carbon	60.55
Ash	2.61
Sulphur	0.54
Phosphorus	0.002

Hane's opening—Marshall Branch—

Coal	17″
Slate	4″
Coal	32″
Shale	8″
Coal	45″

Analysis.

Moisture	0.35
Volatile matter	37.41
Fixed carbon	58.10
Ash	4.14
Sulphur	0.96
Phosphorus	0.012

Holbrook opening—McPeak's Branch—

Coal	40″
Shale	12″
Coal	70″

Analysis.

Moisture	2.07
Volatile matter	35.73
Fixed carbon	55.79
Ash	6.41
Sulphur	0.60

Alex Isom's opening—Elkhorn Creek—

Coal	42″
Shale	10″
Coal	49″

Analysis.

Moisture	1.29
Volatile matter	36.28
Fixed carbon	59.10
Ash	3.33
Sulphur	0.55
Phosphorus	0.002

Ben Potter opening—Ben's Branch—

Coal	42″
Shale	9″
Coal	52″

Analysis.

Moisture	0.20
Volatile matter	37.96
Fixed carbon	58.87
Ash	2.97
Sulphur	0.91
Phosphorus	0.009

Mat Blevins' opening—Joe's Branch—

Coal	41"
Shale	3"
Coal	54"

Analysis

Moisture	2.22
Volatile matter	36.10
Fixed carbon	59.28
Ash	2.40
Sulphur	0.64

Wm. Potter opening—Cane Branch—

Coal	41"
Shale	5"
Coal	45"

Analysis

Moisture	0.20
Volatile matter	37.96
Fixed carbon	58.87
Ash	2.97
Sulphur	0.92
Phosphorus	0.009

John Wright opening—Elkhorn Creek—

Coal	39"
Shale	9"
Coal	44"

Analysis

Moisture	2.27
Volatile matter	36.45
Fixed carbon	58.45
Ash	2.83
Sulphur	1.12

John Venter's opening—Elkhorn Creek—

Coal	46"
Shale	19"
Coal	48"

Analysis

Moisture	1.31
Volatile matter	39.55
Fixed carbon	54.91
Ash	4.23
Sulphur	0.98
Phosphorus	0.003

The highest elevation of the Elkhorn coal is just above the mouth of Marshall Branch of Elkhorn where it forms a pronounced dome and where it is 1,720 feet A. T. Dipping rapidly from there to the northwest it is 1,620 at the extreme head of Marshall Branch. Another smaller dome shows on Cane Branch with an elevation of 1,640 A. T.

On the branches of Elkhorn the following are elevations of the Elkhorn coal in addition to those already given:

Mouth of McPeak's Branch	1,600
Head of McPeak's Branch	1,640
Mouth of Ben's Branch	1,575
Head of Ben's Branch	1,640
Mouth of Joe's Branch	1,580
Head of Joe's Branch	1,615
Mouth of Cane Branch	1,610
Head of Cane Branch	1,610
Mouth of Little Elkhorn	1,570
Mouth of Beaver Dam Branch	1,610
Head of Little Elkhorn	1,580
In Potter's Gap	1,620
Head of Main Elkhorn	1,550

On the head waters of Elkhorn Creek and of the Kentucky River the Fire Clay Coal is found at an elevation of 400 feet above the Elkhorn coal. It is opened in the road that goes over the hill from McRoberts to Jenkins at a point just below the gap where the road reaches the summit and at other places in the immediate vicinity.

NORTH FORK OF KENTUCKY RIVER.

On the waters of the North Fork the Elkhorn coal begins as a workable coal at the mouth of Thornton where it is about 5 feet thick. On the head of Thornton it is about 4 feet. Below Thornton it splits and is hardly workable. On Millstone it ranges from 5 to 6 feet in thickness and about 180 feet above the river, but thins down somewhat farther up the creek. On the waters of Boone Fork it is everywhere thick and is opened in a great many places. Openings are as below:

Mines 211-212—Elevation 1,479—

Slaty shale	
Coal	45″
Clay	2″
Coal	29″
Clay.	

Mine 213—Elevation 1,522—

Slaty shale	
Coal	42″
Clay	6″
Coal	39″
Clay.	

Mine 214—Elevation 1,515—

Slaty shale	
Coal	42″
Clay	2″
Coal	40″
Clay.	

Mine 215—Elevation 1,486—

Slaty shale	
Coal	42″
Clay	3″
Coal	39″
Clay.	

Hughes' opening—Potter's Fork—

Coal	42″
Clay	5″
Coal	48″

Analysis

Moisture	0.37
Volatile matter	37.87
Fixed carbon	59.12
Ash	2.64
Sulphur	0.89
Phosphorus	0.008

Ike Wright opening—Potter's Fork—

Coal	52″
Clay	5″
Coal	52″

Analysis

Moisture	2.10
Volatile matter	37.46
Fixed carbon	57.35
Ash	3.09
Sulphur	0.53

E. Newsom opening—Ramey Fork—

Coal	56.5″
Clay	4 ″
Coal	37.5″

Analysis

Moisture	1.28
Volatile matter	36.96
Fixed carbon	58.04
Ash	3.72
Sulphur	1.01
Phosphorus	0.011

Ike Potter opening—Potter's Fork—

Coal	22.5″
Slate	1 ″
Coal	30.5″
Clay	3.5″
Coal	50.5″

Analysis

Moisture	2.22
Volatile matter	37.19
Fixed carbon	58.41
Ash	2.18
Sulphur	0.52
Phosphorus	0.001

Joe Hall opening—She Fork—

Coal	46″
Clay	2″
Coal	36″

Analysis

Moisture	1.64
Volatile matter	37.59
Fixed carbon	58.17
Ash	2.60
Sulphur	1.05
Phosphorus	0.003

John Wright opening—Wright's Fork—

Coal	44.5″
Clay	2.5″
Coal	39.5″

Analysis

Moisture	1.59
Volatile matter	36.88
Fixed carbon	59.06
Ash	2.47
Sulphur	0.54
Phosphorus	0.001

Bore Hole No. 4—Elevation, 1,606—

Coal	51″
Clay	19″
Slate	69″
Coal	50″

Little Laurel Branch—Elevation 1,582—

Coal	48″
Clay	6″
Coal	49″

Head of Orchard Branch—Elevation 1,610—

Coal	21″
Clay	8″
Coal	31″
Clay	7″
Coal	38″

Head of Ritter Branch—Elevation, 1,587—

Coal	30″
Clay	6″
Coal	36″

Potter's Fork above mouth—Elevation 1,459—

Coal	57″
Clay	2″
Coal	26″

Stewart Branch of Potter's Fork—Elevation 1,503—

Coal	24″
Clay	4″
Coal	51″

Bear Branch of Potter's Fork—Elevation 1,535—

Coal	24″
Clay	5″
Coal	43″

Opposite mouth of Bear Branch—Elevation 1,521—

Coal	55″
Clay	3″
Coal	29″
Clay	3″
Coal	20″

Potter's Fork above Gray's Branch—Elevation 1,598—

Coal	45″
Clay	4″
Coal	57″

Bore Hole No. 9 at head of Potter's Fork—Elevation 1,601—

Coal	42″
Clay	9″
Coal	45″

Wright's Fork above mouth—

(1)		(2)	
Coal	24″	Coal	24″
Clay	1″	Clay	1″
Coal	38″	Coal	37″
Elevation 1,459		Elevation 1,470	

Wright's Fork below Bottom Fork—

(1)		(2)		(3)	
Coal	26″	Coal	18″	Coal	24″
Clay	2″	Clay	1″	Clay	2″
Coal	43″	Coal	37″	Coal	36″
Elevation 1,497		Elevation 1,495		Elevation 1,481	

Head of Bottom Fork—Elevation 1,471—

Coal	27″
Clay	3″
Coal	35″

Wright's Fork between Bottom Fork and She Fork—

(1)		(2)	
Coal	30″	Coal	12″
Clay	3″	Clay	1″
Coal	39″	Coal	38″
Elevation 1,510		Elevation 1,514	

(3)		(4)	
Coal	53″	Coal	50″
Clay	3″	Clay	3″
Coal	45″	Coal	41″
Elevation 1,497		Elevation 1,515	

Boone Fork above mouth of Potter's Fork—Elevation 1,439—

Coal	24″
Clay	2″
Coal	43″

Boone Fork—at mouth of Wright's Fork—Elevation 1,436—

Coal	62″

Boone Fork above mouth of Wright's Fork—Elevation 1,443—

Coal	39″
Clay	2″
Coal	19″

On Little Creek of Boone—Elevation 1,401—

Coal	64″

Yont's Fork of Boone above Little Creek—Elevation 1,424—

Coal	33″
Clay	1″
Coal	36″

Yont's Fork above Quillan Fork—Elevation 1,403—

Coal	26″
Clay	1″
Coal	46″

On the waters of the North Fork the following are elevations of the Elkhorn coal above sea:

Head of Wolf Pen Branch of Yonts Fork	1,380
Mouth of Wolf Pen Branch	1,400
Mouth of Quillan Fork	1,410
Mouth of Little Creek	1,430
Mouth of Wright's Fork	1,460
Head of Bottom Fork of Wright's Fork	1,475

Head of She Fork	1,430
Mouth of She Fork	1,500
Head of Tom Bigg's Branch	1,550
Head of Bark Camp Branch	1,530
Head of Wright's Fork	1,500
Mouth of Potter's Fork	1,470
Mouth of Ramey Fork	1,550
Head of Ramey Fork	1,590
Head of Gray's Branch	1,590
Head of Potter's Fork	1,600
Head of Little Laurel Branch	1,590

RUSSELL FORK.

MARROWBONE CREEK, PIKE COUNTY.

The Marrowbone coals are developed by a railroad which leaves the Chesapeake and Ohio at the mouth of Marrowbone Creek and runs up to near the head of Cassell Fork. Two coals are mined which lie from 160 to 180 feet apart and have been known as Lower and Upper Elkhorn respectively. As explained on a previous page, these coals are both below the thick Elkhorn coal of the Jenkins and McRoberts region and more suitable names for them would be Lower and Upper Marrowbone. Mines are operated by the Marrowbone Coal and Coke Company which has a mine and coke ovens at Rockhouse, the Henry Clay Coal and Coke Company with a mine on the upper vein at Henry Clay, the Big Branch Coal Company with a mine on the upper vein on Big Branch, the Greenough Coal and Coke Company with mines at Hellier, and the Allegheny Coal & Coke Company with mines and coke ovens on Long Fork of Cassell Fork at the head of the railroad line. Following are sections of the coals on these mines and also sections of the two veins on the Elkhorn Coal and Coke Company property:

Marrowbone Coal and Coke Company—

Lower vein—		Upper vein—	
Slate		S. S.	
Coal	3″	Laminated coal	10″
Laminated coal	14″	Coal	36″
Coal	32″		

Henry Clay Coal and Coke Company—

Laminated coal	10″
Coal	39″

Big Branch Coal Company—

Laminated coal	8″
Coal	38″

Elkhorn Coal & Coke Company—

S. S.		S. S.	
Laminated coal	16″	Slate	8″
Coal	35″	Laminated coal	8″
Fire clay	3″	Coal	38″

Greenough Coal & Coke Company—

S. S.		S. S.	
Laminated coal	18″	Shale	
Coal	30″	Splint	2″
Fire clay.		Laminated coal	10″
		Coal	35″

Allegheny Coal and Coke Company—

Lower vein—		Upper vein—	
Slate and shale		S. S.	
Laminated coal	19″	Slate	5″
Coal	32″	Splint	2″
Fire clay.		Laminated coal	6″
		Coal	36″

These coals correlate, the lower vein with the Syck (Jim Dotson or Fed's Creek) coal of Pike County and the upper vein with the Van Lear-Freeburn coal. Elevations above sea of these coals have been given on all maps and reports heretofore considerably too high, the lower vein being shown on the map of the Elkhorn Coal Field (Stone—U. S. Geological Survey) as about 1.375 above tide at the old Edgewater mine above Hellier. The actual elevation of Hellier is 1,135 above tide and this would make the lower coal 240 feet above Helleir, which is much too high. This discrepancy in elevation may have caused the error by which the upper one of these two coals was correlated with the thick coal at Jenkins. A coal about 140 feet above the Upper Marrowbone coal and lying close to the tops of the higher hills on Cassell's Fork is probably the extension of the Elkhorn coal in this section.

At the head of Cassell Fork and Russell Fork is the Flatwoods coal extending under the high table land known as the Flatwoods between the waters of Shelby

and Marrowbone Creeks. This coal was first described by Prof. Crandall and has since been opened and measured by different geologists and attempts made to correlate it with coals in the West Virginia and Pennsylvania coal fields. It is simply the fire clay coal of Eastern Kentucky and its rider, the latter here close down onto the fire clay coal. An opening on this coal at the head of Cassell Fork of Marrowbone gave:

Coal	4 ″	
Slate	2½″	
Coal	21 ″	
Slate	1 ″	
Coal	2½″	
Slate	1 ″	
Coal	63 ″	Fire clay rider.
Shale	18 ″	
Coal	2 ″	
Shale	6 ″	
Coal	18 ″	
Shale	28 ″	
Coal	18½″	
Flint Clay	4 ″	Fire clay coal.
Coal	28 ″	

A section of this coal at the head of Russell Fork gave:

Section of Flatwoods Coal—

S. S.	
Slate	20 ″
Coal	7 ″
Slate	3 ″
Coal	18 ″
Slate	1 ″
Coal	3 ″
Slate	0.5″
Slaty coal	8 ″
Coal	12 ″
Slate	0.5″
Coal	20 ″
Bone, coal, slate	2 ″
Coal	39 ″
Slate	5 ″
Coal	24 ″
Slate	0.5″

Section of Flatwoods Coal—Continued—

Coal	2 "
Slate	24 to 30 "
Coal	19 "
Flint clay	6 "
Coal	32 "

This coal is about 400 feet above the Elkhorn coal (the same as at the head of Elkhorn Cr.) and 540 feet above the Upper Marrowbone coal. The summit of the Flatwoods plateau is about 700 feet above the Flatwoods coal. (For a vertical section of the measures up to the Flatwoods coal see Beaver Creek of Russell Fork.)

FERRELL CREEK, PIKE COUNTY.

On Ferrell's Creek the Lower Marrowbone coal is reported by Prof. Crandall as about 30 inches thick and 540 feet above Russell Fork.

The Upper Marrowbone (Van Lear-Freeburn) seam is opened at a number of places on the upper waters of Ferrell's Creek with the following bed sections.

Road Fork of Ferrell's Creek—Freeburn coal—

Laminated coal	7″
Coal	25″
Splint	4″
Coal	22″

Head of Ferrell's Creek—Freeburn coal—

Laminated coal	5″
Coal	24″
Splint	5″
Coal	23″

Brush Fork of Ferrell's Creek—Freeburn coal—

Coal	9″
Laminated coal	4″
Coal	50″

At C. B. Bingham's—Freeburn coal—

Laminated coal	15″
Coal	23″
Splint	2″
Coal	24″
Slate	1″
Coal	4″

The Elkhorn coal is also opened about 160 feet higher in the hills as follows:

On Brush Fork of Ferrell's Creek—Elkhorn coal—

Bone	2″
Coal	50″
Slate	4″
Coal	20″

On head of Ferrell's Creek—Elkhorn coal—

Coal	32″
Slate	3″
Coal	22″
Coal and slate	7″
Coal	19″

BEAVER CREEK OF RUSSELL FORK, PIKE COUNTY.

In the railroad cut between Elkhorn City and the mouth of Beaver is exposed the lowest coal in the Upper Big Sandy Valley with the possible exception of one or two thin coals in the upturned measures in the Breaks and along the face of Pine Mountain. If, as explained in the first part of this article, the heavy sandstone at Elkhorn City is the Nuttall Sandstone, as so correlated by Dr. I. C. White, this coal is the lowest coal in the Kanawha as developed in Kentucky and may possibly correlate with the Lower War Eagle coal of West Virginia. This coal has been known heretofore as the Ellswick seam and this name will be retained for this seam on Russell Fork and its tributaries.

Just above the mouth of Beaver and about 60 feet above the level of Russell Fork an opening on this coal gave:

Ellswick coal—

Coal	33″
Slate	8″
Coal	7″

There is only a small area of the coal exposed above drainage, as it goes under a short distance up Elkhorn and Beaver Creeks and below the mouth of Beaver Creek on Russell Fork.

From 190 to 200 feet above the Ellswick coal is another coal which has been known as the Auxier. On Beaver an opening one-fourth of a mile above the mouth of the Right Fork gave,

Auxier coal—
Slate
Coal .. ..34 "
Slate .. .. 4.5"
Coal .. ..12 "

About 280 feet above the Auxier coal is a seam which is locally workable and in places quite thick. On the Tug Fork side this seam is known as the Presbyterian School seam. On Beaver Creek on the Left Fork it has the following bed section:

Presbyterian School seam—
Slate
Coal .. ..50"

Near the head of Left Fork of Beaver and about 360 feet above the Presbyterian School seam—Freeburn (Upper Marrowbone) coal—
Slate
Laminated coal ......14"
Coal .. ..34"
Clay .. .. 4"
Coal .. ..16"

On head of Left Fork and about 160 feet above the Freeburn coal—Elkhorn coal—
Slate
Coal .. ..26 "
Clay .. .. 7 "
Coal .. ..43 "
Slate .. .. 0.5"
Coal .. ..30"

On Right Beaver—Syck (Lower Marrowbone) coal—
S. S.
Slate
Coal .. ..36"

On Right Beaver, 190 feet above last—Freeburn coal—
Slate
Coal .. ..46"

On Right Beaver, 160 feet above last—Elkhorn coal—
Slate
Coal .. ..29"
Splint .. .. 1"
Coal .. ..32"
Clay .. .. 2"
Coal .. ..23"

A general vertical section from Beaver Creek to the Flatwoods region would show as follows:

Summit of Flatwoods—
Interval 150 to 200 feet.
Four foot coal—
Interval 530 feet.
Flatwoods coal (Fire clay coal and rider)—
Interval 400 feet.
Elkhorn coal—
Interval 140 to 165 feet.
Freeburn (Upper Marrowbone) coal—
Interval 180 ft. to 200 ft.
Syck (Lower Marrowbone) coal—
Interval 150 to 180 ft.
Presbyterian School seam—
Interval 280 to 300 ft.
Auxier coal—
Interval 190 to 200 ft.
Ellswick coal—
Interval 60 feet.
Russell Fork.

These intervals, however, are barometric and subject to correction. There are a number of thinner coals included within the limits of the above section of which no present account is taken.

LEVISA FORK.

LOWER POMPEY CREEK, PIKE COUNTY.

The Freeburn coal is thinner than it is on the creeks further up Levisa Fork, three openings showing it as follows:

(1)	(2)	(3)
Slate	Slate	Coal .. ..45"
Coal ....41"	Coal .. .. 7"	
	Coal and slate.... 2"	
	Coal .. ..33"	

The Jim Dotson or Lower Marrowbone coal about 180 feet below the Freeburn shows:

(1)		(2)		(3)	
Slate		Slate		Slate	
Coal	2"	Coal	1.5"	Coal	46"
Slate	4"	Slate	4 "	Shale	1"
Coal	34"	Coal	38 "	Coal	2"

UPPER POMPEY CREEK, PIKE COUNTY.

Jim Dotson or Lower Marrowbone coal—

Slate	
Coal	39"

Freeburn coal—

(1)		(2)	
S. S.		Slate	
Coal	14 "	Coal	13"
Slate	1 "	Slate	1"
Coal	32 "	Coal	13"
Clay	2 "	Slate	1"
Coal	8.5"	Coal	18"
		Slate	1"
		Coal	11"

GRAPEVINE CREEK, PIKE COUNTY.

On Grapevine the Freeburn coal is a little over 400 feet above Levisa Fork. Three openings show as follows:

(1)		(2)		(3)	
Slate		Slate		Slate	
Coal	16"	Coal	6 "	Coal	21"
Slate	7"	Slate	0.5"	Laminated coal	5"
Coal	23"	Coal	10"	Coal	24"
Laminated coal	6"	Laminated coal	4 "	Slate	19"
Coal	54"	Coal	15 "	Coal	49"
		Slate	17 "		
		Coal	41 "		

LICK CREEK, PIKE COUNTY.

On Levisa Fork below the mouth of Lick Creek—Freeburn coal—

S. S.	
Coal	87"
Fire clay.	

Jim Dotson coal—

Coal	29"
Slate	5"
Coal	14"

Near the mouth of Lick Creek and about 550 feet above Levisa Fork—Freeburn coal—

Coal	77 "
Shale	1.5"
Coal	9 "

Jim Dotson (Fed's Creek) coal—

Slate	
Coal	46 "
Slate	0.5"
Coal	6 "
Slate	0.5"
Coal	7 "

On Spring Fork of Ellswick Fork—Jim Dotson coal—

Coal	51"

On head of Ellswick Fork—Freeburn Coal—

Slate	
Laminated coal	19"
Coal	28"
Splint	10"
Coal	14"

On Road Fork of Lick Creek—Freeburn Coal—

Coal	24"
Splint	5"
Coal	21"

Head of Lick Creek—Jim Dotson coal—

Coal	48"

Freeburn coal—

Coal	60"

BIG CREEK OF LEVISA FORK, PIKE COUNTY.

On the Lynn Hollow—Freeburn coal—

Coal	10"
Laminated coal	10"
Coal	53"

On the Third Left Fork—Jim Dotson (Fed's Creek) coal—

Coal	48″

On Spruce Pine Branch—Freeburn coal—

Coal	11″
Laminated coal	9″
Coal	24″
Splint	18″
Coal	8″

The Jim Dotson coal is about 190 feet below the Freeburn coal, the latter being nearly 600 feet above Levisa Fork. The Presbyterian School seam of Peter Creek is opened at several places about 125 feet below the Jim Dotson coal and ranging in thickness from 34 to 36 inches.

FED'S CREEK, PIKE COUNTY.

On Motley Branch one mile above mouth of Fed's Creek—Lower Marrowbone (Jim Dotson or Fed's Creek) coal—

Slate	
Coal	48″
Clay.	

Freeburn coal—

S. S.	
Slate	24″
Coal	6″
Laminated coal	8″
Coal	45″
Slate	1″
Coal	8″

On Spruce Pine Branch—Jim Dotson coal—

Coal	56″

Freeburn coal—

Coal	50″

On Fed's Creek near Estepp's—Presbyterian School coal—

Slate	
Coal	10″
Slate	1″
Coal	27″

James Dotson opening on Fed's Creek—Jim Dotson (Lower Marrowbone) coal—

S. S.	
Slate	24″
Ccal	79″
Slate.	

On head of Fed's Creek—Jim Dotson coal—

Coal	80″

Freeburn coal—

Coal	8″
Laminated coal	9″
Coal	43″

On Fed's Creek there is a thickening of the vein known locally as the James Dotson coal, which is the coal 180 to 200 feet below the Freeburn coal, and which corresponds in position to the Lower Marrowbone coal. This, however, does not seem to hold good across the ridge on the Peter Creek side where this coal seems to be either thin or split.

LITTLE CARD CREEK, PIKE COUNTY.

On Little Card Creek the Freeburn coal is about 600 feet above Levisa Fork. An old opening given by Prof. A. R. Crandall was:

Freeburn coal—

Shale	
Coal	4 ″
Laminated coal	3 ″
Coal	46 ″
Shale	2 ″
Coal	9 ″
Shale	2.5″
″Coal	5 ″
Bituminous shale.	

Analysis.

Moisture	5.64
Volatile matter	23.30
Fixed carbon	64.26
Ash	6.80
Sulphur	0.549

No other openings are available at present on this creek.

BIG CARD CREEK.

One-fourth of a mile above mouth and 190 feet above river—Auxier coal—

Coal	44″

On Road Fork—Presbyterian School coal—

Coal	12″
Bone	3″
Coal	15″
Slate	1″
Coal	20″
Slate	1″
Coal	3″

On the head of Big Card—Jim Dotson's (Fed's Creek) coal—

Slate	
Coal	29″
Slate	4″
Coal	17″

Freeburn coal—

Coal	60″

JOHN'S CREEK, FLOYD AND PIKE COUNTIES.

At the mouth of John's Creek the Van Lear coal is just above high water, being brought down by the southerly dip from the Paint Creek dome. It is mined at Auxier on Levisa Fork, just above the mouth of the creek, by the North East Coal Company, which has bridged the Big Sandy river and has their main entry on Osborn Branch on the east side of the river. They have put in a modern plant and have drifted clear through the ridge on to John's Creek and are now driving in the ridge between Miller's and John's Creeks. The accompanying map will show the locations of the plants both at Auxier and at Van Lear at the mouth of Miller's Creek. The Van Lear coal is exposed here along the river and up John's Creek with its usual character and thickness to where it goes under drainage on John's Creek below the mouth of Daniel's Creek. The seam ranges in thickness from 45 to 60 inches and is dipping up John's Creek from the Paint Creek dome and against the fall of the creek, the coal being about 635 feet A. T. at the mouth of the creek and under drainage, as stated above, at the mouth of Daniels Creek at an elevation of 595. The coal is also dripping up John's Creek above the mouth of Daniels and up the river and goes under the railroad just above the Mary Luck mine which is around the first bend above Auxier. Going up John's Creek the reversed dip and rise of the rocks to the southeast going up the northwest flank of the Warfield anticline brings the Van Lear coal close to the surface and probably above, but it was not seen as a workable coal although a coal showing in the bank of the creek below Dick's Creek may be this coal cut down in thickness. The Warfield anticline crosses in the big bend of John's Creek above the Brandy Keg bridge and the fault which is prominent above the anticline on Tug Fork shows in the cliffs on the east side just below the sharp bend in the creek below the mouth of Dick's Creek. The fault seems to be dying out to the west, however, and was not seen on Levisa Fork. The reversal of dip and fall of the measures to the southeast toward the syncline already mentioned on Tug and Levisa Forks, together with the rise of John's Creek itself, would keep this coal under drainage above.

From the mouth of Daniels' Creek for some distance up John's Creek only thin coals are to be seen. The Van Lear coal is under drainage and the two coals above it are not workable. A thick coal is reported higher in the hills, but nearly all openings were fallen in and only a few could be seen. On the east side of John's Creek, about one-half mile above Hager's Gap, and about 350 feet above the creek, is an opening on this coal.

S. S.	
Black slate	6″
Coal	13″
Shale	1″
Coal	22″
Slate.	

And on Big Branch, probably the same coal:

Slate	
Coal	3″
Slate	1″
Coal	40″
Slate.	

Up the creek from this point only thin coals were seen up to the mouth of Dick's Creek where the second coal above the Van Lear coal which is thinner down the creek gets to be of workable thickness again.

Openings on this vein on Dick's Creek are as follows:

At mouth of Dick's Creek—

Slate	
Coal	37" (150 ft. above creek)
Slate	½"
Coal	10"

One-half mile up Dick's Creek—

S. S.	
Slate	6"
Coal	39"
Slate.	

On Mud Lick Branch of Dick's Creek—

Slate	
Coal	39"
Slate.	

On Road Fork of Dick's Creek—

Coal	36"

At mouth of Laurel Fork of Dick's Creek—

Coal	64"

The coal goes under drainage just above this point. Above Dick's Creek the coal is thinner and dipping down under the creek to the syncline. Numerous openings have been made up to the mouth of Sycamore Creek but, with the exception of the coals high in the ridges, all seem to be on veins too thin to be workable. Just above the mouth of Sycamore Creek the rising dip to the southeast, reversing from the syncline, brings what is locally known as the "big vein" above drainage rising from there up stream faster than the fall of the creek.

At creek level above Sycamore Creek this seam has a bed section,

Slate	
Coal	12"
Slate	15"
Coal	42"

This coal correlates with the Elkhorn coal of Levisa Fork and Southern Pike County and the Alma coal of Tug Fork. At the mouth of Little Brushy it is about 20 feet above the creek with this bed section,

Coal	41"
Slate	6"
Coal	7"
Slate	6"
Coal	11"
Slate	13"
Coal	16"

MILLER'S CREEK OF JOHN'S CREEK.

One half way up and 10 feet above the creek—Coal under Elkhorn (Ivel coal)—

Slate	
Coal	10"
Slate	1"
Coal	20"
Slate.	

Just above last—Elkhorn coal—

Slate	
Coal	33"
Slate	8"
Coal	10"
Slate.	

On Clark Branch of Miller's Creek—Ivel coal—

Slate	
Coal	10"
Slate	1"
Coal	21"
Slate.	

At mouth of Long Branch of Miller's Creek, Top bench of Elkhorn coal—

Slate	
Coal	26"
Slate	36"

One-third of a mile below head of Miller's Creek—Fire Clay coal—

S. S.	
Slate	15"
Coal	18"
Flint clay	4"
Coal	8"
Slate.	

In ridge at head of Miller's Creek—Fire Clay coal—

S. S.
Coal .. ..20"
Flint clay .... 3"
Coal .. ..16"
Slate.

In ridge between Miller's Creek and Stone Coal Creek—Fire Clay coal—

S. S.
Coal .. ..17"
Flint clay .... 3"
Coal .. ..15"
Slate.

On John's Creek, below the mouth of Joe's Creek—Ivel coal—

Slate
Coal .. ..10"
Slate .. .. 3"
Coal .. ..18"
Slate.

JOE'S CREEK.

One-half mile up Joe's Creek—Ivel coal—

Slate
Coal .. ..10"
Slate .. .. 2"
Coal .. ..20"
Slate.

On Joe's Creek and above last opening—Elkhorn coal—

Slate
Coal .. ..21"
Slate .. .. 4"
Coal .. .. 5"
Slate .. .. 6"
Coal .. ..12"
Slate .. ..17"
Coal .. ..12"
Slate.

Further up Joe's Creek—Elkhorn coal—

Slate
Coal .. ..26"
Slate .. .. 5"
Coal .. ..14"
Slate .. .. 5"
Coal .. ..18"
Slate.

Joe's Creek, three-fourths of a mile above mouth—Elkhorn coal—

Slate
Coal .. ..25"
Slate .. ..11"
Coal .. ..12"
Slate .. .. 5"
Coal .. ..17"
Slate.

At same place—Ivel coal—

Coal .. ..36"

One-fourth of a mile below forks of Joe's Creek—Elkhorn coal (near drainage)—

Slate
Coal .. ..12 "
Slate .. ..13 "
Coal .. ..16 "
Slate .. .. 1 "
Coal .. .. 7 "
Slate .. .. 1 "
Coal .. .. 1.5"
Slate.

Above forks of Left Fork of Joe's Creek—Elkhorn coal—

S. S.
Slate .. ..20"
Coal .. ..26"
Shale .. ..54"
Coal .. ..18"
Slate .. .. 1"
Coal .. ..10"
Slate.

At this point and over on the Levisa Fork waters the coal is split in two benches by a thick parting of shale.

At head of Right Fork of Left Fork of Joe's Creek, Fire Clay coal—

Slate
Coal .. ..24"
Flint clay .... 3"
Coal .. .. 9"

Head of Right Fork of Joe's Creek—Fire Clay coal—

S. S.
Coal .. ..21"
Flint clay .... 4"
Coal .. ..16"

John's Creek at Pinson Branch, three-fourths of a mile above Joe's Creek—Elkhorn coal—

Slate	
Coal	22"
Slate	4"
Coal	5"
Slate	7"
Coal	12"
Slate	6"
Coal	17"
Slate.	

John's Creek, one and a half miles above Joe's Creek—Elkhorn coal (75 feet above creek)—

Slate	
Coal	22"
Slate	1"
Coal	6"
Slate	18"
Coal	12"
Slate	2"
Coal	18"
Slate.	

BENT'S BRANCH.

At mouth of Bent's Branch—Ivel coal—

Coal	16"
Shale	5"
Coal	24"

One mile up Bent's Branch, on left—Elkhorn coal—

Coal	13"
Slate	2"
Coal	7"
Slate	13"
Coal	22"

At same place, on right of creek—Ivel coal—

Coal	16"
Shale	5"
Coal	24"

One and a half miles up Bent's Branch—Elkhorn coal—

Coal	11"
Slate	1"
Coal	14"
Slate	13"
Coal	30"

At the mouth of Bent's Branch Prof. Crandall gives—Broas coal—(375 ft. above creek.)

Coal	2"
Shale	2"
Coal	24"
Bone	5"
Coal	13"

Six foot coal—(675 ft. above creek.)

Shale	
Coal	14 "
Shale	2.5"
Coal	52 "
Clay.	

On Smith's Branch, one and a half miles above Bent's Branch—Ivel coal—

Coal	14"
Clay	5"
Coal	16"

On Bevin's Branch—Elkhorn coal—

Coal	20 "
Slate	11 "
Coal	37.5"

At the mouth of Ground Hog Branch the Van Lear-Freeburn coal comes up, the top of the seam showing in the branch.

Three-fourths of a mile up Ground Hog Branch—Ivel coal—

Coal	18"
Shale	12"
Coal	13"

At the head of Ground Hog Branch—Ivel coal—

Coal	12"
Shale	6"
Coal	26"

At mouth of Lawson Branch—Freeburn coal—

Coal	6 "
Cannel	6.5"
Coal	33 "

One-half mile up Lawson Branch—Freeburn coal—

Coal	4″
Cannel	5″
Coal	41″

One mile up Lawson Branch—Freeburn coal—

Coal	1″
Slate	5″
Coal	38″

One-half mile above Lawson Branch—Freeburn coal—

Coal	6″
Cannel	6″
Coal	33″

On Stinking Creek—Elkhorn coal—

Coal	16″
Shale	28″
Coal	9″
Bone	2″
Coal	28″

On Meathouse Creek, two openings on the Freeburn coal—

(1)		(2)	
Coal	3″	Coal	1″
Parting	1″	Laminated coal	1″
Coal	45″	Coal	8″
		Parting	1″
		Coal	44″

On John's Creek above Ground Hog Branch, the three coals, Van Lear-Freeburn, Ivel and Elkhorn are opened as shown above.

One first branch below Hurricane Creek—Freeburn coal—

Coal	1″
Laminated coal	1″
Coal	48″

On Hurricane Creek two openings on the Elkhorn coal—

(1)		(2)	
Coal	16″	Slate	
Slate	12″	Coal	16″
Coal	18″	Slate	10″
Slate	1″	Coal	21″
Coal	41″	Slate	6″
		Coal	34″

In ridge between Hurricane Creek and Jonnican Creek—Elkhorn coal—

Slate	
Coal	18″
Slaty coal	11″
Coal	20″
Slate	6″
Coal	35″

On Elkhorn Creek, two openings on the Dwale coal—

(1)		(2)	
Slate		Slate	
Coal	3″	Coal	4″
Splint coal	2″	Splint coal	2″
Coal	33″	Coal	40″

At head of Rattlesnake Branch of John's Creek—Dwale coal—

Slate	
Coal	3″
Splint coal	4″
Coal	23″

At mouth of Layne's Branch of John's Creek—Dwale coal—

Slate	
Coal	4″
Splint coal	3″
Coal	23″

At forks of Layne's Branch—Dwale coal—

Slate	
Coal	10″
Splint coal	4″
Coal	30″

LONG FORK OF JOHN'S CREEK.

Mouth of Long Fork—Freeburn coal—

Coal	21″
Laminated coal	7″
Coal	41″

One and a half miles up Long Fork—Freeburn coal—

S. S.	
Slate	
Coal	10″
Laminated coal	10″
Coal	18″
Slate	3″
Coal	26″

One and three-quarter miles up Long Fork—Freeburn coal—

S. S.	
Slate	
Coal	15″
Laminated coal	9″
Coal	39″

Two miles up Long Fork—Freeburn coal—

S. S.	48″
Shale	12″
Coal	12″
Laminated coal	7″
Coal	37″

Near head of Long Fork—Freeburn coal—

(1)		(2)		(3)	
Coal	8″	Coal	8″	Bone	2″
Laminated coal	10″	Laminated coal	9″	Coal	16″
Coal	38″	Coal	21″	Laminated coal	8″
		Slate	5″	Coal	28″
		Coal	22″		

John's Creek Above Mouth of Long Fork.

At head of Hardin's Branch—Freeburn coal—

S. S.	
Shale	48″
Coal	21″
Laminated coal	5″
Coal	33″

Above mouth of Hardin's Branch—Freeburn coal—

S. S.	
Coal	14″
Laminated coal	9″
Coal	33″

At mouth of Pritchett's Fork—Freeburn coal—

S. S.	
Coal	15″
Laminated coal	7″
Coal	35″

Coon Creek of John's Creek.

On Burning Fork of Coon Creek—Van Lear coal—

Coal	18″
Slate	30″
Coal	12″
Slate	32″
Coal	20″

On Grassy Fork of Coon Creek—Van Lear coal—

Coal	39″

On Frozen Creek of Coon Creek—Van Lear coal—

Coal	13″
Slate	1″
Coal	3″
Slate	6″
Coal	33″
Slate	1″
Coal	10″

At head of Frozen Creek—Van Lear coal—

Coal	12″
Slate	1″
Coal	41″

On Coon Creek above Frozen Creek—Van Lear coal—

Coal	18″
Slate	15″
Coal	15″
Slate	1″
Coal	10″
Slate	3″
Coal	18″

At head of Sloan Fork of Coon Creek—Van Lear coal—

Coal	13 ″
Slate	1 ″
Coal	34 ″
Slate	½″
Coal	12 ″

COALS ON TUG FORK.

On Tug Fork attempted correlations of the coals with the coals further east in West Virginia and in Pennsylvania have been made, with considerable resulting confusion as to their actual relative correlation at different points on the river.

On the lower part of Tug Fork between Big Creek and Williamson the section as usually given is:

Borderland coal,
Upper Thacker coal,
Lower Thacker coal,
Alma coal,
Freeburn coal.

The interval between the Freeburn and the Alma varies from 80 to 160 feet, and there is another coal (unnamed in this section) between the two. The Alma and Upper Thacker vary from 160 to 220 feet apart with a coal between. The Lower Thacker of the section further up the river is a split from the Thacker and cannot be identified here. The Borderland is from 300 to 350 feet above the Upper Thacker with several thinner coals between.

Further up Tug Fork the section generally given is:

Coalburg coal,
Winifrede coal,
Taylor coal,
Cannel seam,
Upper Thacker coal,
Lower Thacker coal,
Alma coal,
Freeburn coal.

The correlation of the upper ones with the coals further east is doubtful. The Winifrede is supposed to be the southward extension of the Borderland seam although the interval between the so-called Winifrede and Upper Thacker is about 500 feet instead of a little over 300 as at Borderland. It seems more probable that the Borderland is about at the horizon of the old "Broas" coal of Martin County and that the Winifrede of this section represents the "F" coal of the same region and is more likely the Coalburg coal of West Virginia. As evidence of the confusion existing in these correlations, a mine near Williamson on the Thacker coal is called "Freeburn" although the mine is about 300 feet above the river and the Freeburn is in the river bank. For

the present no attempt can be made at correlating these higher coals (there are others higher still in the high ridges between Tug and Levisa Forks) and the local names will be used as far as possible for the lower coals.

As mentioned on a previous page, the Warfield coal (which is tentatively correlated with the Van Lear-Freeburn coal) is carried under drainage up the river by the reversed dip from the Warfield anticline. The Freeburn coal does not come up above the river until brought up, by the rising dip from the syncline, at a point near the mouth of Turkey Creek. At the mouth of Big Creek the Alma coal is above drainage and the vertical section is:

Thick coal,
Interval 130 ft.
Borderland coal,
Interval 135 ft.
Coal,
Interval 235 ft.
Thacker coal,
Interval 110 ft.
Alma coal,
Interval 40 ft.
Tug Fork,
(Freeburn coal about 60 ft. below drainage.)

BIG CREEK, PIKE COUNTY.

At the mouth of Big Creek the Alma coal is about 40 feet above Tug Fork and the Thacker about 150 feet, with a thinner coal in between. Going up the creek there is not much rise in the measures, the coals rising about with the creek. On Long Branch the Thacker is opened with this bed section:

Coal	12"
Slate	4"
Coal	37"

At Rural P. O. on the main Creek—Alma (Elkhorn) coal—

Coal	11"
Slate	1"
Coal	32"
Slate	1"
Coal	18"

On Road Fork above Canada P. O.—Alma (Elkhorn) coal—

S. S.	
Coal	12"
Slate	2"
Coal	12"
Slate	3"
Coal	13"
Slate	4"
Coal	14"

On main creek above Canada P. O.—Alma (Elkhorn) coal—

Coal	15"
Slate	4"
Coal	14"
Slate	4"
Coal	16"

One mile above the mouth of Big Creek at Mine No. 2 of the Borderland Coal Company, the Thacker coal is opened 160 feet above Tug Fork with bed section:

Thacker coal—

S. S.	
Coal	12 "
Slate	4.5"
Coal	37 "
Slate.	

and 305 feet above it, the Borderland coal 48 inches thick.

At the Borderland No. 1 mine, two miles above, at the head of the branch opposite Borderland the same coal is 5 feet 5 inches thick, and 486 feet above Tug Fork.

At Chattaroi the Alma seam is just above the Norforlk & Western Railroad and badly split up.

TURKEY CREEK, PIKE COUNTY.

Turkey Creek runs into Tug Fork on the Kentucky side at the second bend about two miles below Williamson. The Freeburn coal is just below drainage, showing above the river for the first time in the bank at the mouth of Jewel Branch, just above the water's edge, where it is about 30 to 32 inches thick. Jewel Branch is on the Kentucky side and about half way between the mouth of Turkey Creek and Williamson.

The first coal above the Freeburn (Ivel) is opened on the river bank just above the mouth of Turkey 32 inches thick. The Alma coal 105 feet higher has begun to split up and is not workable. The next coal above, the Upper Thacker, is the most prominent coal opened.

Following are bed sections of openings on Turkey Creek:

In point of hill below mouth of Turkey Creek—Upper Thacker coal—

Coal	15"
Slate	26"
Coal	21"

On ridge just above last opening—Upper Thacker coal—

Coal	6 "
Shale	2.5"
Coal	37 "

Opposite Hurricane Gap Branch of Pigeon Roost Fork—Alma Coal—

Coal	17"
Slate	7"
Coal	14"
Shale	8"
Coal	14"

Head of Pigeon Roost Fork, two openings:

(1)		(2)	
"Taylor" coal—		"Winifrede" coal—	
Coal	44"	Coal	46"

Head of Lower Lick Branch of Poll Taylor Fork—Upper Thacker coal—

Coal	44"

Head of Dark Hollow Branch of Poll Taylor Fork—Upper Thacker coal—

Coal	48"

Head of Left Fork of Caney Fork—Upper Thacker coal—

S. S.	
Slate	40"
Coal	5"
Slate	3"
Coal	30"
Black slate	1"
Coal	12"

Head of Right Fork of Caney Fork—Taylor coal—

Coal	48"

On Left Fork of Money's Branch of Turkey Creek—Cannel seam:

S. S.	
Splint	6 "
Slate	0.5"
Splint	6 "
Slate	1 "
Cannel	17.5"
Black slate and coal	4"
Semi-cannel	10.5"
Black slate	2.5"
Semi-cannel	12.5"
Slate	0.5"
Coal	1 "
Slate.	

On Right Fork of Money's Branch—Cannel seam—

Coal	10"
Shale	10"
Cannel	22"
Shale	6"
Coal	21"

On Colt Fork of Turkey Creek, two openings on Upper Thacker—

(1)		(2)	
Slate		Coal	49"
Coal	4 "		
Slate	3 "		
Coal	27 "		
Black slate	1.5"		
Coal	13 "		
Slate	3 "		
Coal	1 "		
Slate.			

Head of Turkey Creek—Upper Thacker coal—

Coal	48"

In the ridge between the head of Turkey Creek and the waters of Big Creek, two openings in the "Winifrede" seam:

(1)		(2)	
Coal	40"	Coal	46"
Slate	3"	Slate	3"
Coal	24"	Coal	26"

On a branch just below the mouth of Turkey Creek are two openings:

Upper Thacker coal—

Slate	
Slate and coal	3"
Coal	5"
Slate	2"
Coal	25"
Black slate	2"
Coal	11"

"Taylor" coal—

Slate	12 "
Coal	2.5"
Slate	1 "
Coal	17.5"
Black slate	0.5"
Coal	32 "
Slate.	

POND CREEK, PIKE COUNTY.

Pond Creek comes into Tug Fork on the west side just above the town of Williamson which is located in West Virginia. The Norfork and Western Railroad at Williamson is 665 A. T. Opposite the mouth of Pond Creek the place of the Freeburn coal is in the river bank just below the level of the Norfork & Western Railroad. The coal is rising rapidly up Pond Creek and its elevation at the head of the creek at mine No. 7 is 1,032 A. T. The Pond Creek Coal Company is mining the Freeburn seam on both forks of Pond Creek, having bridged the Tug Fork and built a railroad up the main creek nearly to the head, with branch lines up Blackberry Fork and Narrows Branch.

Mine No. 1 is located at Hardy on Blackberry Branch, Mine No. 2 on Narrows Branch, Mine No. 3 at Stone, on the main creek, Mine No. 4 on Pinson Fork, Mine No. 5 on the main creek and Mines Nos. 6, 7 and 8 near the head of the creek at and above McVeigh respectively. The Pond Creek Coal Company will probably also open a mine on the Thacker and Borderland seams this year. Following are bed sections of some of the openings on Pond Creek going from the mouth up the creek.

In point of hill above mouth of Pond Creek—Freeburn coal—

Coal	6″	
Laminated coal	6″	Elevation 698.
Coal	24″	

On left one-half mile above mouth of Pond Creek—Freeburn coal—

Coal	4″	
Laminated coal	6″	Elevation 725.
Coal	36″	

At mouth of Road Fork—Freeburn coal—

S. S.		
Coal	7″	
Laminated coal	7″	
Coal	39″	(40 ft above creek.)

On right, half way up Road Fork—Freeburn coal—

Slate		
Coal	4″	
Laminated coal	3″	(30 ft. above creek.)
Coal	42″	

In ridge at head of Road Fork—"Winifrede" coal—

S. S.	
Coal	40 ″
Bone	0.5″
Coal	26 ″

On right of Pond Creek opposite mouth of Meeting House Branch—Freeburn coal—

S. S.		
Coal	7″	
Laminated coal	7″	(70 ft. above creek.)
Coal	40″	

On Pond Creek below Smith's Branch—Freeburn coal—

Shale and S. S.		
Coal	7″	
Laminated coal	6″	Elevation 790.
Coal	38″	
Slate.		

On Peg Branch, four openings all on Freeburn coal—

(1)

S. S.	
Shale	5″
Fire clay	10″
Coal	6″
Laminated coal	6″
Coal	36″

(2)

S. S.	
Coal	3″
Slate	13″
Coal	8″
Laminated coal	9″
Coal	29″
Slate	4″
Coal	21″

(3)

Coal	5″
Laminated coal	6″
Coal	35″

(4)

Shale	
Coal	4″
Shale	18″
Coal	9″
Laminated coal	7″
Coal	41″
Slate	3″
Coal	21″

On Pond Creek between Peg Branch and Mud Lick—Freeburn coal—coal—

Slate		
Coal	8″	
Laminated coal	8″	Elevation 808.
Coal	41″	

Near head of Mud Lick—Freeburn coal—

Slate		
Coal	7″	
Laminated coal	5″	Elevation 808.
Coal	42″	

At head of Scant's Branch, three openings—

(1) Freeburn coal—

Slate	
Coal	5″
Laminated coal	7″
Coal	36″

(2) Freeburn coal—

Shale	18″
Coal	5″
Laminated coal	7″
Coal	33″
Shale	5″
Coal	24

(3) Alma coal—

Slate	
Coal	51″

On left, below mouth of Coburn Fork—Freeburn coal—

Slate		
Coal	5 ″	
Laminated coal	6.5″	Elevation 860.
Coal	39.5″	

Half way up Coburn Fork, two openings on Freeburn coal:

(1)

Slate	
Coal	7″
Laminated coal	8″
Coal	34″

(15 ft. above creek.)

(2)

S. S.	
Coal	6″
Laminated coal	7″
Coal	35″

(20 ft. above creek.)

Above Coburn Fork, two openings on Freeburn coal:

(1)		(2)	
Slate		Slate	
Coal	13″	Coal	7″
Laminated coal	9″	Laminated coal	8″
Coal	39″	Coal	40″
Slate	8″	Slate.	
S. S.		(Elevation 845)	
(Elevation 844.)			

On Mill Branch—Freeburn coal—

Slate
Coal .. 9″
Laminated coal 3″ Elevation 849.
Coal .. 43″

One mile up Mullin's Fork—Freeburn coal—

Slate
Coal .. 12″
Laminated coal 6″
Coal .. 44″

On left, above Mullin's Fork—Freeburn coal—

Slate
Coal .. 9″
Laminated coal 10″
Coal .. 47″
Slate.

At mouth of Pinson Fork—Freeburn coal.

Coal .. 7″
Laminated coal ..8″ Elevation 873.
Coal .. 44″

Pond Creek below Runyon's Fork—Freeburn coal—

S. S.
Coal .. 11″
Laminated coal 6″
Coal .. 45″
Slate .. 4″
S. S.

Pond Creek at mouth of Runyon's Fork—Freeburn coal—

S. S.
Coal .. 14″
Laminated coal 6″ Elevation 958.
Coal .. 42″
Slate.

BLACKBERRY FORK OF POND CREEK.

On left, above mouth of Blackberry Fork—Freeburn coal—

S. S.
Slate .. 60″
Coal .. 5″
Laminated coal 9″
Coal .. 38″
Slate.

On left of creek at Hardy—Freeburn coal—

Slate.
Coal .. 9″
Laminated coal 6″
Coal .. 40″
Slate.

At mouth of Narrows Branch—Freeburn coal—

Slate
Coal .. 8 ″
Laminated coal 7 ″
Coal .. 30 ″
S. S. 0.5″
Coal .. 6.5″

On right above mouth of Narrows Branch—Freeburn coal—

Slate
Coal .. 7.5″
Laminated coal 8 ″
Coal .. 58 ″
Slate.

At mouth of Mud Lick Branch—Freeburn coal—

Slate
Coal .. 6″
Laminated coal 7″
Coal .. 41″ Elevation 812.
Slate.

On the ridge between Narrows Branch and Mud Lick Branch the upper coals have been opened with the following sections:

"Winifrede" seam—

Coal
Slate .. 18″
Coal .. 1″ Elevation 1756.
Slate .. 16″

Coal (not correlated)—

S. S.		
Coal	21″	
Bone	2″	
Coal	6″	
Bone	1″	Elevation 1554.
Coal	12″	
Slate.		

Coal (not correlated)—

S. S.		
Coal	14″	
Bone	10″	Elevation 1498.
Coal	20″	

"Taylor" seam—

S. S.		
Coal	24″	
Slate	5″	Elevation 1420.
Coal	13″	

Upper Thacker seam—

Slate		
Coal	24″	
Bone	3″	
Coal	15″	Elevation 1181.
Slate	2″	
Coal	7″	

The elevation of the Freeburn coal at the base of this section would be about 855 feet and of the Alma 960 feet.

In the ridge at the heads of the two forks of Narrows Branch are two openings in the "Winifrede" seam:

(1)		(2)	
S. S.			
Splint coal	74″	Splint coal	76″
Slate.		Slate.	

In the the top of the high ridge at the head of Pond Creek, Prof. Crandall gives a six-foot coal at 1,150 feet above the Runyon coal, the latter being the Freeburn coal. This is still higher than the highest coal shown in the above section.

Following are average bed sections on the Freeburn coal at the different mines of the Pond Creek Coal Company:

No. 1 Mine, at Hardy on Blackberry Fork—

Slate		
Coal	4″	
Laminated coal	6″	Elevation 749.
Coal	40″	

No. 2 Mine, on Narrows Branch—

Coal	5″	
Laminated coal	7″	Elevation 768.
Coal	38″	

No. 3 Mine, at Stone on main creek—

S. S.		
Slate	8″	
Coal	2″	
Splint	2″	Elevation 868.
Laminated coal	6″	
Coal	41″	

No. 4 Mine, on Pinson Fork—

S. S.		
Slate	8″	
Coal	7″	Elevation 974.
Laminated coal	6″	
Coal	40″	

No. 5 Mine, on Main creek—

Coal	12″	
Laminated coal	7″	Elevation 893.
Coal	46″	

No. 6 Mine, at McVeigh—

Coal	7″	
Laminated coal	6″	Elevation 958.
Coal	40″	

No. 7 Mine, above McVeigh—

S. S.		
Coal	13″	
Laminated coal	8″	Elevation 1032.
Coal	44″	
S. S.		

No. 8 Mine, above McVeigh—

Slate	12″	
Coal	17″	
Laminated coal	10″	Elevation 1024.
Coal	45″	
Slate	6″	
S. S.		

At the mouth of Pond Creek the interval between the Freeburn and Alma seams is 105 feet and between the Alma and Upper Thacker about 210 feet. The bed section of the coal between the Freeburn and the Alma is:

Slate	
Coal	22″
Slate	1″
Coal	26″

The Freeburn correlates with the Van Lear, the Alma with the Elkhorn and the one between with the Ivel.

Analyses of the Pond Creek Coal Company's coals as furnished by them, are as follows:

Mine	Moisture	Volatile Matter.	Fixed Carbon.	Ash	Sulphur
No. 2	2.30	32.50	60.40	4.80	0.65
No. 3	2.44	33.32	60.20	4.04	0.70
No. 5	1.70	31.30	60.62	6.38	0.77
No. 6	1.62	31.84	62.66	3.88	0.52
No. 7	1.54	31.80	61.86	4.80	0.71
No. 8	1.46	30.84	60.80	6.90	0.67

BRANCH ON KENTUCKY SIDE, ONE MILE ABOVE POND CREEK.

On Tug Fork below mouth of the branch—Freeburn coal—

Laminated coal	6″	
Coal	36″	Elevation 697

Above mouth of branch—Alma coal—

Coal	22″	
Slate and fire clay	14″	Elevation 778.
Coal	42″	

Lower Thacker coal—

Slate	12″	
Coal	6″	
Slate	8″	Elevation 888.
Coal	22″	

Upper Thacker coal—

Coal	37″	
Fire clay	1″	Elevation 988.
Coal	14″	

Coal seam—

Coal	20″	
Slate	4″	Elevation 1523.
Coal	7″	

Coal seam—

Coal	12″	
Slate	4″	Elevation 1598.
Coal	20″	

Analysis.

	Alma.	Upper Thacker.
Volatile matter	38.42	38.08
Fixed carbon	57.40	50.44
Ash	4.18	11.40
Sulphur	0.89	0.50

THACKER COAL MINING COMPANY.

In the ridge on the Kentucky side between Rose Siding and Thacker and above the mouth of Hatfield Creek:

Section in mine—Thacker coal—

Slate	
Coal	46″
Fire clay	2″
Coal	25″

Analysis.

Moisture	0.64
Volatile matter	34.92
Fixed carbon	58.79
Ash	5.45
Sulphur	0.93
Phosphorus	0.006

BRANCH ON KENTUCKY SIDE ABOVE LAST AND HALFWAY BETWEEN WILLIAMSON AND SPRIGG.

The following coals have been opened on this branch:

Alma coal—

Slate		
Coal	16″	
Slate	6″	Elevation 778.
Coal	42″	

Upper Thacker—

Coal	7″	
Fire clay	1″	Elevation 988
Coal	59″	

"Winifrede" (correlation as locally used)—

S. S.		
Splint	4″	
Fire clay	1″	Elevation 1523.
Splint	68″	
Slate.		

"Coalburg" (correlation local)—

S. S.		
Splint	3 ″	
Mother coal	0.5″	Elevation 1598.
Splint	52″	

BURNWELL MINES, BURNWELL COAL & COKE COMPANY, KENTUCKY SIDE, OPPOSITE SPRIGG, W. VA.

Freeburn coal—

Mine No. 2—		Mine No. 3—		Mine No. 4—	
Coal	5″	Coal	6″	Coal	5″
Laminated coal	7″	Laminated coal	5″	Laminated coal	8″
Coal	42″	Coal	31″	Coal	52″
Elevation 777		Elevation 791		Elevation 777	

At Sprigg Prof. I. C. White gives the following vertical section from a high knob east of Sprigg down to the Norfolk and Western Railroad:

	Feet	Feet
Sandy shales and sandstone	30	30
Coarse massive sandstone with pebbles	60	90
Coal bloom and sandy shales	10	100
Soft, yellow sandstone	65	165

	Feet	Feet
Concealed	5	170
Dark shale and coaly clay (Roaring Creek coal).		
Massive, coarse sandstone, pebbly in top (Roaring Creek)	130	300
Concealed	30	330
Sandstone	100	430
Coal bloom (Coalburg?)		
Concealed and sandy shales with impure limestone nodules	100	530
Gray, micaceous sandstone	70	600
Coal bloom.		
Concealed	20	620
Massive sandstone (flaggy below)	50	670
Concealed	20	620
Massive sandstone (flaggy below)	50	670
Coal.		
Concealed	10	790
Flaggy and massive sandstones	120	910
Shales and slate	10	920
Coal—Upper Thacker: Coal 8″, Shale 5″, Coal 32″, Slaty cannel 3″, Cannel 4″	4	924
S. S. and concealed	70	994
Coal—Lower Thacker	2 2-3	997
S. S. and concealed	125	1,122
Coal bloom.		
Sandy and limy shales, with iron ore	10	1,132
Shales	5	1,137
Coal—Alma (Peerless): Hard coal 7″, Soft coal 4″, Hard coal 13″, Soft coal 4″, Splint coal 8″	3	1,140
Fire clay and sandy shales	5	1,145
Massive sandstone	35	1,180
Sandy shales	20	1,200
Coal: Coal 6″, Slate 1″, Coal 11″	1½	1,202
Shales	7½	1,209
Massive sandstone	40	1,249
Coal—Warfield (No. 2 Gas)	4	1,253
Shales and concealed	75	1,328
Coal, Hatfield Tunnel (Powellton)	2	1,330
Concealed to Tug Fork	60	1,390

In this section, which would, of course, also apply to the measures on the Kentucky side, the Alma seam is the Elkhorn and probably the No. 2 Gas, the one between the Warfield and the Alma is the Ivel and probably the Powellton, the Warfield is the Freeburn and Van Lear and probably the Eagle or No. 1 Gas and the Hatfield Tunnel coal the thin coal shown everywhere under the Van Lear coal on the Levisa Fork.

Prof. White also gives a section a short distance above this on the Kentucky side from the top of Little Coon Knob to the Hatfield Tunnel between Sprigg and Matewan.

	Feet	Feet
Coarse grayish sandstone	40	40
Sandy shales	10	50
Massive, coarse, pebbly sandstone	50	100
Shales and concealed	110	210
Massive sandstone and concealed	100	310
Shales, coaly at base	10	320
Coarse sandstone and concealed	110	430
Gray, massive sandstone	60	490
Coal	1	491
Massive sandstone	60	551
Coal	1	552
Concealed and massive sandstone	110	662
Gray, sandy shales	70	732
Massive sandstone	40	772
Upper Thacker coal: Coal 12″, Fire clay 4″, Coal 18″, Fire clay 4″, Coal and clay 22″	5	777
Concealed	55	832
Lower Thacker	4	836
Concealed, sandstones and shales	100	936
Concealed	30	966
Massive sandstone	20	986
Alma	3	989
Fire clay and concealed	5	994
Massive sandstone and concealed	130	1,124
Sandy shales	10	1,134
Warfield coal	5	1,139
Shales, sandstone and concealed	70	1,209
Hatfield Tunnel coal	1½	1,210
Shales	5	1,215
Massive sandstone	15	1,230
Sandy shales to N. & W. at east end of tunnel	20	1,250

On page 314 he gives a similar section at Matewan on the West Virginia side.

COON BRANCH (BELOW BLACKBERRY CREEK) PIKE COUNTY.

Three openings on the Alma seam:

(1)		(2)		(3)	
Hard coal	7″	Draw slate		S. S.	
Soft coal	4″	Coal	48″	Coal	41″
Hard coal	13″			(Allburn C. and C. Co. mine).	
Soft coal	4″				
Splint	14″				

Allburn Coal and Coke Company's Mine—Upper Thacker seam—

Slate	
Coal	46″
Fire clay	2″
Coal	14″
Clay	3″
Coal	7″

A rapid rise to the southeast has brought the Freeburn coal about 200 feet above Tug Fork at the mouth of Coon Branch. The Alma and Upper Thacker are the two principal coals on the creek, the Freeburn having locally thinned down. Both seams are mined by the Allburn Coal and Coke Co. Following are analyses of the coals from the Allburn:

	Alma.	Thacker
Moisture	0.612	0.64
Volatile matter	35.240	34.92
Fixed carbon	57.430	58.79
Ash	6.710	5.45
Sulphur	0.550	0.93
Phosphorus	0.003	0.006

BLACKBERRY CREEK, PIKE COUNTY.

At the mouth of the creek the Freeburn coal is over 200 feet above Tug Fork and the measures are rising up the creek and, much more rapidly, to the southeast. The Freeburn, Alma and Upper Thacker are the principal coals, all getting high in the hills going up Tug Fork. The Freeburn coal is the same as the old Davis coal of Peter Fork and the old Hatfield coal of the main creek. The Thacker coal is being mined on Peter Fork by the Blackberry and Kentucky Coal Company.

Following are bed sections of openings on Blackberry creek.

In point of hill just above mouth of creek, two openings:

(1)		(2)	
Freeburn coal—		Alma coal—	
Coal	5″	S. S.	
Laminated coal	4″	Coal	6″
Coal	33″	Slate	4″
		Coal	42″
		Fire clay.	

At mouth of Peter Fork of Blackberry—

(1)		(2)	
Freeburn coal—		Alma coal—	
Coal	6″	Draw slate	2″
Laminated coal	5″	Coal	41″
Coal	42″	Slate.	

Head of Big Rock Branch of Peter Fork—

(1)		(2)	
Freeburn coal—		Alma coal—	
Slate		Slate	
Coal	6″	Coal	3 ″
Laminated coal	4″	Slate	1 ″
Coal	38″	Coal	3 ″
		Slate	0.5″
		Coal	40 ″

On Wolf Pit Branch of Peter Fork—

(1)		(2)	
Freeburn coal—		Alma coal—	
Coal	7″	Coal	55″
Laminated coal	5″		
Coal	46″		

On next branch above Wolf Pit Branch—

(1)		(2)	
Freeburn coal—		Alma coal—	
Slate		Coal	54″
Coal	6″		
Laminated coal	4″		
Coal	44″		

(3)		(4)	
Lower Thacker—		Thacker—	
S. S.		Coal	26″
Draw slate	3″	Slate	2″
Coal	32″	Coal	26″
Slate	4″	Slate	18″
Coal	21″	Coal	18″

The Thacker opening given above is at the No. 2 mine of the B. & K. C. Co. The vertical section here is:

Upper Thacker,
  Interval 75 ft.
Lower Thacker,
  Interval 40 ft.
Alma,
  Interval 115 ft.
Freeburn,
  Interval 140 ft.
Peter Fork.

the interval between the Alma and Upper Thacker having been cut down from what it is down Tug Fork.

At mouth of Road Fork of Peter Fork—Freeburn coal—

Slate	
Laminated coal	10″
Coal	7″
Laminated coal	5″
Coal	40″

At No. 1 mine at head of Road Fork—

Thacker coal—		Thacker coal—	
Mouth of mine:		Face of mine:	
Coal	42″	Slate	
Slate	6″	Coal	54″
Coal	17″	Slate	4″
		Coal	17″
		Fire clay.	

Head of Hatfield Branch of Blackberry—

(1)		(2)	
Freeburn coal—		Alma coal—	
Coal	6″	S. S.	
Laminated coal	5″	Coal	12″
Coal	39″	Slate	1″
Elevation 959.		Coal	34″

On Slate Branch of Blackberry—Freeburn coal—

Slate	12″
Coal	17″
Laminated coal	10″
Coal	45″

Elevation 1062.

At head of Dial's Branch of Blackberry—

(1)		(2)	
Freeburn coal—		Alma coal—	
Draw slate	5 ″	S. S.	
Coal	7 ″	Coal	4″
Slate and coal	1.5″	Slate	1″
Coal	38 ″	Coal	32″
		Slate.	

At mouth of Rockhouse Branch of Right Fork of Blackberry—
Freeburn coal—

Coal	10″
Laminated coal	5″
Coal	52″

In ridge between Dial branch and Rockhouse Branch—"Winifrede" (local name) coal—

S. S.	
Splint	3″
Mother coal	2″
Splint	73″
Slate.	

In ridge between Rockhouse Branch and Middle Fork—"Winifrede" coal—

Splint	8″
Slate	6″
Splint	59″
Slate	8″
Coal	18″
Slate.	

Near head of Right Fork of Blackberry—Freeburn coal—

S. S.	
Coal	9″
Laminated coal	4″
Coal	44″

Elevation 1069

Main Creek oposite Blue Spring Branch—Freeburn coal—

Coal	56″

At mouth of Blue Spring Branch—

(1)		(2)	
Freeburn coal—		Alma coal—	
Slate		Slate	
Coal	6″	Slaty coal	4″
Laminated coal	6″	Slate	12″
Coal	36″	Coal	50″
Slate.		Slate.	

Elevation 1,034.

(3)		(4)	
Lower Thacker—		Upper Thacker—	
Slate		Slate	
Coal	41″	Coal	36″
Slate	21″	Slate	6″
Slaty clay	16″	Slaty coal	9″
Coal	14″	Slate	10″
		Coal	19″

At head of Blue Spring Branch—Freeburn coal—

Coal	54″

On Netley Branch of Blackberry Creek—

(1)		(2)	
Freeburn coal—		Alma coal (Split)—	
S. S.		Lower Bench	
Slate	3″	Slate	
Coal	8″	Coal	25″
Laminated coal	5″	Slate.	
Coal	44″		

Opposite Oldhouse Branch of Blackberry Creek—Freeburn coal—

Coal	11″
Laminated coal	4″
Coal	54″

At mouth of Oldhouse Branch—Freeburn coal—

Coal	48″

At mouth of Seng Camp Branch—Freeburn coal—

S. S.	
Coal	10″
Laminated coal	4″
Coal	58″

On Seng Camp Branch—Freeburn coal—

Coal	7″
Laminated coal	6″
Coal	38″

One half mile above Seng Camp Branch—Freeburn coal—

S. S.	
Coal	7″
Laminated coal	6″
Coal	38″

PETER CREEK.

On Peter Creek the Freeburn, Alma and Thacker seams are the principal coals although lower coals are locally workable. The Turkey Gap Coal Company has a mine on the Freeburn seam at the mouth of the creek and opposite Delorme a station on the N. & W. R. R., and another farther up the creek on the Upper Thacker seam. At the mouth of the creek the Freeburn coal is over 400 feet above Tug Fork. The measures are rising to the southeast. The elevation of the N. & W. at Delorme is 728 and the elevation of No. 1 mine is 1,123.

At No. 1 Mine—Freeburn coal—

Coal	7″
Laminated coal	6″
Coal	49″

At head of branch just above mouth of Peter Creek—Freeburn coal—

Coal	7″
Laminated coal	6″
Splint	12″
Coal	10″
Splint	12″
Coal	15″

At head of same branch—Upper Thacker coal—

Coal	20″
Splint	22″
Coal	13″
Bone	4″
Coal	12″

At head of second branch on right above mouth of Peter Creek—Freeburn coal—

(1)

Coal	7″
Laminated coal	5″
Coal	42″

(2)

Coal	50″

Freeburn coal in Mine No. 4—

S. S.		
Draw slate	8″	
Coal	7″	Elevation 1126.
Laminated coal	6″	
Coal	46″	

Analysis.

	Without Laminated	With Laminated	Slack
Moisture / Volatile matter	34.73	34.43	33.86
Fixed carbon	58.92	57.74	58.54
Ash	6.35	7.83	7.60
Sulphur	0.61	0.62	0.67

Coke Analysis.

	Lower bench	Full seam
Moisture	0.22	0.30
Volatile matter	0.42	0.14
Fixed carbon	93.26	93.46
Ash	5.10	6.10
Sulphur	0.55	0.46

Upper Thacker in Mine No. 2—

S. S.		
Shale	36″	
Coal	43″	
Fire clay	2″	
Coal	12″	Elevation 1403.
Fire clay	2″	
Coal	7″	

Analysis.

Moisture / Volatile matter	38.04
Fixed carbon	56.72
Ash	5.24
Sulphur	1.06
Ash in coke	9.24
Sulphur in coke	0.76

Vertical Section at Mine No. 2.
Top of hill,
Interval 250 ft.
Thacker coal,
Interval 280 ft.
Freeburn coal,
Interval 370 ft.
Presbyterian School coal,
Interval 50 ft.
Creek.

At head of Mill Branch of Peter Creek—Freeburn coal—

Coal	6″	
Laminated coal	5″	Elevation 1172.
Coal	48″	

At head of branch on opposite side of Peter creek—Freeburn coal—

Coal	7″
Laminated coal	6″
Coal	49″

At head of next branch on right above Mill Branch, Left Fork of branch—Freeburn coal—

Coal	6″	
Laminated coal	7″	Elevation 1100.
Coal	46″	

Right Fork of branch—Freeburn coal—

Laminated coal	9″	
Coal	45″	Elevation 1093.

At head of Paint Rock Branch of Peter Creek—Freeburn coal—

Coal	5″	
Slate	5″	Elevation 1095.
Coal	48″	

One and one-half mile above mouth of Peter Creek—Presbyterian School coal—

Shale	
Coal	5 ″
Slate	¼″
Coal	16 ″
Slate	1¾″
Coal	8 ″

Same coal, one-half mile below Forks of Peter Creek—

Coal	42″

Same coal, one-fourth mile below Forks of Peter Creek—

Slate	
Coal	3 ″
Slate	0.5″
Coal	20.5″
Bone	2 ″
Coal	25 ″

This coal is about 350 feet below the Freeburn coal and is only 22 inches thick at the mouth of the creek, increasing rapidly in thickness, as shown by the above sections, going up the creek, getting up to 53 inches before it goes under drainage.

On Rockhouse Fork of Peter Creek a full section of the different coals has been opened and reported as follows:

At the mouth of Rockhouse Fork—
Top of hill,
Interval 200 ft.
Thacker coal
Interval 60 ft.
Lower Thacker coal,
Interval 60 ft.
Alma coal,
Interval 115 ft.
Freeburn coal,
Interval 305 ft.
Coal,
Interval 40 ft.
Presbyterian School coal,
Interval 60 ft.
Bed of Peter Creek.

On Rockhouse Fork of Peter Creek—Presbyterian School coal (60 ft. above creek)—

Coal	24″

40 feet above this is a coal 20 inches thick—

About 350 feet above the School House coal—Freeburn coal—

(1)		(2)	
Coal	18″	Sandy shale	36″
Bone	6″	Dark shale	7″
Coal	48″	Coal	7″
		Laminated coal	11″
		Coal	45″

About 115 feet above the Freeburn—Alma coal—

Coal	48″

Higher in the hill—Lower Thacker coal—

Coal	50″
Cannel coal	4″

Higher in the hill, three openings—Thacker coal—

	(1)	(2)	(3)
Coal	45″	43″	43″
Bone	4″	7″	6″
Coal	12″	21″	18″

"Top" vein—

Coal	26″
Shale	6″
Coal	4″
Shale	15″
Coal	4″
Shale	6″
Coal	23″
Shale	4″
Coal	24″

On Big Branch of Left Fork of Peter Creek—Freeburn coal—

Coal	39″	
Laminated coal	5″	(370 ft. above creek.)
Coal	25″	

Just below mouth of Left Fork of Peter Creek—Freeburn coal—

S. S.		
Coal	41 ″	
Laminated coal	5½″	(370 ft. above creek.)
Coal	25″	

Analysis by McCreath.

Moisture	2.060
Volatile matter	31.040
Fixed carbon	58.382
Ash	7.960
Sulphur	0.536

At head of Road Fork of Left Fork of Peter Creek—Freeburn coal—

S. S.		
Coal	11″	
Laminated coal	6″	Elevation 1480.
Coal	53″	

One-fourth mile up Phillips Branch of Left Fork of Peter Creek—Presbyterian School coal—(375 ft. below Freeburn coal)—

Slate	
Coal	39″

At head of Phillips Branch—Freeburn coal—

Coal	14″
Laminated coal	4″
Coal	52″

On Beech Fork of Left Fork of Peter Creek—Jas. L. Dotson opening (Presbyterian S. H. coal) above mouth of Beech Fork—Presbyterian S. H. coal—

Coal	43″
Shale	2″
Coal	3″

(This is not the "Jim Dotson" or Feds Creek coal. The latter as opened on Feds creek at the Jim Dotson opening, correlates with the lower Marrowbone coal.)

On Beech Fork—Freeburn coal—

Coal	14″
Laminated coal	6″
Coal	50″

At head of Beech Fork—Freeburn coal—

S. S.	
Coal	13″
Laminated coal	5″
Coal	52″

On Left Fork of Beech Fork—Freeburn coal—

Coal	15″
Laminated coal	6″
Coal	52″
Slate	7″
Coal	12″

On Widows Fork of Left Fork—Freeburn coal—

Coal	10″
Laminated coal	4″
Coal	25″
Splint	12″
Coal	15″

One mile above Jamboree on Left Fork—Freeburn coal—

S. S.
Shale .. ..24"
Coal .. ..20"
Laminated coal ...... 7"
Coal .. ..55"

On head of Layne's Branch of Left Fork of Peter Creek—Freeburn coal—

Coal .. ..17"
Laminated coal ...... 6"
Coal .. ..50"

Analyses of coal from this opening were made by different chemists:

	Volatile matter	Fixed carbon	Ash	Sulphur
Scott	32.31	59.78	7.91	0.56
Mathewson	36.97	58.89	3.14	0.79
Williams	36.07	58.88	5.60	0.43

(Top bench.)

	Volatile matter	Fixed carbon	Ash	Sulphur
Scott	34.63	61.31	4.06	0.50
Mathewson	32.94	62.12	4.94	0.78
Williams	33.67	58.57	7.76	0.51

(Bottom bench.)

	Volatile matter	Fixed carbon	Ash	Sulphur
Mathewson	31.00	52.75	16.25	0.46

(Laminated coal.)

Analysis of Coke.

	No. 1	No. 2
Volatile matter	1.75	3.20
Fixed carbon	94.05	90.95
Ash	4.22	5.85
Sulphur	0.42	0.49

Two miles above Jamboree on Left Fork—Freeburn coal—

Shale
Coal .. ..21"
Laminated coal ...... 4"
Coal .. ..59"

At head of Prater Fork of Left Fork—Freeburn coal—

Shale
Coal .. ..25"
Laminated coal ...... 8"
Coal .. ..55"

On left Fork of Peter Creek four miles above Jamboree—Freeburn coal—

S. S.
Coal .. ..10"
Laminated coal ...... 6"
Coal .. ..41"

On Bill Allen Branch of Left Fork—Freeburn coal—

Coal .. ..13"
Laminated coal .... 6"
Coal .. ..57"

Analysis by McCreath.

Moisture	1.60
Volatile matter	31.80
Fixed carbon	56.94
Ash	9.07
Sulphur	0.59

On Grassy Fork of Left Fork—Freeburn coal—

Coal .. ..15"
Laminated coal .... 7"
Coal .. ..60"

At head of Left Fork of Peter Creek—Freeburn coal—

S. S.
Shale
Coal .. ..10"
Laminated coal ......12"
Coal .. ..53"

On Calloway Branch of Right Fork of Peter Creek—Three-fourths mile from mouth—Freeburn coal—

Shale .. ..36"
Coal .. ..13"
Laminated coal .... 7"
Coal .. ..49"

Analysis.

Moisture	1.09
Volatile matter	34.50
Fixed carbon	61.27
Ash	3.14
Sulphur	0.51
Phosphorus	0.012

B. T. U. 14740

On Calloway Branch—Alma coal (110 ft. above Freeburn)—

S. S.
Coal .. ..30"
Slate and coal.......... 8"
Coal .. ..18"

On Road Fork of Right Fork of Peter Creek—Freeburn coal—

Coal .. ..12"
Laminated coal .... 6"
Coal .. ..44"

Alma coal—

S. S. ....72 "
Coal .. .. 7 "
Shale .. .. 1.5"
Coal .. ..19 "
Fire clay ....16 "
Coal .. ..12 "

Lower Thacker coal—

Coal .. ..30"

On Bear Branch of Right Fork—Freeburn coal—

S. S.
Shale .. .. 6"
Coal .. ..14"
Laminated coal ...... 6"
Coal .. ..48"

On Smith's Fork of Right Fork—Freeburn coal—

S. S.
Coal .. ..14"
Laminated coal .... 8"
Coal .. ..45"
Fire clay .... 5"
Coal .. .. 9"

At head of Right Fork of Peter Creek—Freeburn coal—

Shale
Coal .. ..13"
Laminated coal .... 6"
Coal .. ..44"

POPLAR CREEK.

On Poplar Creek the Majestic Collieries Company is operating three mines on the Freeburn coal.

A complete vertical section of the measures on Poplar Creek is as follows:

Top of hill,
Interval 150 ft.
Coal (called Thacker),
Interval 74 ft.
Coal (called Glen Alum),
Interval 45 ft.
Coal (called Lower Glen Alum)
Interval 75 ft.
Coal,
Interval 33 ft.
Alma coal,
Interval 140 ft.
Freeburn coal,
Interval 200 ft.
Thin coal (Place of Jim Dotson coal),
Interval 110 ft.
Presbyterian S. H. coal,
Interval 130 ft.
N. & W. R. R.

On this section the coals called locally Glen Alum and Lower Glen Alum appear to be the same as those called Thacker and Lower Thacker further down Tug Fork.

The bed sections of these coals are as follows:

Presbyterian S. H. seam—
Coal about.. ....48"

Freeburn seam—
S. S.
Draw slate .... 5 "
Coal .. ..19½"
Laminated coal .... 8¾"
Coal .. ..55¼"
S. S.

Alma seam—
S. S.
Coal .. ..48½"
Slate.

Seam above Alma—

S. S.	
Draw slate	4 "
Coal	7½"
Slate	¾"
Coal	33 "
Slate	3 "
Coal	3 "

Lower Glen Alum seam—

Slate	
Coal	36 "
Slate.	

Glen Alum seam—

Slate	
Coal	60½"
Slate.	

Thacker seam—

Slate	
Coal	59 "
Slate	2½"
Coal	6 "
Slate	18 "
Coal	22 "
Slate	20 "
Coal	35 "
S. S.	

The seam above the Alma corresponds in position and thickness with the seam above the Elkhorn on Levisa Fork. The upper seam (called Thacker) appears to be the seam called the "Cannel" seam lower down Tug Fork.

Analysis of the Freeburn seam is:

Moisture	1.70
Volatile matter	32.42
Fixed carbon	62.42
Ash	3.46
Sulphur	0.83

VULCAN.

The Vulcan Coal Company is located on the Kentucky side about two miles above the mouth of Peter

Creek. The company has a mine on the Freeburn seam and one on the Thacker seam. The latter is not now in operation.

The Freeburn is given as 472 feet above the N. & W. R. R. and the elevation of the latter opposite the tipple 733 feet. The Alma is here 138 feet above the Freeburn and the Thacker 119 feet above the Alma. A section of the Freeburn in the main entry is:

Slate	
Coal	6"
Black slate	2"
Coal	8"
Laminated coal	6"
Coal	48"
Clay.	

The laminated coal varies in thickness from 4 to 7½ inches.

Analysis of the Freeburn coal is:

Moisture	1.30
Volatile matter	32.41
Fixed carbon	62.04
Ash	3.46
Sulphur	0.89

The Alma is reported as about 57 inches and the Thacker about 51 inches.

BARREN SHE CREEK.

Freeburn coal—

Slate	
Coal	16"
Laminated coal	6"
Coal	60"

KNOX CREEK.

The mouth of Knox Creek is just above Devon, a station on the N. & W. in West Virginia. The Freeburn coal is split along the river, regaining its full thickness up the tributaries back from the river. At the mouth of Knox Creek it is about 550 feet above the N. & W. R. R.

Knox Creek crosses the State line above the mouth of Camp Creek, the greater portion of its drainage area lying in West Virginia.

At the head of Turkey Fork of Knox Creek—Freeburn Coal—

(1)		(2)		(3)	
S. S.		Coal	18″	Coal	14″
Coal	16″	Laminated coal	7″	Laminated coal	5″
Laminated coal	7″	Coal	48″	Coal	45″
Coal	46″				

One hundred and forty feet above the Freeburn—Alma coal—

Coal	42″

About 60 feet above the Alma seam is—

S. S.	
Slate	5″
Coal	8″
Slate	2″
Coal	15″
Slate	5″
Coal	12″

About 65 feet above the last is—

Slate	
Coal	19 ″
Clay	0.5″
Coal	12 ″
Slate	0.5″
Coal	15 ″

and 65 feet above that—

Coal	34 ″
Slate	0.5″
Coal	16 ″

Analysis of Freeburn coal gave—

	Laminated Coal	Rest of Vein
Moisture	2.80	1.456
Volatile matter	28.30	31.944
Fixed carbon	54.02	60.673
Ash	14.80	5.300
Sulphur		0.537

On the Right Fork of Hurricane Creek—Freeburn coal—

(1)		(2)	
Coal	18″	S. S.	
Bone	7″	Coal	23″
Coal	60″	Laminated coal	4″
		Coal	39″

At three other openings on Hurricane the total thickness of the Freeburn is 72 inches, 73 inches and 86 inches respectively.

TABLE OF CONTENTS.

ECONOMIC GEOLOGY OF TELL CITY AND OWENSBORO QUADRANGLES.

BY A. F. CRIDER.

CHAPTER I.

TELL CITY QUADRANGLE.

Introduction.—The Tell City Quadrangle includes the western half of Hancock and the northeast part of Daviess County, Kentucky, and a small area in Perry County, Indiana. It is just west of the eastern border of the Western Coal Field. The Ohio river enters the quadrangle on the eastern edge three miles north of the center and flows north and west to Troy, Indiana, and from thence takes a southwesterly direction and leaves the quadrangle a little below Grandview, Indiana.

Blackford Creek is the largest tributary to the Ohio in this quadrangle. It rises near the southeast corner of the quadrangle and flows through a broad, meandering valley in a northwest direction and enters the Ohio opposite Grand View, Indiana. Caney creek, Driskell branch, Butchers creek and Little Yellow creek enter Blackford creek from the east. There are no large tributaries from the west.

Pup creek is the next largest stream. It has its headwaters near the southern boundary of the quadrangle, a little east of the center, and flows in a northwest direction parallel to the general course of Blackford creek, and leaves the quadrangle on the west a little south of the center. Lead and Yellow creeks drain the northern and eastern areas and flow into the Ohio.

Hawesville, the county seat of Hancock county, is located on the Ohio river at the extreme eastern edge of the quadrangle. Lewisport, the next town of importance on the Kentucky side, is an old town that is located on the Ohio in the north central part of the quadrangle. Maceo, the only other town of importance, is located on the extreme western edge of the quadrangle.

The Louisville, Henderson and St. Louis Railroad enters the quadrangle on the east at Hawesville and follows the Ohio river valley to Adair, where it cuts across the narrow projection of the river hills through a low divide. From here, to where it leaves the quadrangle at Maceo, it follows the main alluvial valley of the Ohio.

TOPOGRAPHY.

The topography of the quadrangle presents three distinct varieties, the ridge land, the slopes and the valleys. The highest elevations are in the eastern and southeastern part where the hills rise to a maximum of 660 feet above sea level, or about 280 feet above the Ohio river at Hawesville, while the average relief above the streams in this area is only 175 feet. There is a gradual decrease in elevation from the east and southeast to the northwest where the highest hills are about one hundred feet lower than in the eastern part.

In some parts of the quadrangle the main divides are broad and have a considerable area of level farming land on the ridges. In a greater part of the area, however, the network of streams has cut far into the center of the divide. In many places streams heading on opposite sides of the divide have formed low gaps through which roads may be constructed thereby greatly decreasing the grade.

On the headwaters of the streams, in the southeast part of the quadrangle, on the river hills from Hawesville north, and a small area near the center of the quadrangle, between Blackford and Yellow creeks, the slopes are steep. The hills facing the Ohio river from Hawesville north to a point north of Adair are so abrupt that to build roads from the river valley to the hills it is necessary to follow the streams. From Adair to Blackford creek the slopes of the river are more gentle, but become precipitous again between Blackford and Little Blackford creeks.

South of Pup creek the country merges from the rough hilly region on the east to a gently rolling plateau which is the best farming land in the quadrangle.

Between one-third and one-half of the area of the quadrangle is bottom land, the Ohio river valley forming

the largest area of level land. It comprises a strip of land twenty-three miles long with an average width of one and one-half miles, or a total area of about 34 square miles.

Blackford Creek, excluding its tributaries, has about fifteen square miles of bottom land most of which is subject to overflow during excessive rains. There is a fall of forty feet from a point where the stream leaves the hills to the coalition of Horse Fork and Sulphur Fork, a distance of twelve miles, disregarding the meanders of the stream. This would give a fall of 3 1-3 feet to the mile, which would be sufficient to carry off any ordinary rain fall through a straight channel. The soil of this valley is very fertile and only needs the straightening of the channel to make it very valuable farming land.

The various tributaries of Blackford Creek, together with Pup Creek, Lead and Yellow Creeks, have an extensive area of bottom land somewhat larger than that of Blackford Creek.

Farming and coal mining are the chief pursuits of the inhabitants of the quadrangle. The broad and fertile valley of the Ohio river affords excellant farming land for corn, wheat, oats, alfalfa and clover, and the hill lands, most of which are subject to cultivation, produce an excellent quality of tobacco, grain and pasturage.

GEOLOGIC STRUCTURE.

The rocks of the Tell City quadrangle are of Carboniferous age and belong entirely to the Pennsylvanian series. Along the eastern border of the quadrangle, in the vicinity of Hawesville and Lead Creek, the Conglomerate sandstone, with its characteristic quartz pebbles, forms the lowest rocks of the quadrangle. South of Lead Creek the Conglomerate lies a few feet below drainage and is covered by shales and sandstones of what is commonly called the Coal Measures. The rapid rise of the strata to the east brings up the full thickness of the Conglomerate and the underlying Chester group in Breckinridge County a short distance up the Ohio River from Hawesville. In a deep well on Caney Creek, near the eastern edge of the quadrangle, the Chester limestone was found at a depth of about 140 feet below the creek bottom.

With the exception of the two places mentioned above, Hawesville and Lead Creek, the Coal Measures above the Conglomerate form the bed rock of the entire quadrangle.

A distinction should be made between the "bed rock" and the later deposits of Loess, loam and still more recent river and creek alluvium. The bed rocks are the hard sandstones, shales, slates, limestones and clays, all of which are highly stratified, and form the principal parts of the hills and underlying strata. The coals which are mined in this region, are found in the bed rocks, and in these only.

Covering the hills nearest the Ohio river is a thick mantle of loess and reddish loam which, in most places, covers the underlying stratified rocks and forms the rich agricultural lands along the river. The thickness of this mantle decreases in proportion to the distance from the river. A few miles back from the river it loses a greater part of its lime and is a thin deposit of reddish clay, and where not protected, washes readily into gullies.

Stream alluvium fills the valleys of the Ohio River and the larger streams. Recent borings on the banks of the Ohio River near the western border of the quadrangle, and at the Owensboro Water Works plant, show that the river, in its early history, has scoured out its valley to a depth of 117 to 122 feet. The channel has been filled in more recent times with sands, gravels, silt, clays and carbonaceous matter.

A generalized section is given on another page showing the relation of the various coals from the top of the Conglomerate at Hawesville to the highest coal on the road between Pellville and Knottsville, and serves as a key to the stratigraphy of the region.

HAWESVILLE COAL.

The lowest coal that has proven to be of any commercial value in the Tell City Quadrangle is the one that has been most worked in the town and vicinity of Hawesville. It was first called Hawesville coal by David Dale Owen in the First Series, Kentucky Geological Survey Reports, and that name has been retained by all subsequent geologists of the Kentucky Geological Survey. It is the equivalent of the Cannelton coal, of Perry County, Indiana, which occurs in the river hills on the north side of the Ohio River from Hawesville.

The geological horizon of the Hawesville coal has been variously estimated from 50 feet to 148 feet above the top of the Conglomerate. Mr. P. N. Moore, page 21, Vol. D., Kentucky Geological Survey, Reports on Western Coal Field, places the maximum distance in Hawesville at 115 feet. At the Hancock mines he places the coal 50 to 55 feet above the top of the Conglomerate.

Mr. Cox, former State Geologist of Indiana, places the same coal 148 feet above the Conglomerate at Cannelton, Indiana. Mr. Owen makes the interval about the same as Mr. Cox.

The difference given by the various geologists is doubtless due to the fact that the greater distances were reckoned from the top of the heavy bed of Chester sandstone, which is a coarse heavy bedded sandstone easily mistaken for the Conglomerate and the lesser distances from the top of the Conglomerate.

The present writer took the top of the Conglomerate as the basis for determining the horizon of the Hawesville coal and at no place was the distance found to be over 75 feet. At the G. W. Newman mine, 4 miles south of town, the Hawesville coal is only 32 feet above the Conglomerate which was found to be 100 feet thick in an oil well which was drilled about 200 feet from the mine. On the Hartford road, on the north side of Lead Creek, just outside of Hawesville, the Conglomerate is 40 feet below the Hawesville coal. In the east side of the town of Hawesville the distance between the coal and Conglomerate is 75 feet.

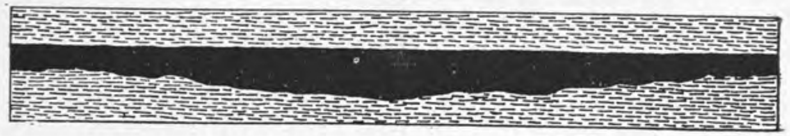
The thickness of the Hawesville coal varies from a few inches to 5 feet as the maximum with an average, where worked, of 3 feet 10 inches. The nature of the coal and the irregularity in thickness explain the manner in which it was formed. In every mine where it has been worked for any length of time the coal has been found to be in lenticular areas varying from a small patch to 20 acres or more in extent. The thickest coal is invariably found to be in the central part of the basin from whence it gradually thins in every direction until a point is reached where it becomes too thin to be worked profitably. The quality of the coal on the outskirts of the rim is as good as it is where the coal is thickest. Between the basins the coal thins down to a few inches, but apparently never does entirely cut out. It is evident, therefore, that the non presence of a workable coal over the entire area is not due to erosion after the deposition of the coal but to lack of deposition. The basins had been cut out before the coal was formed and were filled with coal to the top or a little beyond the top of the basins. The formation of the coal was checked soon after the basins were filled.

The thickness of the coal is, therefore, very irregular. The coal will have a thickness, in the central part of the basin, of 5 feet or more and will gradually thin to the outer edges of the basin. It is usually worked until it thins to about 30 to 34 inches and then abandoned.

There seems to be a general impression among all the miners who have operated in this field that the Hawesville coal does not occur under the highest hills, the idea prevailing that the high hills cut out the coal. They claim that the coal is always cut out in like manner in every direction from the center of the basin whether the edge is near the high hills or entirely in the low hills. The mines have practically all been opened in the low hills or, if they are opened on the sides of the high hills, it is quite likely that the center of the basin, where the coal was the thickest, was originally out in the valley between the hills and only the edges are opened, the remainder having been carried away by recent erosion. That this is the case is shown by the fact that, in at least two places, at the old Hawes mine (not the shaft) and the Rodawall-Jennings mine, the thick coal was under the high bluff at Hawesville. At two places openings were made entirely through the hill on the coal. In prospecting for this coal it as likely to be located under the highest hills as under the lowest and medium height hills.

The greater variation or thinning of the coal takes place from the bottom rather than from the top. In addition to the thinning of the coal towards the edges of

the basin, in most of the mines there is a pronounced dip to the northwest which further complicates matters and makes mining difficult. The most pronounced dips are the results of the folding which accompanied the faulting to which this region has been subjected.



Basin in Hawesville Coal.

On account of its irregularity, the coal has, in places, evaded the early prospector who left small areas of good coal located close in to Hawesville. A case in point is on the G. W. Newman property, in Hawesville, where a drill hole was put down far below where the coal should be under normal conditions, but the dip had carried the coal just five feet below the point where the drill was stopped. Later the coal was found near the crop and followed under the hill where an extensive area of fine coal was mined for years.

The coal is overlaid by a black slate which forms a good roof for mining purposes and, unless faulted, keeps the mine dry. The black slate is from 12 to 20 feet thick and is overlaid by a good building sandstone, which may be seen in various places in the eastern part of the quadrangle.

The coal has a black slate floor 4 to 30 inches thick which, in places is a "bone" containing more or less coal, and is sometimes worked with the coal. Underneath the black slate is a bed of fire clay.

Throughout the district there is a slight undulation in the surface of the bottom, with a dip to the west or northwest. In practically all of the mines there are slight undulations or rolls which displace the coal 4 to 12 inches out of its normal position. These rolls are sometimes accentuated into faults which may displace the coal an amount equal to the thickness of the vein, or even more. In the mine now operated by Jas. H. Aldridge, one mile south of Caney Creek, on the Hawesville and Pellville road, a fault with 25 feet throw is reported. In the town of Hawesville a fault of 75 feet displacement brings the Hawesville coal 75 feet lower on the northwest side of the fault than it is on the southeast side. Two levels were made through the hill at Hawesville on the same vein within 200 yards of each other one 75 feet higher than the other.

The Hawesville coal has been mined in the vicinity of Hawesville for more than sixty years. This was one of the largest mining centers in western Kentucky before the Civil War. The greater part of the coal north of Lead Creek has been worked out. On both sides of Caney Creek, along the Pellville and Hartford road, there are seven or eight mines now in operation. Some of these mines are shipping a small amount of coal, but the distance from the railroad or river, and the lack of good roads, prevent them from entering into a contract to ship coal regularly. There is a small area between Blackford and Lead Creeks in this quadrangle, and a still larger area to the east, where the Hawesville coal has not yet been touched. In the center of the basin the coal varies from 3 feet 6 inches to 5 feet, with an average of 3 feet 10 inches. In the Thomas Railey mine and in the Jas. H. Aldridge mine the coal is reported to average 4 feet.

Going south from Caney Creek the coal thins gradually until Blackford Creek is reached where it becomes too thin to be worked. At Walter Brown's, one mile south of Chambers, the coal is 44 inches. At the Steve Gentry mine, 3-4 miles south of Brown's, it is reported 33 inches. At Joshua Glovers, 3-4 miles south of Blackford Creek, the coal is reported to be 28 inches. At Charles Rice's bank, one mile north of Sulphur Fork, on the Hartford road the coal is 33 inches. An opening has been made on a coal one-half mile south of Goreing at an elevation of 500 feet. It is probable that this is the Hawesville coal as the following section would seem to indicate:

Section at Goreing.	Feet.
Gray Shale	20
Sandstone	50
Black Slate	10
Coal	2
Fire Clay	2½

South of the Goreing and the Glover openings, the coal is very thin and has never been opened for mining.

Along the Hawesville-Pellville and the Hawesville-Hartford roads, as far south as Sulphur Creek, there are numerous exposures of the Hawesville coal. All of the mines in Hawesville and on the waters of Lead Creek, in this quadrangle, are now closed. The coal is reported to be all worked out, but the elevation of the old mines enables us to calculate the dip of the coal.

At the Thomas Railey mine on the extreme eastern edge of the quadrangle, 3-4 miles north of Caney Creek, the coal is 500 feet above sea level. At the G. W. Newman mine, one mile west of the Railey opening, the coal is 490 feet above sea level, giving a westward dip of 10 feet to the mile. At the Jas. H. Aldridge mine, 1-2 mile south of the Newman mine, the coal is 500 feet above sea level giving a dip to the north, at this place, of 20 feet to the mile. At the Charles Rice bank, 3-4 mile north of Sulphur Fork, on the Hawesville and Hartford road, the coal is 500 feet above sea level. At the Walter Brown opening 2 miles west on the Pellville road, the coal is 480 feet above sea level. It is at an elevation of 460 feet at the Joshua Glover opening, 3-4 miles south of Blackford Creek, on the Pellville road.

The dip of the strata to the west, as shown by a persistent bed of limestone and coal just underneath it, is 20 feet to the mile. This holds good for all the territory west of the Hawesville and Knottsville road to Blackford Creek. West of a line drawn through Knottsville and Waitman the Coal Measure rocks are covered with a mantle of loess and it is difficult to get any vertical sections.

The Hawesville coal is the lowest coal worked in this quadrangle. Seventy feet below this is an 18 inch seam of coal which is 5 feet above the top of the Conglomerate. This lower coal shows as a stain in the east side of Hawesville with 5 feet of fire clay between it and the Conglomerate.

On the Hartford road, just outside of Hawesville, an opening was made on this lower coal by Mr. Alsop, but it was found to be only 18 inches thick and was abandoned. This is the only place known to the writer where this coal has been prospected.

In the river bluff, a short distance above Hawesville, is a still lower coal stain which comes in a bed of shale in the Conglomerate. The dip of the rocks to the west carries the Conglomerate below the surface in this quadrangle and this inter-Conglomerate coal, likewise, does not come to the surface in area comprised within this quadrangle.

Evidence of Cannel Coal.

There has been considerable discussion by Moore, Norwood and others as to the horizon of the Breckinridge cannel coal, the mines of which were located in the southeastern part of Hancock County. The cannel coal was from 24 to 33 inches thick and was regarded as one of the finest cannel coals in the world. It was only 25 to 30 feet above the Chester limestone and was, therefore, a sub-Conglomerate or Chester coal. It occupied an independent basin and its absolute identity with any other coal has been a matter of conjecture.

At two localities in the Tell City Quadrangle there is some slight evidence of the presence of a vein of cannel coal. The writer did not see the coal at either place, but the evidence is such that he regards it of sufficient importance to give it a place here.

In the first branch to the south of Goreing, on Mr. C. J. Isom's land, is an old opening which was made in a two-foot vein of coal on the east side of the road. The coal underlies 10 feet of black slate, above which comes 50 feet of sandstone. Below the coal comes 2 1-2 feet of fire clay. This is regarded by the writer as the Hawesville vein.

Another vein of coal was struck in a well at Mr. Isom's house, just across the branch from the opening on the Hawesville coal, and 17 feet below it. The coal was not penetrated for fear it would spoil the water in the well. Mr. Isom said the coal had an unusual black, shiny color and that he could ignite it with a match. When placed on the fire he stated the coal burned like it was a block of oil.

The other place where cannel coal is said to be present is in a well on the east side of the Hawesville and Hartford road 1-4 mile south of Sulphur Fork. The coal was not penetrated and its thickness was not determined. It is stated by men who worked in the well that the coal taken out was a black shiny coal that was easily cut into rings with a knife.

Quality of the Hawesville Coal.—The following analysis of this coal was made by Dr. Peter and Mr. Talbutt, chemists of the old Survey. The samples were collected by Mr. P. N. Moore and used in his report on the Geology of Hancock County, Kentucky Geological Survey, Report on the Western Coal Field, Vol. D., page 26:

Moisture	5.12	3.30	5.20	5.10	5.46
Volatile Matter	36.28	39.00	38.70	41.20	33.14
Fixed Carbon	47.60	50.50	48.50	46.60	55.20
Ash	11.00	7.20	7.60	7.10	4.20
Total	100.00	100.00	100.00	100.00	100.00
Coke	58.60	57.70	56.10	53.70	59.40
Sulphur	4.038	3.373	2.266	3.331	1.368
Specific Gravity	1.357	1.268	1.336	1.292	1.308

The coal is regarded by the local trade as a superior coal to any other coal obtainable in Western Kentucky. It makes an excellent shop coal and has plenty of oil and life for domestic purposes. It burns to a white ash with little or no clinker.

The only sulphur of any consequence in the coal is a thin band which occurs a little above the center of the vein in a parting of mineral charcoal. When dry the charcoal forms a smut between the layers. This is known by the miners as "mother-of-coal." The parting varies in thickness from an inch to 6 inches with an average of 4 inches. The amount of sulphur in the mother-of-coal may be a thin band the thickness of a knife blade or it may form the greater part of the mother-of-coal parting. The band of mother-of-coal, with its accompanying streak of sulphur, is one of the characteristic features that serves to identify the Hawesville coal, separating the main coal into an upper and lower bench. In the Squire Aldridge mine the upper bench is 10 inches thick and where the band of mother-of-coal thickens the bottom coal thins and the upper remains constant.

In the Thomas Railey mine the band of mother-of-coal is about 3 inches thick and is present throughout the mine. The sulphur band is very thin or entirely absent.

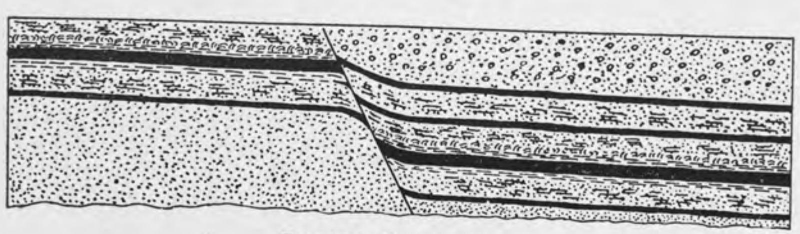
The Hawesville coal has thin black lustrous bands between thicker bands of a dull appearance. It is hard and brittle and breaks easily at right angles to the bedding. It does not soil the hands in handling, except the band of mother-of-coal near the center of the seam.

It is mined exclusively by pick by undercutting at the bottom. The coal breaks from the top often producing cubical blocks as large as one man can load.

HAWESVILLE FAULT.

In the hills in the town of Hawesville and for a mile or two to the south the outcrop of the Hawesville coal is more or less complicated by block faulting. Some of the leading miners of this section state that there is a series of faults with seven distinct levels where the coal occurs, but this has not been verified by the writer. One of the fault lines has been located which extends N. 21° E. It occurs in the Hartford road at Hawesville on the brow of the hill leading down to Lead Creek. It is a normal fault with the down-throw side on the northwest. The rocks in the plane of the fault stands at an angle of 70 to 75 degrees and are bent at a high angle for some distance on both sides of the actual break. The amount of displacement, as shown by the different elevations of the Hawesville coal on either side of the faults, is 75 feet on the side of the ridge facing the Ohio River and somewhat less on the Lead Creek side.

South of Lead Creek the fault is nowhere discernible.



Fault at Hawesville.

The Hawesville coal before being worked out underlaid the hills between the river and Lead Creek. The mouth of the old Trabue mine in Hawesville was just a short distance southeast of the fault line and was opened on the coal at an elevation of 515 feet. About 200 yards to the northwest, the mouth of the old Rodawall-Jennings mine is 440 feet, or 75 feet lower than the same coal in the Trabue mine.

The same coal was opened in the west end of Hawesville at the old Hawes mine. The distance from the old Rodawall-Jennings opening to the old Hawes mine is 1,800 feet. At the latter place the coal is 15 to 20 feet lower than at the Rodawall-Jennings opening. At the old Adair shaft, one mile below town, the coal is reported to have been struck at 104 feet below the surface. The coal is said to have been 4 feet and one inch at the bottom of the shaft, which was located on the first bench of the high bluff overlooking the Ohio River bottom. Drifts were made out under the river bottom for a distance of 100 yards or more—old breaks are still very marked on the north side of the L., H. & St. L. railroad track—where they encountered a thin roof overlaid by river gravel and water which finally came into the mine and flooded the entire works. This was 50 to 70 feet below the surface of the present river bottom.

At the old Trabue opening on Mr. Aldridge's place the Hawesville coal is 45 higher than it is 1,500 feet to the west at the old opening up the branch from the school house in Hawesville. The fault which shows on the Hartford road, on the Lead Creek side, comes between the above mentioned places.

From the old Rodawall-Jennings opening, a few feet west of the main fault, to the old Hawes opening in the lower edge of town, a distance of 1,800 feet, the dip is 10 feet. From here to the old Adair shaft, one mile below town, another fault has brought the coal down 84 feet below the Hawes opening. The dip flattens greatly to the west as shown by the overlying strata.

AREA OF HAWESVILLE COAL.

In the river bottom between Hawesville and the Adair shaft, and for a short distance beyond, are some small areas which are thought to contain some good coal that could be worked, provided a certain amount of caution were used against running long drifts out under the river bottom until the main body of coal near the bluff is worked out. A few well chosen core-drill holes would determine the character and thickness of the roof, the character of which would limit the distance it would be safe to venture under the bottom for the coal.

Owing to the lenticular nature of the Hawesville coal it is difficult to define its area with accuracy, but from its known outcrops and dip some word may be said that will be helpful in locating the coal.

It is found above drainage in the hills between Hawesville and the Sulphur Fork, forming an irregular triangle which is 3 1-2 miles wide at the southern end and 1-2 mile wide at Hawesville, including about 12 square miles. West of this it goes below drainage and later coals are found in the hills. The Hawesville and Knottsville road, as far south as Blackford Creek, may be said to mark the western boundary of the coal; in all the territory west of this it is found below drainage.

In the eastern part of this area the coal outcrops at about 500 feet above sea level, which is about 50 feet above the beds of the large streams and dips to the west at the rate of 20 feet to the mile. The interstream areas rise to an elevation of 600 feet giving an extensive area, within the prescribed territory, where the coal should be found.

Throughout the area examined the Hawesville coal is overlaid by 10 to 12 feet of black shale, above which comes a sandstone, which, in places, is 40 to 50 feet thick and may serve as a surface guide in locating the coal. At a number of places the sandstone outcrops in the roads and on the hillsides while the coal below is covered.

The interval between the Hawesville coal and the Lead Creek limestone coal, which is the next workable coal above the Hawesville, is 185 feet.

There is a thin coal 30 feet above the Hawesville coal, as shown in the bluff at Hawesville. At the mouth of Persimmon branch, 1-2 mile below the old Hawes mine, the dip has carried it down to an elevation of about 400 feet. The coal is exposed in the branch at Mr. Walsch's barn where it is only 4 inches thick. It is overlaid by 25 feet of black shale which has recently been investigated for the purpose of making sewer pipe. Underneath the thin coal comes a bed of plastic fire clay, the thickness of which is not shown in the branch.

In the Adair shaft, one mile below Hawesville, a vein of coal 18 inches thick is reported to have been struck at a point 60 feet above the main Hawesville coal.

The same coal has been opened on the south side of Indian Hill, about 60 feet above the Joshua Glover opening. It is reported to have been worked for a short time, but was abandoned on account of the thinness of the vein.

The coal may be found in practically the same territory as the Hawesville coal 30 to 40 feet higher in the hills. It comes close above the top of the thick sandstone, which is found to overlie the Hawesville coal. It is not of commercial thickness.

JAMES MASON COAL.

This name was given to this coal by Mr. P. N. Moore in the report on the Geology of Hancock County, Kentucky Geological Survey, Report on the Western Coal Field, Vol. D, page 28. He places the coal 120 to 168 feet above the Hawesville coal and 40 to 50 feet below the next higher coal, the latter being just underneath a ledge of limestone.

The writer was unable to verify some of the intervals given by Mr. Moore. He places the limestone coal 160 to 220 feet above the Hawesville coal, and the Mason coal 120 to 168 feet above the Hawesville coal.

At the old Adair shaft the limestone coal has been opened on the hill just 80 feet, measured by hand level, above the top of the old shaft. The shaft was reported to be 104 feet deep which would make the interval between the Hawesville coal and the limestone coal 184 feet.

Mr. Moore stated that the Adair shaft was reported 60 to 80 feet. This would make the interval between the limestone coal and the Hawesville coal 140 to 160 feet instead of 160 to 220 as he has it in his general section.

The limestone with its accompanying coal, outcrops in the four quarters of the quadrangle and is the horizon from which all the coals are best reckoned. At the Adair shaft the relative positions of the Hawesville coal and the limestone coal are established. Measured sections of the limestone coal and the underlying Mason's coal were made at four different places with results agreeing with the above.

The writer was unable to locate the Mason opening, but a coal which corresponds to the Mason coal was seen at Will Robb's place and at Petrie where the coal was just being opened. The elevation of the opening was 400 feet above sea level. The following section was made of the Robb opening.

	Inches.
Shale	..
Coal	7
Fire Clay Parting	8
Coal	5
Fire Clay	..

The same coal was seen in the Hawesville and Owensboro road just east of Lead Creek, at a point 27 feet below the limestone coal.

It was observed on the road 2 1-2 miles west of Hawesville, on the Utility road, at a point 25 feet below the limestone coal.

It was seen in a ditch in the road 30 feet below a ledge of limestone on the north side of Indian Hill.

At the Owensboro Sewer Pipe Company's mine, where the L., H. & St. L. R. R. crosses Blackford Creek, a coal has been recently uncovered which is perhaps the same as the Mason coal, but it is 25 feet lower than it is in the eastern part of the quadrangle. The following section gives the relative position of the coal to the limestone coal, next to be described.

Section at Owensboro Sewer Pipe Company's clay mine:

	Feet.	Inches.
Shaly sandstone	....	....
Fossiliferous limestone in layers, with thin bands of clay between	11	....
Shale	12	....
Coal	....	14-16
Fire-clay	6- 7½	....

	Feet.	Inches.
Blue shale	7	....
Harder sandy shale with thin bands of sandstone	48	....
Hard block coal	....	14-18
Fire clay of greenish cast	5	....
Shale, bed of Blackford Creek	....	....

LEAD CREEK LIMESTONE.

On the main waters, as well as on some of the tributaries of Lead Creek, is a limestone the base of which is about 255 feet above the top of the Conglomerate. It outcrops in the Tell City Quadrangle, in Kentucky, at numerous places west of a line drawn from a point one mile below Hawesville, southward through Indian Hill. East of this line the rise of the strata to the east carries it beyond the tops of the hills.

It is found above drainage between the waters of Lead and Blackford Creeks. In the hills on either side of Blackford Creek the westward dip has carried it down to or but little above the bottom of the latter stream. From here the dip reverses and rises to the west and the limestone is found 30 feet higher on the hills on the waters of Little Blackford Creek than it is on main Blackford Creek, three miles to the east.

The Lead Creek limestone, with its accompanying coal, forms the key rock to the district. It is made up of three, and perhaps four ledges, ranging in thickness from a few inches to 8 or 10 feet, extending through an interval of 30 to 40 feet. The lowest division is the thickest and forms the roof to the Lead Creek coal. In the eastern part of the area, for a distance of 5 to 7 feet above the coal, the limestone is poorly cemented and breaks down quickly where exposed to the weathering agents, and forms a sticky plastic clay. The readiness with which it breaks down may lead one to believe that the limestone does not come down to the coal, but at J. W. Bozarth's there are only 4 inches of shale between the coal and hard limestone. The same is reported to be the case in the old H. W. Wilson mine. In the western part of the area, as shown in the Owensboro Sewer Pipe Company's mine, there is an interval of 12 feet of shale between the limestone and the underlying coal.

Six to seven feet above the base of the limestone there is a 4-inch band of flint one foot from the top of the ledge. In places this limestone is of a dark blue color and contains large crinoid stems, brachiopods and other fossils. It has a tendency to break into long straight rectangular blocks. On steep hillsides, where the limestone is present, large boulders may be found far down the hill from their original bed. This is often confusing in locating the underlying coal. In such cases the coal may be located by the bench which is formed by the limestone in place.

The second ledge of limestone comes 10 to 12 feet above the top of the lowest division. On weathered exposures it assumes a brownish yellow color and is of honey-combed structure. It contains crinoid stems and some other fossils. It may be recognized from the lower ledge by its brownish color and general flinty nature.

The upper division of the limestone is 30 to 40 feet above the main coal seam. This ledge is about two feet thick and is of a dark blue color. It contains crinoid stems in abundance, some of which are 7-10 of an inch in diameter. A thin coal occurs below the top limestone.

At only two places were the three distinct divisions of the limestone found in the same hill; one was at G. B. Dishman's, near the head waters of Pup Creek, and the other on the Hawesville and Adair road, about 3-4 mile a little west of south of Petrie.

The individual outcrops of the limestone are mentioned in connection with the Lead Creek coal.

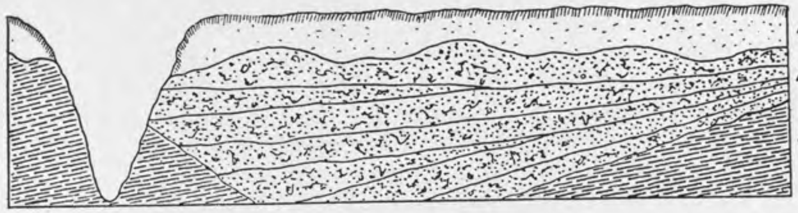
The Lead Creek limestone of Hancock County, Kentucky, is believed to be the equivalent of the Minshall limestone of Indiana, where it is found in the river bluffs at approximately the same elevation above the Hawesville or Cannelton coal.

As a result of the study of the fossils associated with this limestone in Indiana Mr. David White,* of the U. S. Geological Survey, places the boundary between the Alleghany and Pottsville formations of the Appalachian coal field at about the top of the limestone.

*Thirty-third annual report of the State Geologist of Indiana, 1908, page 58.

On this hypothesis there would be only two coals of the Pottsville formation, in this quadrangle that have been worked to any extent. These are the Hawesville and the Lead Creek coals.

At the Owensboro Sewer Pipe Company's mine, on Blackford Creek, there is a pronounced unconformity at about the horizon of the Lead Creek limestone. At this point a coarse-grained sandstone lies unconformably on a bed of shales. As shown in the cut, the place marks the location of a stream channel which was eroded in the shales and subsequently filled by the sandstone.



Shale eroded by sandstone.
1. Loam
2. Sandstone
3. Shale.

LEAD CREEK COAL.

This coal, so frequently referred to above, is first seen, coming west from Hawesville, about a mile below town. A line drawn from there to Indian Hill, and from the latter place to St. Lawrence church, marks the eastern limit of the coal. West of this line the coal may be traced in more or less frequent outcrops to within one mile of the western boundary of the quadrangle.

Along its eastern outcrop the coal occurs at an elevation above sea level of 490 feet near the Ohio river and 520 feet on Indian Hill. The northward dip between Hawesville and Adair is 13 feet to the mile. The westward dip in the latitude of Martindale is 20 feet to the mile. The westward dip in the latitude of Petrie is likewise 20 feet to the mile.

The coal is 60 feet lower at G. B. Dishman's, 2 1-2 miles west of Indian Hill, than it is on Indian Hill, giving a dip of 24 feet to the mile between these two points.

The westward dip continues at the rate of 16 to 20 feet to the mile until a point is reached about one mile west of where Blackford Creek leaves the hills. From here to the western edge of the quadrangle the dip is reversed, as shown by the outcrop of the coal and the limestone at the Owensboro Sewer Pipe Company's mine, and at Ed. Taylor's place, 1 1-2 miles east of Maceo.

The diagram in figure 7 shows the rapid dip of the strata from near Hawesville to a little beyond Blackford Creek and the more rapid reverse dip from there to within a mile and a half of the western edge of the quadrangle. The actual locations of the various divisions of the diagram, from 1 to 7 inclusive, may be seen by referring to corresponding numbers on the map accompanying this report. Numbers 1, 2, 3, 5 and 6 are practically on an east and west line; number 4 is 1 1-2 miles north and number 7 two miles south of this line.

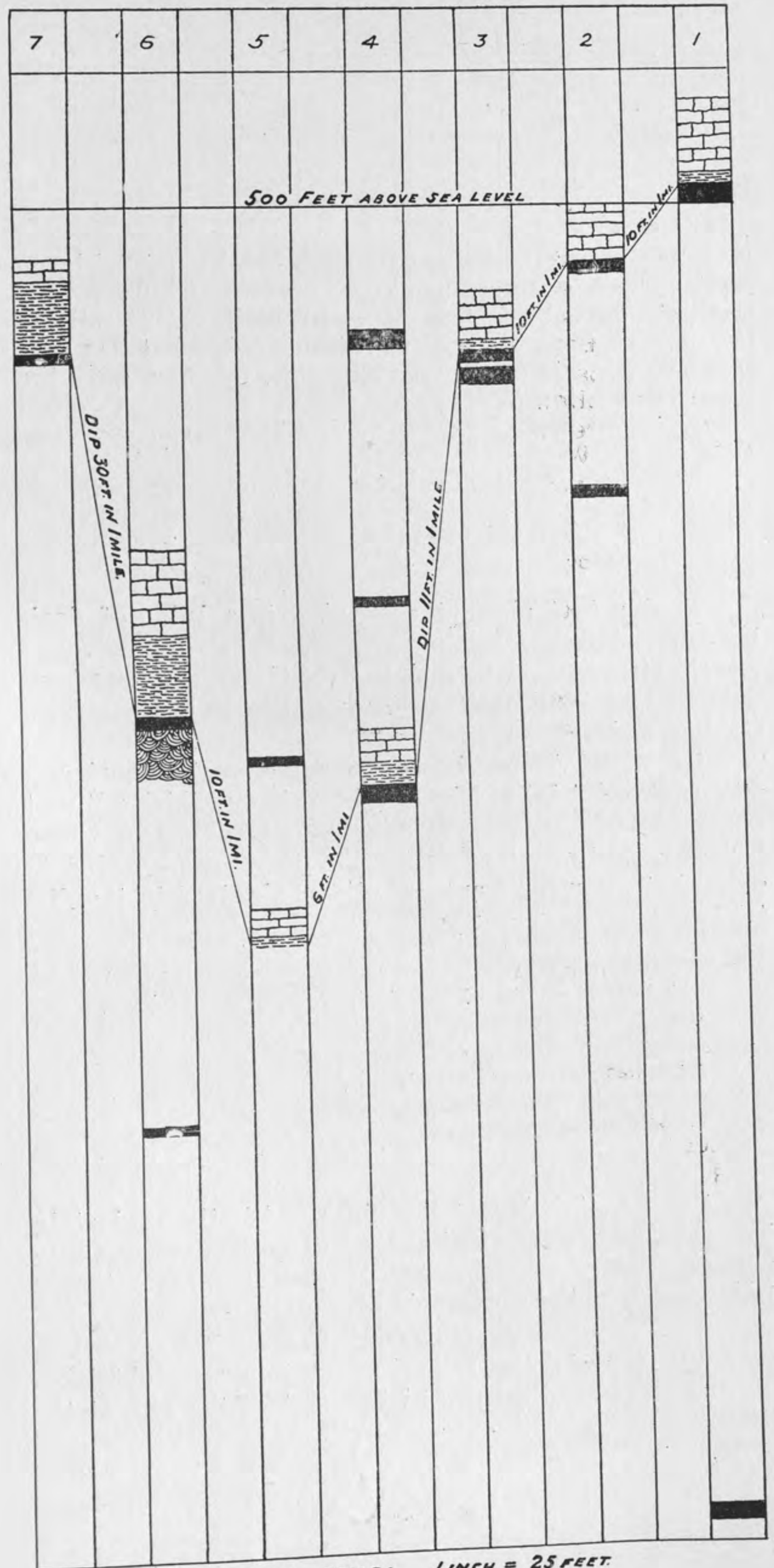
The Lead Creek coal is well developed in the eastern part of the area. It has been mined at H. W. Wilson's, 3 miles west of Hawesville, on the Utility road, where it is reported to be 3 to 3 1-2 feet thick without parting. The opening has now fallen in. Blocks of limestone are present in the hills above the old opening.

The same coal has been opened just beneath a 10-foot ledge of limestone on the hill above the old Adair shaft, one mile below Hawesville. The thickness of the vein could not be determined.

Three openings have been made on this coal on the road between Hawesville and Adair, northwest of Lead Creek. At J. W. Bozarth's, one mile west of Lead Creek, the following section was obtained at the mouth of the opening:

	Feet.	Inches.
Limestone	7	....
Black shale	..	4
Coal	..	7
Clay parting	..	9
Coal	..	30
Fire clay.		

At this place, and at the one next to be described, the coal has a 0 to 10-inch clay parting, in the upper part of the vein. The coal below the parting is reported to



VERTICAL SCALE: 1 INCH = 25 FEET.

Fig. 7.

Showing dips between Hawesville and Yelvington.

be an excellent burning coal and breaks out in large blocks. The coal here has 20 to 50 feet of hill above it and extends unbroken to Albert Whistle's, one mile to the north, where the coal has been opened but has now fallen in. Mr. Whistle, who made the opening, gave the following section of it:

	Inches.
Slate roof	....
Coal	7
Clay parting	10
Coal	24

Twelve feet above the opening is a ledge of dark blue limestone containing numerous fossils including crinoid stems 5-8 of an inch in diameter. The limestone splits easily, with the bedding plane into long, thin, straight slabs.

Mr. J. W. House has an opening on this coal one mile south of Adair. The coal is 30 inches thick without parting. It has a fire-clay floor and a shale roof. The following section made at the mouth of the opening is somewhat different from any others obtained in the district:

	Ft.	In.
Thin-bedded weathered limestone	2	..
Coal	..	8
Gray shale	5	..
Hard blue limestone	2	..
Rotten limestone	5	..
Covered—perhaps shale	5	..
Coal	2	6

A five-foot ledge of limestone, with the coal stain below, outcrops at the foot of the hill in the road one mile north of Utility. Coming still further south it outcrops in the road on the north side of Indian Hill.

Two and one-half miles southwest of Indian Hill at G. B. Dishman's the following section was obtained. The coal has been opened at the foot of the hill, at the little grist mill, but was found too thin to work:

	Feet	Inches
Gray slate containing thin bands of sandstone	20	
Coal stain	thin	
Fire clay	5	
Gray to blue shale	8	
Very hard blue limestone containing an abundance of crinoid stems, some 7/10 of an inch across	1	
Covered	10	
Blue crinoidal limestone	2	
Covered	10	
Limestone with few crinoid stems	2	
Blue clay	3	
Dark limestone		4
Rotten dark blue clay shale		4
Coal		6
Gray fire clay.		

Between Dishman's and Gatewood the country is dotted with coal banks which supply the neighboring territory with coal. This is a higher coal than the Lead Creek coal.

The Lead Creek limestone, with its accompanying coal, is found against at Haywood Smother's 3 1-4 miles west of Gatewood. A fault at this place has brought down the next higher coal on a level with the limestone coal. The mine Mr. Smothers is now operating is a higher coal than the Lead Greek coal, but just across a small drain, not 200 feet to the west, the limestone coal has been opened, but is now fallen in. Large blocks of limestone taken from the old mine are piled up near the mouth of the opening. The limestone is filled with fossils.

The limestone coal was formerly opened at Tom Bivin's, one mile north of Haywood Smother's. The coal is reported to be 29 inches thick. Blocks of limestone are still present on the old gob pile.

On the Lewisport and Yelvington road, at a point one mile south of Blackford Creek, the blue fossilliferous limestone shows in the bed of the branch at an elevation of 400 feet. Four feet of shale underlies the limestone.

At the Owensbore Sewer Pipe Company's mine, where the L., H. & St. L. R. R. crosses Blackford Creek, a section of the limestone, and underlying coal, was given on a previous page. At this place the coal has thinned to 14 to 16 inches and has 12 feet of blue shale above and 7 feet of fire clay below it. In places in the eastern part of the quadrangle the limestone comes down and forms the roof of the coal. At no other place was seen such a thickness of fire clay beneath the coal.

The upper part of the fire clay, in the Owensboro Sewer Pipe Company's mine, has a dark gray tint and is slickensided. The central and lower parts of the bed are stratified and contain very small particles of mica, and sulphide of iron, which render it unsuitable for high grade fire brick.

On Mr. Ed. Taylor's place, 1 1-2 miles due east of Maceo, the Lead Creek limestone and coal are found on the round hill just east of the old Yelvington road at an elevation of 480 feet above sea level. Above the limestone comes 15 feet or more of shale.

In Indiana the lowest stratum of the Lead Creek limestone marks the position of the Minshall coal, which comes underneath the base of the limestone. The upper and lower block coals are placed 35 and 70 feet, respectively, below the Minshall coal.*

In Kentucky the block coals are stratigraphically above the Lead Creek limestone coal. The Lead Creek coal in Kentucky is a block coal, and the Adair coal, which has made the reputation of the Western Kentucky block coals, comes 20 to 40 feet above the Lead Creek coal. The average thickness of the Adair Block coal is 3 feet. It has a hard shale roof and a bone floor 18 inches thick. Above the shale roof is a micaceous and highly siliceous shale or sandstone.

At Adair, Hancock County, an outcrop of what is taken to be the top of the Lead Creek limestone is 35 feet below the Adair Block coal. Mr. Lamar, who operates a mine on the Adair Block coal, reports a 16-inch vein of coal, which, as determined by the writer, is 30 to 35 feet below the Adair Block coal.

In the twenty-third annual report of the State Geologist of Indiana, the Minshall coal with its black shale roof and overlying limestone was confused with the number V coal—number 9 of Kentucky—which is 300 feet higher in the series, but was correctly correlated in the report of 1908.

*Thirty-third annual report, 1908, type section opposite page 54.

ADAIR COAL.

At an interval of 20 to 35 feet above the Lead Creek coal and about 40 feet below the Lewisport coal is a 3-foot vein of coal that is found in the northeast and the northwest quarters of the quadrangle. The eastern limit of the outcrop is practically the same as that of the Lead Creek coal. It comes high up in the hills northwest of Petrie and has been mined for a number of years in the high hills north of Adair.

At the Hinkle bank, one mile northwest of Petrie, at Adair and at the Charles Miles' bank the coal is of workable thickness. This is a block coal of excellent quality. It leaves no clinker and burns to a white ash. At the Hinkle bank the coal is 2-feet thick as measured at the mouth of the opening. It has a black shale roof and a hard shale floor. A few feet below the opening is a 10-foot ledge of sandstone, the base of which must be near the top of the limestone.

At the R. W. Woods bank, 1 1-4 miles northeast of Adair, the coal is 2 feet to 2 feet 10 inches thick without parting. It has a gray slate roof and 4 inches of black slate floor, underneath which is a gray fire clay. The coal burns to white ash.

The same coal is now being worked at the foot of the hill east of Charles Miles' house, one half mile north of St. Lawrence church. The coal is 3 1-2 feet thick and is regarded by those who use it as being freer from sulphur than any coal in this region. It contains mother-of-coal and burns to white ash.

At no other place known to the writer has this coal been worked. It shows as a bloom at an elevation of 510 feet on the hill 1-2 mile east of Utility where it is about 30 feet above the limestone coal.

Where Yellow Creek leaves the hills it shows in the hill to the south 20 feet above the limestone coal.

The same coal has been opened at Jim Dorsey's, one mile south of Blackford Creek, on the Lewisport and Yelvington road. The opening had fallen in when the writer visited it.

It is probable that the coal that has been opened on the road side at A. M. Roberts, one mile west of and a little south of the mouth of Butcher's Creek, is the Adair coal.

Lewisport Coal.

This coal derived its name from the fact that it was mined in the hills south of Lewisport. It is the most persistent coal in the quadrangle. Its geological horizon is 60 to 65 feet above the Lead Creek coal and is about 315 feet above the Hawesville coal.

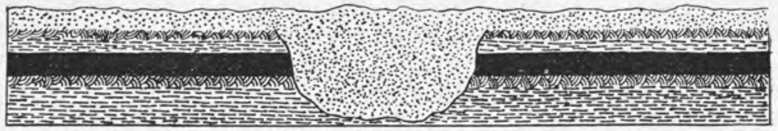
The central third of the quadrangle extending north and south may be said to limit the area where the Lewisport coal is worked. In the eastern part of this quadrangle on the headwaters of South Fork of Yellow Creek it rises to near the tops of the ridges. The westerly dip brings it down to about 30 feet above the level of Blackford Creek in the vicinity of Scythia. In the northern part of the area this coal is not worked west of Blackford Creek.

The dip of the strata in this locality has been referred to under the discussion of the Lead Creek coal. On page 32 Report on the Geology of Hancock County, Kentucky Geological Survey, Report on the Western Coal Field, Vol. D., Mr. P. N. Moore states that the dip of the Lewisport coal to the west is 25 to 50 feet to the mile. He states on the same page that the rise of the rocks to the east brings the coal to the tops of the hills at the head of South Fork of Yellow Creek. This brings the eastern outcrop of the coal to the surface at an elevation of about 540 feet above sea level. With a westerly dip of his lowest estimate, 25 feet to the mile, it would bring the coal down to an elevation of 365 feet above sea level or 25 feet below the bed of Blackford Creek at a point where the L. H. and St. L. R. R. crosses that stream. As a matter of fact the limestone coal, which is 50 to 65 feet below the Lewisport coal, is present in the hill above the creek at an elevation 435 feet above sea level. This would place the Lewisport coal 120 to 135 feet too low at this point according to his estimate. The dip to the west in this latitude, taken as a whole, is only 7 feet to the mile. In the eastern part of the area the dip is 20 feet to the mile while in the western half there is a strong reverse dip to the east. The coal in the hills back of Lewisport is at about the same elevation above sea level as it is in the southern part of the quadrangle east of Knottsville.

The coal is now being mined in the hills south of Lewisport between the waters of Little Yellow Creek and Yellow Creek. These mines supply the town of Lewisport and the adjacent territory.

Mr. J. W. Butcher is operating a mine in the first hill south of Yellow Creek and north of the Hawesville and Lewisport road. The interval between this and the Lead Creek coal is 60 feet, as shown by the outcrop of the limestone and underlying coal on the opposite side of the hill from the mine.

The coal is 4 to 5 feet thick with an average of 4 feet 4 inches without parting. The top of the coal is practically level with a slight irregularity in the bottom which accounts for the variation in the thickness of the vein. It has a plastic fire clay floor with a 4-inch band of shale between the fire clay and the coal. The shale is mined with the coal.



Showing Erosion Channel in Lewisport Coal.

Just above the coal is a band of greenish "shell rock" or rotten limestone which is filled with macerated fossils. It averages 5 inches thick but is not present throughout the mine. In some places in the mine the roof is a gray shale which will stand in an 18-foot room without timbering. In other places there is a black slate roof.

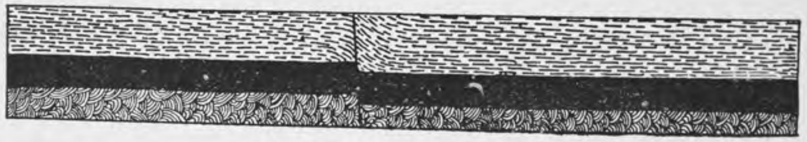
The upper third of the vein is a hard lump coal of good quality. Below this comes a softer, smutty coal 10 to 16 inches thick, with more or less sulphide of iron. The bottom division is somewhat similar to the top.

On the south side of the ridge and one-half mile south of the Butcher mine, on the Elmer Adkins land, Mr. J. W. Dixon is working the Lewisport coal. The vein is from 4 feet to 4 feet 6 inches thick with 1 to 7 inches of gray shale on bottom with fire clay below. The fire clay is at least 5 feet thick.

The rotten limestone containing the macerated shells is not over 2 inches thick at any place, and in places is entirely absent.

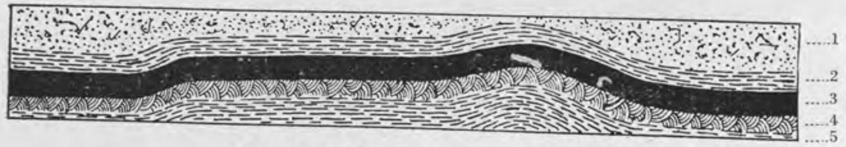
The coal has black slate roof 6 to 11 feet thick. Above this comes a soft sandstone which is well exposed at the spring just east of Mr. Adkins' house.

In places rolls or faults are encountered which cut the coal down to one foot thick. At these faults the slate roof is turned up at a high angle with a vertical displacement of as much as 18 inches in the coal. The cracks or breaks in the coal are usually filled with mud.



Fault in Lewisport Coal.

About 20 inches from the bottom is a band of mother-of-coal 8 inches thick which contains sulphide of iron. There is some peacock coal in the top layer. Coal burns with a red ash, which is characteristic of the Lewisport coal throughout the district.



Showing Folds in Lewisport Coal.
1. Sandstone.
2. Shale.
3. Coal.
4. Fire Clay.
5. Shale.

At the head waters of the north fork of Little Yellow Creek are a number of openings which mark the place of the Finley Mines. A branch railroad from the main line of the L. H. and St. L. Railroad was constructed up Little Yellow Creek to the mines which were extensively operated for a number of years. It is claimed by some of the miners who worked in the mine that the coal was not anything like exhausted when the property was abandoned and the railroad track torn up.

Just east of the Martindale road from the Finley mine is a small mine owned by Charles McDaniel. The coal is very regular throughout the mine and averages 4 feet thick. Coal has considerable sulphur and burns with a red ash. The mother-of-coal parting is here 20 inches thick. It is mined and burned with the coal. The vein has a black slate roof and 2 inches of gray slate on the bottom with fire clay below. The coal is not worked at any point on the east side of Blackford Creek between the Charles McDaniel mine and Gatewood.

The best development of the Lewisport coal is found in the hills south of Gatewood between the waters of Blackford and Pup Creeks. The ridges are usually broad and rise 50 to 60 feet above the coal. All of the openings are made on the west side of the ridges. The dip of the strata is to the west and by opening on the west side the mines have a good drainage. At Mr. L. McDaniels' an opening was formerly made on the east side of the ridge but had to be abandoned on account of water.

The coal is mined at H. E. Lotts, 1-4 mile south of Gatewood. The coal is solid and averages 36 inches thick. It has a fire clay floor and gray shale roof, and burns to a red ash.

One-half mile south of Gatewood on the west side of the Gatewood and Knottsville road Mr. L. McDaniel has a mine on the Lewisport coal. The coal is from 3 to 9 feet thick with an average of 4 feet. It has a black slate floor 18 inches thick with gray shale roof. The band of rotten limestone above the coal is well developed in this mine and contains some fairly well preserved fossils. The coal has a small percentage of slack and would make a fairly good shipping coal. In the opening now being worked the coal has a most brilliant peacock flower. It is rich in gas, is a free-burning coal that has little or no clinker and leaves a red ash.

It seems to be a general impression among the miners that whenever highly brilliant peacock colors are found in this coal a fault may be expected in the immediate vicinity. The mine is opened on the west slope of a strong fold or fault. The westward dip in the mine is something like 20 feet in 100 yards.

Two miles south of Gatewood on the west side of the Knottsville road Mr. E. Darrell has an opening on the same coal as the McDaniel mine. The coal is 3 feet 8 inches to 4 feet 4 inches without parting with an average thickness of 3 feet 10 inches. It is an excellent shooting coal which cuts from top to bottom. The coal dips from the center of the hill to the outcrop on either side. The following is a section at the mouth of the mine:

	Feet	Inches
Slate	10	
Sandstone, soft friable	10	
Shale	10	
Gray slate which contains fossils near coal	....	4
Blue falling clay	....	4
Coal—average	3	10
Black shale in places a "bone coal"	....	3
Dark gray siliceous fire clay, very hard until water strikes it when it becomes soft and rotten.		

The Lewisport coal has its most eastward outcrop on the north side of Indian Hill where it has been partially opened showing 32 inches of coal with a slate roof. The opening is about 70 feet above the Lead Creek coal.

The next mine opened to the south of Ed Darrell's is the W. I. Miles' mine on the right side of the Gatewood and Knottsville road, three miles from Knottsville. The coal is from 3 feet to 4 feet 6 inches with an average of 3 feet 10 inches. It has a fire clay floor and a thin band of draw slate above the coal with sandstone above the slate. Between the draw slate and the coal is about 4 inches of blue clay filled with broken shells with an occasional one intact. They are replaced by sulphide of iron. This blue fossil band comes down with the coal when mined or falls soon after. The roof is rough and knotty. The mine has wavy bottom with trough and crest axes extending north and south.

Mr. E. G. O. Fowler has just opened a small mine in the Lewisport coal about 1-2 mile south of the Miles' opening. The altitude of the Fowler opening is 20 feet higher than the Miles opening, showing a strong dip to the north at this point. The coal is 3 feet 8 inches thick without parting and has some peacock flowers near opening. Has shale roof and fire clay floor. The coal burns to a red ash.

One half mile east of the Fowler mine Mr. A. A. Higdon has a small mine on the Lewisport coal at about the same elevation as the Fowler opening, and 60 feet above the Lead Creek coal, which has been opened on Mr. G. B. Dishmans' place, about 1-2 mile to the south. The coal is 3 to 4 feet thick without parting. It has a shale roof and fire clay floor. The coal has very little pyrite and is regarded as a good domestic coal. The hill above the coal is not steep and the roof is open which lets more or less mud into the coal.

Six to eight small mines are opened on the Lewisport coal within a radius of two miles of Knottsville. These mines are principally in the hills between the Waters of Pup Creek on the north and the waters of Panther Creek on the south.

At the Charles Miles' bank the coal is 34 inches; at Sam Bickets, one mile east of Knottsville, it is about 36 inches. One-half mile farther west at the Joe Roberts bank it is only 33 inches. At T. H. O'Bryan's, one mile southeast of Knottsville, the coal is from 1 to 3 feet thick. One mile south of O'Bryan's, at the C. N. Higdon bank, the coal is 2 1-2 to 3 feet thick. At all of the above mentioned mines the coal has the characteristic fire clay floor, black slate or shale roof with the mother-of-coal parting in the center, and the thin macerated shell rock above. Wherever the coal has been found it burns to a red ash.

Near the foot of the hills on the north side of the road leading west from Gatewood, south of Blackford creek, the Lewisport coal is now being worked on a small scale at the following places: S. Hardeman's, 1-4 mile northeast of Scythia; at Drewey Smothers, 1-2 mile northwest of Scythia; at Ernest Walker's and Haywood Smother's, 1 1-4 miles northwest of Scythia. The thickness of the coal in these places varies from 23 to 36 inches. A few feet above the coal is a soft friable sandstone which breaks down readily under the action of weathering agents.

North of Haywood Smothers, and extending as far west as Yelvington and north to the Ohio river bottom, is a soft friable sandstone very similar in general appearance to that in the vicinity of Scythia. The base of this sandstone is about 460 feet above sea level. At three places coal stain is found 25 to 30 feet above the base of the sandstone. The underlying Lewisport coal, which has become gradually thinner to the west, has disappeared or at least has not been opened in this region.

Coals above the Lewisport Coal.—At the extreme headwaters of Pup Creek, and just 3 miles due east of Knottsville, Mr. J. W. Watham has opened a vein of coal on the south side of the road near the base of a 25 to 30-foot ledge of coarse grained, cliff-forming sandstone. The elevation of the coal is 540 feet above sea level. About 3-4 mile west of the Watham opening, and 50 feet below it, the Lewisport coal outcrops in the road.

About 150 yards due east of the opening underneath the cliff of sandstone, and 35 feet above it, Mr. Watham has another small mine. It has a coarse grained sandstone roof with a shale floor. The coal has a peacock flower and is much broken up by rolls and faults, one of which is reported to have 8 feet displacement of the strata. The coal is 3 feet to 3 feet 6 inches. Coal burns to a white ash. The upper Watham coal has been opened 3-4 mile due east of the Watham opening on the south side of the Pellville road.

One mile due south of Knottsville the same coal outcrops in the road where the following section was obtained:

	Feet	Inches
Stiff fire clay	2	
Coal		8
Gray fire clay	3	
Laminated micaceous sandstone	6	
Coarse-grained, poorly cemented, cross-bedded sandstone to bottom of hill	20	

The ridge between the headwaters of Pup and Blackford Creeks rises to an elevation of 660 feet above sea level. At an elevation of 580 feet Mr. Sam Watham is working a small vein of coal which is 2 1-2 to 3 feet thick with a shale roof and black slate floor with fire clay below. The coal burns to white ash. This coal is about 40 feet above the J. W. Watham coal which has been opened under the heavy cliff of sandstone 3-4 mile to the west. It is doubtless the same coal as the upper coal worked by Mr. John Watham, although it has a different roof.

Another thin coal shows in the same hill 15 feet above the Sam Watham opening. This vein has been worked for a short while but the opening is now fallen in.

Two thin coals outcrop in the road, one a half mile north and the other one quarter mile west of Pellville at an elevation of 525 feet. There is a sandstone above and also one a few feet below the outcrop on the west side of town. The following is a section of the outcrop in the road north of town:

	Feet
Covered	
Shale	10
Coal	1
Covered	5
Sandstone	10
Shale	10

The correlation of this coal is somewhat doubtful. If the sandstone below it is the same as that found beneath the upper coal at J. W. Watham's it would be the same coal as the upper Watham coal, but it is 60 feet lower at Pellville than the upper Watham coal. It is more probably the Lewisport coal.

ECONOMIC PRODUCTS.

Coals.

Coal is the most important economic product of the Tell City quadrangle. All of the coal found in this quadrangle belongs to the bituminous class. Two varieties of bituminous coals are found, namely the ordinary soft coal and splint coal, with a possibility of a small amount of cannel coal.

The ordinary bituminous or soft coal is banded in structure and breaks out into cubes, as shown by the Hawesville coal. It breaks with difficulty alone the bedding plane.

The splint coal has a distinct banded structure with a tendency to split along the bedding planes between which are thin bands of mineral charcoal. It breaks with difficulty at right angles to the bedding planes, except along the cleavage planes, which are well developed in block coals. In mining the coal breaks out in thin slabs or rectangular blocks, as shown in the Adair coal.

Four different coals are now being mined or have been mined in this quadrangle, namely, the Hawesville coal, the Lead Creek coal, the Adair coal and the Lewisport coal.

The Hawesville coal has been the most important coal from the standpoint of amount produced, but the greater part of it has been worked out in the hills adjacent to the Ohio River. There is still a large area of this coal practically undeveloped in the hills to the south of Hawesville, where it is easily accessible by slope mining. The thickness of the coal and its well-known reputation as an excellent heating coal would justify a thorough investigation by coal companies for the purpose of providing a means of transportation for placing this coal on the market. It is a hard dense coal that is well adapted to shipping.

The Lead Creek coal has been opened in a number of places in this quadrangle and is regarded as a good heating coal. In some places it is said to contain a cannel coal. The thickness of the coal varies from 24 inches to 36 inches with an average of 30 inches. It is now being worked at only one place, namely, at J. W. House's mine, one mile south of Adair. The thickness of the coal will preclude its being worked in the near future, except for local use.

In the vicinity of Adair the Adair block coal is now worked at the Lamar and at the Woods mines. A large percentage of the coal has been worked out of the hills north of Adair where it was formerly mined on an extensive scale. The output of the two mines finds a ready sale to the local trade. Like the Hawesville coal the Adair coal lies in a basin and has not been found of workable thickness outside of the vicinity of Adair. It lies about 40 feet under the Lewisport coal and has an extensive area in the central and western parts of the quadrangle, where it is quite possible to find it of workable thickness above drainage.

The Lewisport coal is the highest coal that has been worked to any extent in the quadrangle. The output of this coal is greater than the combined output of all the other coals in the quadrangle. There are 18 to 20 small mines now in operation all of which supply the small towns and the neighboring country trade. None of it is shipped.

Unlike the lower coals the Lewisport coal seems to be fairly persistent over a large part of the central third of the quadrangle where it is from 2 to 5 feet in thickness with an average over a large part of the territory, of 3 feet 10 inches. In the northern part of the quadrangle it thins to the west. In the southern part it is not mined at any place west of Knottsville, but there is some evidence that a five foot seam of coal found in a well near Ensor is the Lewisport coal.

Two thin coals which come stratigraphically above the Lewisport coal are found in the highest hills between Knottsville and Pellville, at an elevation of a little below 600 feet. The limited area where they are found precludes them from being worked except for local use. Two small mines are opened on this coal.

Clays and Shales.

There are three general types of clays found in this region. These are the fire clays, the shales and the residual clays. A seven-foot bed of fire clay is now being worked on the south side of Blackford Creek, where the Louisville, Henderson and St. Louis Railroad crosses that stream.

The clay underlies the Lead Creek coal and extends through the hill with a slight dip to the south. The opening of the mine is 23 feet above the level of the railroad switch. It is brought to the surface in small cars drawn by a mule and dumped from a tipple directly into the cars. One to two cars of 40 tons each are mined daily. The clay is shipped to the Owensboro Sewer Pipe Company at Owensboro, where it is manufactured into sewer pipe, flue linings, fire backs and flue pipe.

The 12 foot bed of shale, which comes between the coal and the overlying limestone at this place, is mined by open cut and mixed with the surface red loam and used by the same company in the manufacture of drain tile.

In the vicinity of Hawesville is a 20-foot bed of stratified shales that is probably suitable for sewer pipe, face brick and tile manufacture. A similar deposit is being utilized at Cannelton, Indiana, for the manufacture of sewer pipe.

The red clay loam which forms the surface over practically the entire quadrangle is a desirable material for the manufacture of building brick.

Building Stone and Lime.

In the lower 100 feet of the coal measure rocks are a number of beds of fine grained sandstone which were used extensively, at an early day at Hawesville in the construction of public buildings, foundation walls and residences. It is a stone that is easily worked when freshly quarried and becomes very hard when dry and has proven its value as a building material by the manner in which it has withstood the action of the weathering agents.

It is found in the river bluffs from Hawesville to Adair and a short distance beyond. It also shows in the hills on the waters of Lead and Caney creeks.

Sandstones higher up in the series are found in practically all quarters of the quadrangle. They are used locally for foundation stones for houses and out-buildings.

The Lead Creek limestone at one or two localities has been used for the manufacture of lime. Where it is found in large boulders with little or no overburden it could still be used for that purpose.

Oil and Gas.

A careful analysis of a large percent of the rocks comprising the geological scale in Kentucky will show a small amount of oil disseminated through them. Some of the shales found in the state contain a large amount of oil; so large in fact that by a process of distillation the oil can be obtained in quantities, but the process is too expensive for the present price of oil. The structure of the rocks that has made possible the accumulation of should be known as far as possible before drilling in any undeveloped territory is commenced.

Four conditions are considered necessary for the accummulation of oil and gas in paying quantities. These

are named in the usual order, storage reservoir, cover, structural folds and salt water.

The storage rock must be porous. This may be any kind of rock from a coarse-grained sandstone to a fine-grained limestone. It is a well known fact, however, that the more porous the rock, other conditions being equal, the greater the amount of oil it will contain.

The storage rock containing oil or gas must have an impervious covering that will prevent the escape of these substances into the higher strata. This cover may be a dense, fine-grained rock, sometimes a siliceous limestone, but more commonly a bed of close grained shales.

Where oil and gas have accumulated in large quantities a study of the rocks shows that the earth's crust has been folded into arches or anticlines, monoclines or terraces. Such a structural relief will permit the oil, the gas and the water to arrange themselves in the order of their specific gravity. It is by a close study of the structural relief of a district that the geologist is able to distinguish between favorable and barren districts.

The presence of salt water in the rocks is considered by some geologists as perhaps, the most important condition for the accumulation of oil and gas. It is usually found in all rocks where oil and gas are present in quantity. Where salt water is struck in a well by following up the dip of the strata nearer to the axis of the fold, oil or gas may be found in greater or less quantity. Salt water, by some, is considered the agency by which oil and gas have accumulated, and has proven a valuable guide in developing a territory.

With these preliminary statements the writer will discuss briefly the possibility of finding oil and gas in the Tell City quadrangle.

The first question that naturally presents itself to the investigator, is this: "Are there any oil sands underlying the surface of the area under discussion and at what depth do they occur?

In answer to the first part of the question it may be said that all of the oil-bearing sands that have furnished oil and gas in Western Kentucky, are below the surface in this quadrangle. The uppermost oil sands, except the Conglomerate, which is at the surface in the easter part of the area, are in the Chester group which is the source of oil and gas in southwestern Indiana.

Along the LaSalle anticline of Illinois, where 85 per cent of the oil wells drilled have been productive the oil is obtained at several horizons from the Conglomerate to the Devonian.

At Cloverport, Kentucky, the source of the gas is from the Keokuk limestone of the Waverly. It was found at a depth of 872 feet below the surface.

The source of the oil now being produced in Ohio County, near Hartford, is either the lower part of the Devonian or possibly just below the Devonian in a Niagaran dolomite.

The accompanying geological scale, from the Conglomerate to the Devonian inclusive, and the corresponding oil sands, gives a general idea of what may be expected in drilling for oil and gas in this region. Any of the porous rocks from the coal measures down to and below the Devonian, with the possible exception of the St. Louis, may prove to be a source of oil or gas.

A PARTIAL SCALE IN WHICH OIL AND GAS MAY BE FOUND IN THE TELL CITY QUADRANGLE.

System	Series	Oil Sands.	Estimated Thickness.
Pennsylvanian	Coal Measures.	Probably oil bearing where deep enough under surface.	450 ft.
	Conglomerate.	Oil bearing in Illinois.	0 to 100 ft.
	Chester Group, Shales, Limestones and Sandstones.	Sandstones of this group are oil bearing in Illinois and Southern Indiana, and a probable source in this area. It is also the source of some of the asphalt in Western Kentucky.	600 ft.
Mississippian	St. Genevieve and St. Louis Groups. Mostly Limestones.	Not likely to be a source of oil or gas.	650 ft.
	Waverly Group. Calcareous Shales and Limestones.	Limestone of this group source of gas in Cloverport well. A possible source in this area.	440 ft.
Devonian	Black Shale.	Source of gas in Meade County wells, which supplied gas to Louisville.	
	Limestones.	Source of oil in Ohio ounty wells. Very likely to be oil bearing in this area.	100 ft. or over.

The thickness of the various formations given in the above geological section vary greatly in passing from one section of the country to another rendering it a matter of conjecture, without reliable well records, to ascribe a certain thickness to any formation which is entirely below the surface. It is ,therefore, of the utmost importance in developing a new oil territory to keep a record of all wells and samples of the various materials through which the drill passes. A number of well records in the adjacent territory have been obtained which may give a general idea of the thickness of the formations in the Tell City quadrangle.

The Coal Measure rocks in this area have a total thickness of about 450 feet. This measurement is taken from the tops of the highest hills. The base of the Coal Measure rocks or top of the Conglomerate in the stream valleys will vary from 0 at the surface in the eastern edge of the sheet to about 250 feet below the surface at the western edge of the area.

The Conglomerate sandstone from a well record at Tell City, Indiana, and from measurements along the Ohio River, above Hawesville, is about 40 feet thick.

The full thickness of the Chester Group in the Tell City well was found to be 597 feet.

Well records at Stevensport, Cloverport, Hardinsburg, and on Dog Creek, Hart County, show a thickness of the St. Genevieve and St. Louis varying from 534 feet to 746 feet.

At some of the above mentioned places the Waverly varies from 435 to 468 feet in thickness.

The Devonian shales and limestone will be found to be about 100 feet or more in thickness.

The total thickness of the various groups given in the geological section beginning 250 above the base of the Coal Measure rocks, to the base of the Devonian, will be found to be a little more than 2,000 feet but not to exceed 2,500 feet at the maximum.

Should oil be found in the Chester it would be found at a depth varying from 300 to 900 feet. The next probable oil horizon would be in the Waverly at a depth of 1,540 to 1,980 feet. Should the two mentioned groups prove barren the Devonian limestone below the base of the black shales should be struck at a depth ranging from 2,000 to possibly 2,500 feet.

We have discussed the conditions under which oil and gas have accumulated, the oil and gas horizons that are likely to prove oil-bearing in this quadrangle and the depth of the different horizons. The question now is, "where is the most favorable place to drill for oil or gas?"

Two deep wells have been drilled in the quadrangle, one in the town of Hawesville, and the other 5 miles south of Hawesville. The record of the well at the latter place was kindly furnished the writer by Mr. J. W. Newman, and shows the following:

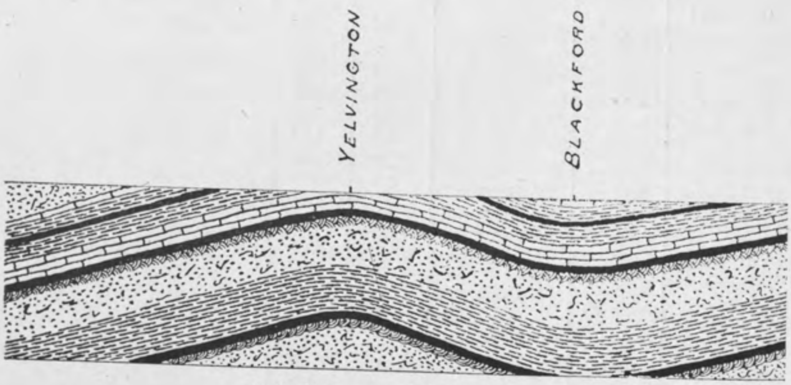
LOG OF NEWMAN WELL.

WELL No. 1.—Drilled for J. H. Snowden; on Newman Farm, Hancock County, Kentucky; Drilling Contractor, Snyder & Rowlee; conductor 10 ft.; 255 ft., 10 inch casing; 1,244 ft., 8 inch casing; water well 65 ft., water at 50 ft.; all casing pulled.

Rock	Color	Hard or Soft / Open of Loose	Thickness.	Depth.	Remarks.
Clay	Yellow	Soft	10	10	Sharp (Cong. and Chester SS.)
Sand	Yellow	Hard	30	40	
Sand	White	Medium	130	170	
Slate	Blue	Soft	50	220	
Lime	Blue	Hard	35	255	
Slate	Dark	Soft	55	310	Broken up formation.
Lime	Gray	Hard	10	320	
Lime	Dark	Medium	60	380	
Lime	Gray	Hard	40	420	
Slate	Red	Soft	25	445	
Lime	Gray	Hard	75	520	
Slate	Red	Medium	10	530	
Gritty	Gray	Hard	25	555	A show of oil and water at 535'.
			......	......	A show of 8 bailers an hour.
Lime	White	Hard	80	635	
Sand	White	Hard	20	655	Water 645.
(Base of Chester)					
Lime	Gray	Hard	225	880	Blue Lick Water at 830.
Lime	Dark	Hard	300	1180	
Lime	Gray	Hard	220	1400	Blue Lick Water at 875.
Lime	Dark	Hard	75	1475	½ bailer per hour.
Gritty lime	Dark	Hard	35	1510	
Lime	Gray	Hard	105	1615	
Gritty Lime	Gray	Hard	10	1625	
Lime	Gray	Hard	175	1800	
Lime	Dark	Hard	50	1850	
Lime	Gray	Hard	25	1875	
Lime	Dark	Hard	25	1900	
Lime	Gray	Hard	10	1910	
Lime	Dark	Medium	55	1965	
Devonian—					
Slate	Dark	Medium	45	2010	
Slate	Brown	Medium	78	2088	Dark brown.
Lime	Gray	Hard	7	2095	
Shale	Brown	Medium	30	2125	Light brown.
Trenton	Gray	Hard	25	2150	
Lime	White	Hard	30	2180	
Lime	White	Hard	40	2220	
Sandy lime	White	Medium	10	2230	One bailer in 3 hours.
Limestone	White	Hard	90	2320	
Limestone	Dark	Hard	10	2330	
Lime	White	Medium	23	2353	Total depth.

*Driller's convention.

It is found from a study of the geological structure of the district that these wells were not located on or near any folds that are likely to prove a suitable location for the accumulation of oil or gas. They were both located on the west limb of the general dip of the strata which rise to the east and southeast. The westward dip continues to about the western boundary of Hancock County. From here to the western edge of the quadrangle the dip is reversed, forming a well marked syncline or trough about where Blackford Creek is located. The eastward dip continues to Yelvington or a little beyond and there reverses again to the west forming a dome or an anticline, the axis of which extends in a slightly northwest-southeast direction. The reversal of the dip from west to east has developed folds or anticlines along which it is quite possible large quantities of oil and gas have accumulated.



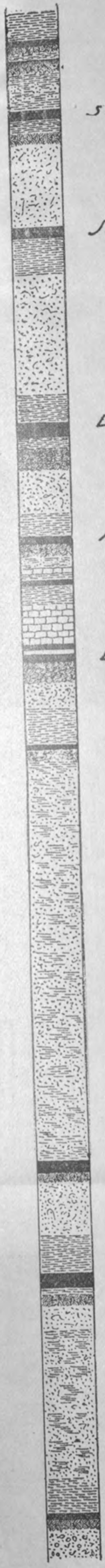
Anticline near Yelvington.

The most favorable location for an oil well in the Tell City quadrangle would be along the western border. A narrow belt of territory two to four miles wide extending southeast from Maceo is worthy of consideration by those desiring to drill for oil and gas.

CHAPTER II—OWENSBORO QUADRANGLE.

INTRODUCTION.

The Owensboro quadrangle lies west of the Tell City quadrangle and east of the Newburg quadrangle. The Ohio River enters the quadrangle on the east three miles north of the center, and runs in a general southerly



Vertical Section.
Scale—1 inch= 40 feet.

direction to Owensboro where it is within two miles of the southern edge of the quadrangle. From Owensboro the river bears in a northwesterly direction and leaves the quadrangle on the west one-half mile south of the center. The Ohio forms the boundary between Kentucky and Indiana. About one-third of the area of the quadrangle lies in Kentucky and two-thirds in Indiana.

About one-half of the area in Kentucky is comprised of first and second bottoms of the Ohio River. In the southeastern corner is a low range of hills which rise on an average of 65 feet above the bottom land. The highest hills in this area rise to an elevation of 100 feet above the bottom or 500 feet above sea level. These hills are largely covered with loess and afford few natural exposures for a study of the underlying strata.

The Ohio River bottom was originally scoured out to a depth of about 120 feet below the present level of the first bottom and subsequently filled to its present elevation.

BON HARBOR HILLS.

In the western part of the quadrangle the monotony of the bottom land is broken by a range of hills known as Bon Harbor Hills. They comprise about six square miles of territory which stands out as a distinct island of coal measure rocks completely surrounded by flood plain deposits of the Ohio River. The highest parts of these hills rise 100 feet or more above the bottom land.

Owensboro, the only town of any consequence in this area, is located on the Ohio River near the southern border of the quadrangle. It is surrounded by a rich argicultural territory, and offers exceptional advantages as a manufacturing center on account of the abundance of cheap coal and excellent transportation facilities.

The Louisville, Henderson & St. Louis Railroad crosses the quadrangle from east to west approximately parallel to the Ohio River. The Louisville & Nashville and the Illinois Central Railroads have branch lines connecting Owensboro with their main lines a few miles to the south.

GEOLOGY.

The older stratified rocks underlying this area are of Coal Measure age and consist of sandstones, shales and coals with thin irregular beds of impure limestone. Very few natural exposures of the Carboniferous rocks are to be found in this area due to the mantle of loess which forms the surface of the hill country for a distance of 15 to 20 miles back from the river.

The few natural exposures that are found in the hills in the southeast corner and in the Bon Harbor Hills west of Owensboro show a westward dip of the strata of 15 to 45 feet to the mile. This dip is not constant across the entire quadrangle, but is interrupted in places by local folds which give a wave-like structure to the stratified rocks. The general effect of the dip is that younger rocks which appear at the surface on the east are carried far below the surface in the Bon Harbor Hills and still later rocks form the surface. Were the strata all horizontal the No. 9 coal, which is now extensively worked in the Bon Harbor Hills, would also appear in the hills in the eastern part of the quadrangle at the same elevation, but the rise of the strata to the east carries this coal beyond the tops of the highest hills east of Owensboro and it is, therefore, useless to try to locate this coal in this quadrangle anywhere east of Owensboro. Fig. 8 shows the effect of the westward dip on the strata.

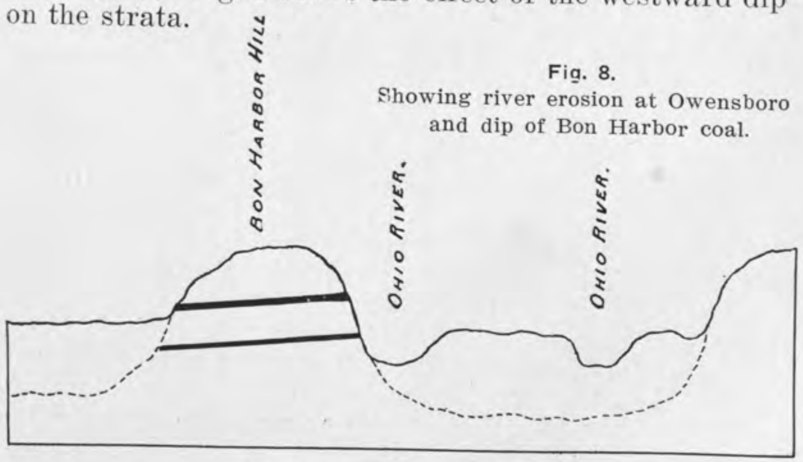


Fig. 8.
Showing river erosion at Owensboro and dip of Bon Harbor coal.

ECONOMIC PRODUCTS.

Coal.

The only mineral of economic importance that is at present being developed in this area is the coal which

underlies the surface of the greater part of Bon Harbor Hills. There are at present nine mines within this area producing coal which is consumed in Owensboro and in the country surrounding. With the exception of the Fern Hill mine, which is reached by the street car line over which the coal is conveyed to the city, the coal is all hauled in wagons from the mines and delivered direct to the consumers.

In addition to the coal the hills east and west of Owensboro contain an inexhaustible supply of Carboniferous shales which could be utilized in the manufacture of face brick, sewer pipe and similar products. At present none of the shales are being operated.

The greater part, if not all of the coal mined in the Bon Harbor Hills, is the No. 9 coal of the Kentucky Survey, and is the equivalent of the No. 5 coal of the Indiana Survey. The geologic structure of the Bon Harbor Hills showing dip and elevations of the principal coal is shown in the cross sections, page 306. The amount and character of the dip from the various points shown on the chart are based on topographic contour, lines and checked by barometric readings.

In the eastern half of Bon Harbor Hills the coal is above drainage and is worked by drift. All of the mines in the western half are worked by shafts ranging in depth from 60 to 140 feet.

The westward dip as shown from the John Rudy mine to the Will Overstreet mine is about 32 feet to the mile. From the old Mice and Schafer opening to the Fern Hill mine the westward dip is 45 feet to the mile. An average dip of the two measurements gives approximately 38 feet to the mile. If this dip was continuous the No. 9 coal would soon dip below the river alluvium west of Bon Harbor Hills and could be struck in deep wells. A number of deep wells in the bottom have failed to locate the coal.

As a matter of fact the No. 9 coal outcrops at low water in Green River. The strong westward dip as observed in Bon Harbor Hills flattens in crossing the wide stretch of bottom land between Bon Harbor Hills and Spottsville or else there is a reverse dip between the two places. From Spottsville to Baskett the dip increases again to 26 feet to the mile; and from Baskett to Henderson it flattens to 7 feet to the mile. However, there may be local folds between these places which would change this dip at various points.

Mice and Schafer Mine.

The most eastward outcrop of coal that has been worked in Bon Harbor Hills is the old Mice and Schafer mine which is located in the most eastward projection of the hills near the Ohio River. The mouth of the mine, which is now worked out and abandoned, is 460 feet above sea level.

John Rudy Mine.

Mr. John Rudy is operating a mine on the same coal as that at the old Mice and Schafer mine. The Rudy mine opening is located at head of the first draw three-fourths of a mile northwest of the Mice and Schafer opening.

This coal is somewhat irregular in thickness. In places a siliceous claystone, known locally as a "horse back," thins the coal to three and even two feet. In a short distance the coal will thicken to a normal thickenss of 4 feet 8 inches. In a few places it thickens to as much as 11 feet where it always has a fire clay parting varying from a knife edge to six inches in thickness. The coal has a treacherous black slate roof, which contains concretions of iron sulphide known locally as "nigger heads," and a fire clay floor.

In driving the main entrance of the mine a black fossiliferous limestone was encountered which rests directly on the coal. Near the center of the deposit it is three feet thick and gradually thins toward the edges and completely disappears within a hundred feet or more to appear again further on. In texture it is a very hard crystalized limestone which is very resistent to the drill and effervesces very freely when treated with hydrochloric acid. It is known by the miners as the "bastard rock."

The coal is drawn out of the mine on an incline by mules and dumped over a tipple into a bin or directly into wagons.

Hoback Mine.

Just west of the hill from the John Rudy mine Mr. Louis Hoback is working the same coal as at the John Rudy mine. The westward dip has carried the coal down near water level. The mine is opened on an incline and the coal drawn from the entrance to the tipple by means of a steam hoist.

The coal here is much more regular than it is at the John Rudy mine. The thickness varies from 4 to 5 feet with an average of 4 feet 6 inches without parting. The quality is a good splint coal with very little sulphur. It was formerly used in Owensboro for making gas. The following is a section made in the mine:

	Feet	Inches
Black slate.		
Dark blue limestone which disintegrates to a plastic clay on exposure to the air. In places it contains macerated shells		8-10
Black "draw slate"		20-24
Solid coal without parting	4	7
Fire clay.		

The main entry of the mine is driven about parallel to a "roll" which extends in a north-south direction. In this roll the shale and thin limestone which comes above the coal in the main entry are cut out by a gray, fine-grained sandstone or gannister which rests directly on the coal. The gannister is very hard, contains mica and broad leaf impressions. The coal was worked out under this "roll" until it had thinned to 2 1-2 feet. The mine is now being worked to the east of the "roll."

Mr. T. A. Mathews, who has worked in this mine for ten years, stated that a 15-inch seam of coal was encountered in the air shaft at a point 15 feet above the main coal.

Fulkerson Mine.

About one-eighth of a mile north of the Hoback mine is another mine operated on the same coal as the John Rudy and the Hoback mine, and is known as the Fulkerson mine. The main entrance is barely high enough above the level of the branch to the west to give drainage. The coal is very regular throughout the mine and averages 4 feet in thickness without parting. It has a black slate roof with two to four inches of "draw slate," and a fire clay floor.

Wilson Mine.

Mrs. Jennie Wilson has a mine on the No. 9 coal in the extreme northern part of the Bon Harbor Hills about one mile west of the Ohio river. The coal is about 30 feet above the track of the Louisville, Henderson and St. Louis railroad or at an elevation of 420 feet above sea level. The coal is hauled to Owensboro in wagons. The following is a section of the mine:

	Feet	Inches
Gray shale	18	
"Draw slate"		16
Coal, without parting	4½-6	
Gray plastic fire clay	13	

There is a slight dip of the coal in this mine to the northwest.

Fern Hill Mine.

The Fern Hill mine is located three miles west of Owensboro at the terminus of the city street car line over which the coal is conveyed to the city. The coal is worked by a shaft which is 60 feet to the bottom of the coal.

The coal in this mine has all the ear marks of the No. 9 coal. The thickness is very regular ranging from 4 feet to 4 feet 6 inches without parting. Above the coal comes a black shale containing numerous kidney-shaped concretions of claystone varying in size from a fraction of an inch to three feet in diameter. Between the black shale and the coal comes a thin band of dark bluish-colored limestone which weathers to a plastic clay on exposure to the air. The limestone contains numerous well preserved fossils. These fossils have been replaced by chalcopyrite and have a brassy-like lustre. They are known by the miners as "periwinkles" and the limestone in which they occur is called "periwinkle rock."

The "periwinkle rock" in some places rests directly on the coal while in a short distance there may be six

inches of "draw slate" between it and the coal. The coal rests on a bed of gray fire clay.

The following is a generalized section of the mine:

	Feet	Inches
Black slate.		
Dark blue limestone ("periwinkle rock")	....	6-12
Draw slate, not everywhere present	....	6-12
Coal	4-4½	
Fire clay.		

The Fern Hill mine has a daily output of 100 tons.

A core hole put down near the shaft of the Fern Hill mine is reported to have penetrated a 3-foot bed of coal 90 feet below the No. 9 coal. It had a sandstone roof and sandstone floor. This is doubtless the same coal as shown at low water in the Ohio river two miles below Owensboro where the river cuts into the foot of Bon Harbor Hills. The coal in the river is just 90 feet below the opening at the John Judy mine, dip not taken into consideration. The following is a section at the river:

	Feet	Inches
Micaceous sandstone	6	
Sandy shale	10	
Black crinoidal limestone	....	2
Black shale	5	
Coal—only top seen—said to be	3	

The strata for a half mile along the river where the above section was made are marked by gentle secondary folds with the axes extending approximately north and south or at right angles to the general dip which is west northwest. The short limp of the secondary folds is on the east and the long limb on the west.

A well on J. Allen Dean's farm near the Fern Hill mine is reported to have passed through a thin coal at a depth of 54 feet below the No. 9 coal.

The following is a record of a well put down near the Fern Hill mine by Mr. D. A. Marshall, of Yelvington, and kindly furnished the writer:

	Feet	Inches
Soil	30	
Yellow sandstone	40	
Shale or soapstone	9	
Slate	2	
Coal		7
Shale or soapstone	67	
Slate	4	
Coal		13
Very hard white sandstone	93	
Shale or soapstone	57	
Slate	3	
Coal	....	18
Very hard white sandstone	122	
Total	431	

Overstreet and Rudy Mine.

About one-half mile west of the Fern Hill mine and just west of the road leading to south, as shown on the accompanying map, is the Overstreet and Rudy mine. The coal is worked by shaft which is 104 feet to bottom of coal. The coal is hoisted to surface by horse power.

The character of the coal, roof and floor of this mine is very similar to that at the Fern Hill mine. The average thickness of the coal is 4 feet 2 inches without parting. It has a black slate roof and fire clay floor. The thin limestone or "periwinkle rock" is persistent throughout the mine, and contains a large number of well preserved fossils. The coal contains a large amount of sulphur which has no regular place in the bed. The larger particles of sulphur are removed from the coal by hand-picking. With a good draft the coal burns up with a very small amount of clinkers.

The general dip of the coal in this mine is to the southwest with secondary folds at right angles to the main dip.

Maglinger Mine.

This mine is located about one-fourth of a mile west of the Overstreet and Rudy mine. The coal is worked by shaft which is 104 feet to the bottom of coal. A steam engine is used for hoisting coal to the surface.

The coal varies from 3 feet 8 inches to 4 feet 4 inches in thickness with a general average of 4 feet. The coal has a fire clay floor with 12 to 14 inches of "draw slate" above. Above the "draw slate" comes the thin band of fossiliferous limestone or "periwinkle rock." The following is a section of the shaft as given by the foreman of the mine:

	Feet	Inches
Soil	1	6
Reddish gray loam	36	
Gravel and sand	8	
Soapstone	3	
Blue "bastard sandstone"	1½-4	
Coal	1	
Fine-grained, micaceous sandstone	21	
Gray shale	60	
Dark colored "periwinkle limestone" which readily disintegrates when exposed to air	1	6
Black slate	1	
Coal	4	
Fire clay.		

The main dip here is to the west with a secondary dip to the north. The secondary dip is due to gentle folds which were observed in all of the mines of this district. The length of the secondary folds is about 200 yards from trough to crest. The increased dip of the coal from the Overstreet and Rudy mine to the Maglinger mine as shown in Figure—— is due to the primary or westward dip accentuated by the secondary dip. The shaft of the former mine was dug on the crest whereas the shaft of the latter mine was dug in the trough of a secondary fold.

The coal is delivered to Owensboro in wagons.

Lee Rudy Mine.

The Lee Rudy mine is located near the extreme southern part of Bon Harbor Hills and one-half mile south of the Overstreet and Rudy mine. The coal is reached by shaft which is 83 feet deep. The elevation of the surface at shaft is 430 feet above sea level.

The following is a section of the mine:

	Feet	Inches
Gray shale	4	
"Periwinkle rock"	....	6-8
Band of sulphide of iron		1
"Draw slate"	....	1-7
Band of sulphide of iron	....	1
Coal without parting	4	2
Fire clay	3	6

At one place in the mine the "periwinkle rock" rests directly on the coal without any "draw slate" between the two. Where the "draw slate" is absent the "periwinkle rock" thickens to two and a half to three times its normal thickness. Just above the coal is a thin band of sulphide of iron which is persistent throughout the mine. Round to oval-shaped concretions of claystones which are found as large as 3 feet in diameter are common in the black shale above the "periwinkle rock."

Throughout the mine is a thin band of "top coal" 4 to 5 1-2 inches in thickness. In places it remains with the roof, but it usually comes with the coal. It has a black, shiny lustre, is very light and has very little heating value.

The mine has a good shale roof which requires little timbering under the main hill.

Secondary folds were observed here as at the other mines. The primary dip is to the west with secondary folds at right angles to the dip.

Patrick Mine.

This mine is located about 250 yards west of the Lee Rudy mine. It is operated by shaft which is 85 feet deep. The coal is lifted by horse and "gin." A gasoline engine is used for pumping out the water.

The thickness of the coal varies from 4 to 4 1-2 feet without parting. Above the main coal and connected with it is the same "top coal" 4 to 6 inches in thickness as observed in the Lee Rudy mine. It rarely comes with the coal, but remains as the roof. The "periwinkle rock" with black shale above is persistent throughout the mine.

Will Overstreet Mine.

Will Overstreet has a mine about one-half mile of the extreme northwest corner of Bon Harbor Hills. The mine is worked by shaft which is 87 feet deep. The elevation of the top of the shaft is 450 feet above sea level.

The same general conditions exist here as was observed in the other mines of Bon Harbor Hills. The coal is somewhat softer than in the other mines and would not make as desirable shipping coal. The output of the mine is sold exclusively to the farmers of the surrounding country who do their own hauling. Mr. Overstreet gave the following strata passed through in digging the shaft:

	Feet	Inches
Red clay	5	
Red clay and sand	6-8	
Red gravel and sand	36-39	
Gray shale	30	
"Periwinkle rock"	2	
Sulphide of iron	....	0-1
"Draw slate"	1	6
Sulphide of iron	....	0-1
"Top coal"	....	4
Coal, without parting	4	8
Fire clay	10	

O'Brien Shaft.

Just across the road to the west of Will Overstreet's mine is an old abandoned shaft known as the O'Brien shaft, which is said to be 120 feet deep. The No. 9 coal is said to have been struck at a depth of 78 feet below the surface. The top of this shaft is 440 feet above sea level or 10 feet lower than the top of the Will Overstreet shaft. Mr. Overstreet gave the following section of the O'Brien shaft below the No. 9 coal.

	Feet	
No. 9 coal.		
Fire clay	10	
Gray micaceous sandstone	35	
Gray crinoidal limestone	....	2
Black "slate"	4	
Coal	3	
Sandstone.		

Oil and Gas.

For a general discussion of oil and gas the reader is referred to pages 298 to 304 of this report. The territory along the eastern border adjacent to Maceo forming the western limit of the dome which is so well marked on the western border of the Tell City quadrangle may be considered as possible oil and gas territory.

GEOLOGY OF THE GEORGETOWN QUADRANGLE.

BY ARTHUR M. MILLER.

The Georgetown Fifteen Minute Quadrangle lies between Longitude 84 degrees 30 minutes and 84 degrees 45 minutes west; and between Latitude 38 degrees and 38 degrees 15 minutes north; and contains an area of 234.87 square miles.

It is included within the counties of Scott, Fayette, Woodford, Franklin and Jessamine; most of it lying within the three first named.

This area is part of a very old land surface, the rocks of which, while all of marine origin, have not been under the sea since the close of Carboniferous Time. During this period of exposure to the air—several million years in extent—it has been subjected to extensive denudation, and the indications are that probably not less than two thousand feet of strata have been removed from over its surface.

In later time the rate of removal of rock waste has not kept pace with the rate of renewal by rock decay, and the bed rock has in general become covered by a thick mantle of residual soil.

During the time that this region has been above the sea it has stood at various heights above it; once at least lying very near to sea level. This latter condition, from evidence obtained mainly outside the limits of the quadrangle, was reached during late Tertiary time. The country in the Mississippi Valley then was very level and featureless, constituting a "peneplain." Since then the portion of this plain lying in Central Kentucky has been elevated to a height of about 1,000 feet above sea level. In its present mature stage of dissection it is known as the "Lexington Peneplain."

That this region is a "rejuvenated peneplain" is evidenced largely by the character of the stream courses.

North and South Elkhorn Creeks, by which the quadrangle is mainly drained, as well as Glenn's, Craig and Clear Creeks, some of whose sources lie within its limits, have very meandering courses even though hemmed in by rocky banks. These trenched meanders give every evidence of the streams having inherited their crookedness from a former base-leveled condition. In many cases the deposits they made upon their flood plains, though not so conspicuous as those made upon its old flood plain by the Tertiary Kentucky River, can still be found along the shoulders of their present valleys. In one instance the upper molar teeth of a tapir were found in these old creek deposits. This was along the banks of Town Branch of South Elkhorn near Yarnallton Station, and is some indication of how great a faunal as well as physiographic change has taken place since that time.

At a very early period in the physiographic history of the region there was developed along a general north and south line a broad low arch known as the "Cincinnati Anticline."

The Georgetown Quadrangle lies on the western flank of this arch, the axis, here with a slight northeast and southwest trend, lying just east of the eastern boundary of the quadrangle.

The general dip of the rocks of this quadrangle therefore is toward the northwest; the average rate is about 10 feet per mile. The drainage is also in this direction, and the fall of the main streams is about at the same rate as the dip of the rock. It follows from this that the highest portion of the quadrangle is in the southeast, where in the region east of the Nicholasville Pike an elevation of 1,050 feet above sea level is reached; and the lowest portion is in the northwest, where as North Elkhorn Creek passes outside of the area it cuts a little below the 700 foot contour. This gives 300 feet as the vertical range of the whole quadrangle.

On account of the prevalence of limestone throughout most of the region there is considerable underground drainage—especially in that portion of Woodford County lying between Versailles and Midway.

Sinks are numerous, caves fairly common and there are many copious springs such as are usual in limestone districts. Settlement of the region in early days was largely controlled by the location of these springs. Lexington, Georgetown and Versailles, the largest towns partly or entirely within the quadrangle, each owes its

first settlement nucleus to the attractive power of a "big spring."

Largest of all of these is the Big Spring at Georgetown. All of these big springs mark the exits of underground streams, into which the surface water finds its way largely through the upland sinks.

In the pioneer days when the country was well wooded and settlement sparse the water gushed forth from these underground channels cool and wholesome; unfortunately now the water in these channels is liable to every sort of surface contamination, and numerous epidemics of typhoid have been traced to the use of this unfiltered water.

From the days of earliest settlement also these big springs were selected as sites for distilleries, the water of which was used in the manufacture of "Bourbon Whiskey." Certain mineral components in the waters of these springs of the Blue Grass region reacting upon the products of fermented corn when heated together produced those ethers which gave to whiskey called "Bourbon" its characteristic aroma and flavor. Even individual differences in the waters of different springs found expression in differences in the whiskies made from them. In this way the product of distilleries along certain streams became celebrated—as for instance the whiskey made on Glenn's Creek, the head waters of which are at Versailles.

THE GEOLOGICAL FORMATIONS OF THE QUADRANGLE.

All the rocks represented in the areal geology of this region belong to the middle portion of the Ordovician Period. They total about 330 feet in thickness.

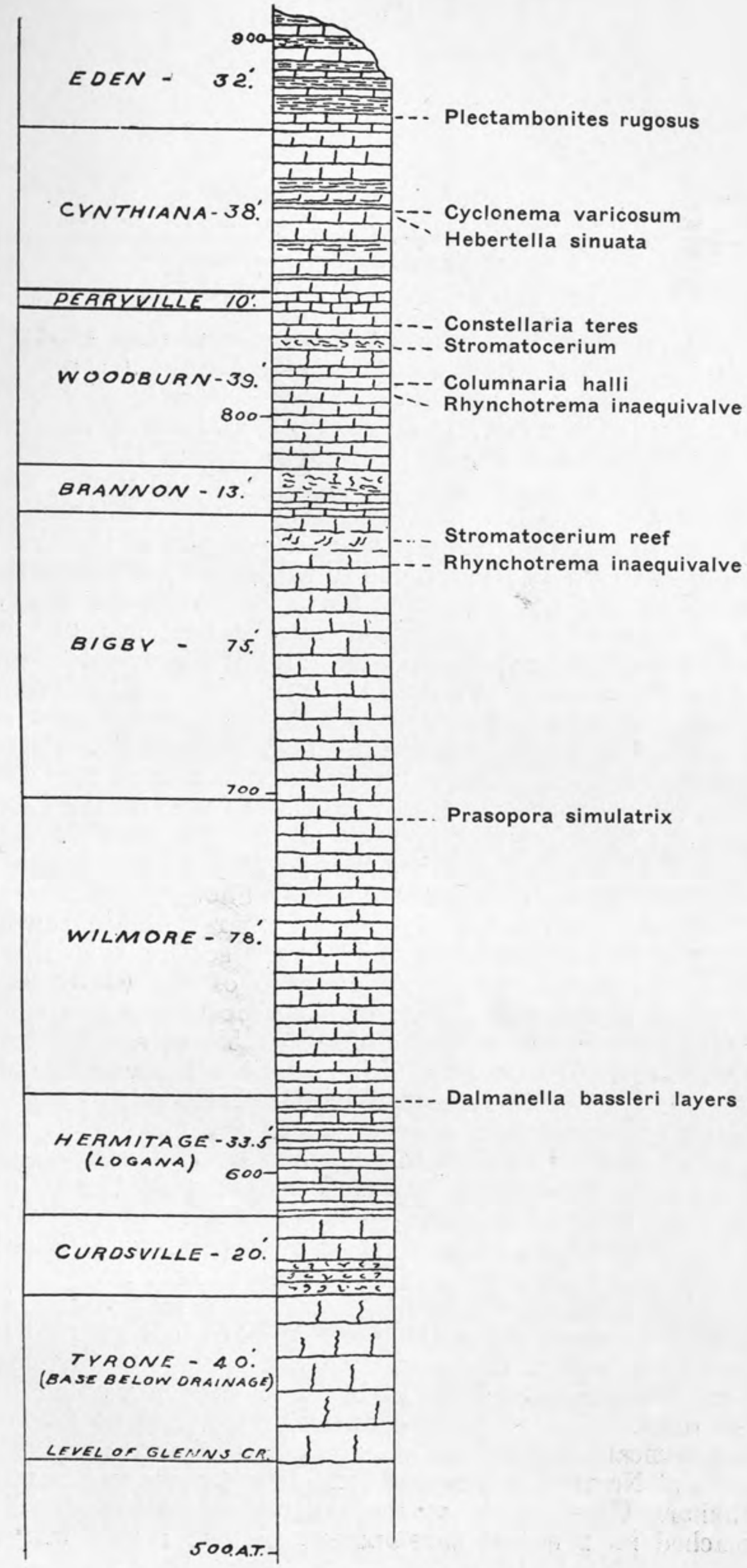
The classification of the Ordovician constituting the surface rocks of the "Inner" Bluegrass region of Kentucky is set forth in the accompanying table. It comprises the series included between the lowest rock exposed at the Kentucky River's edge at Camp Nelson and the top of the highest formation represented in the areal geology of the Georgetown Quadrangle.

Only that portion of the series above the middle of the Wilmore is actually represented in the areal geology of the Georgetown quadrangle.

TABLE OF GEOLOGICAL FORMATIONS FOR THE INNER BLUE GRASS REGIONS OF KENTUCKY

Ordovician	Cincinnatian	Maysville	Paint Lick		70
		Eden	Million		120
		Cynthiana			45
	Mohawkian	Lexington (Trenton)	Perryville	Cornishville	7
				Salvisa	10
				Faulconer	8
			Flanagan	Woodburn	40
				Brannon	15
			Bigby		75
			Wilmore		80
			Hermitage (Logana)		35
			Curdsville		20
		High Bridge (Stone's River)	Tyrone		90
			Oregon		25
			Camp Nelson		285
				Total	925

Nowhere within the limits of the quadrangle is any considerable portion of the foregoing formations exposed in a continuous steep section, but a type section of the whole series from near the top of the Tyrone to a short distance up in the Eden is given at the Old Crow Distillery near the mouth of Glenn's Creek. This locality is not farther than 5 or 6 miles in an air line from the western boundary of the quadrangle and its section, therefore, serves well to illustrate the stratigraphic geology of the area under discussion.



Geological section exposed at the Old Crow Distillery from level of Glenn's Creek to top of hill on North Side of the creek, taken along steep road intersecting the pike at the distillery.

WILMORE AND BIGBY.

Combined thickness of these formations exposed within the quadrangle about 90 feet: Areal outcrop 80.38 square miles.

There is no distinct stratigraphic boundary between the Wilmore and Bigby, both consisting of thin bedded limestones with but little shale between the layers, and hence for mapping purposes they are considered together in this report. Of the above thickness the lower 15 to 25 feet may be assigned to the upper portion of the Wilmore and the remaining 65 to 75 feet to the Bigby. The former is characterized by the presence of the brachiopod Dalmanella bassleri and the chocolate drop shaped bryozoan Prasopora simulatrix. The latter (Bigby Formation) which includes the lower part of what was comprised under the term "Paris," contains more abundantly than any other division what may be designated as the most characteristic fossil of the Lexington Limestone and possibly of the Trenton Formation. This fossil is the brachiopod Rhynchotrema inaequivalve. Hebertella frankfortensis, another brachiopod is also abundant in the Bigby and Upper Wilmore, reaching its culmination lower down in the section than Rhynchotrema inaequivalve. At the top of the Bigby and confined to a vertical range of not over 10 feet is a very characteristic assemblage of fossils. These are the two brachiopods Dinorthis ulrichi and Strophomena vicina, described from this horizon by Prof. Foerste; Cyphotrypa frankfortensis, a bryozoan of globular habit, described and referred to this horizon by E. O. Ulrich; a large corraline fossil, Stromatocerium pustulosum, of probable hydroid affinities, besides other bryozoa, among which may be enumerated Eridotrypa briareus (Ulrich) Eridotrypa? nov. sp., and Peronopora, nov. sp.

The coralline fossil, Stromatocerium pustulosum, is usually so abundant at this horizon as to indicate that it formed a reef in this region in the ancient Ordovician Sea. This is especially so in the northern portion of the quadrangle, where the ancient reef may be traced in practically continuous outcrop across the area on both sides of North Elkhorn and Cane Run Creeks and South Elkhorn Creek north of the latitude of Midway. It reached its greatest development in that region which

is now central about Hillenmeyer (Sandersville). Here very large masses of this fossil of regular conical shape, some of them weighing several hundred pounds, have been built into the rock fences. They are composed of concentric papillose or pustulose layers arranged symmetrically about a center, which is also the center of the base. It is supposed that these layers were secreted by the common membranous base of successive generations of hydroid colonies, which arose in branching stocks from the summits of the pustules with which the calcareous layers are studded.

These coralline masses have undergone secondary calcitic replacement and impregnation so as to give their interiors a crystalline appearance, and doubtless when sawed and polished these interiors would resemble Mexican Onyx.

In this northern portion of the quadrangle the reef is sometimes 6 feet in thickness. The top of it is generally about two feet below the base of the next overlying formation, but sometimes the tops of the cones of stromatocerium are imbedded in its clayey looking layers.

On the map the line of outcrop of the stromatocerium will practically coincide with the base of the Brannon and mark the outline of the areas beyond which commercial deposits of phosphate are not likely to be found.

FLANAGAN.

Thickness 55 feet areal outcrop 120.95 square miles.

This term was applied by Marius Campbell, in his report on the Richmond Quadrangle for the Federal Survey to the rocks occupying the interval between his "Lexington" and "Winchester" Limestones, intending these latter terms to be about synonymous with Linney's Trenton and Hudson Formations in his reports on counties of the Bluegrass Region for the Shaler and Procter Kentucky State Surveys.

Campbell's full designation for the formation was "Flanagan Chert," and the thickness he assigned to it was 40 feet. As a matter of fact it is only the first or lower 13 to 15 feet of this interval that is filled with a siliceous limestone which on weathering forms chert.

It was this weathered phase of the lower part of his Flanagan by which Campbell followed the out crop of the formation in his mapping, and he generally failed to recognize its presence where it had not been brought to the surface by the slow process of atmospheric decay. He states for instance in one place that the formation does not occur south of the Kentucky River; whereas it does occur there, but on account of being on the down-throw side of the Kentucky River Fault, it is exposed there only near the bottom of deep stream channels under a heavy burden of protecting rock where the chert has had no opportunity to develop as the result of weathering. The geologist who was depending on this phase of the formation to follow the outcrop would never recognize its presence there.

We propose for this siliceous bed (it really is only siliceous though its appearance suggests an argillaceous limestone) the name "Brannon" from Brannon Station on the Q. & C. R. R., a little south of the southern boundary of the quadrangle. The first two cuts south of the station expose this formation, the first one the upper, or "bouldery" phase, the second one about a mile from the station, both this upper portion and also the lower even beded layers which are more argillaceous looking. The top of the Bigby, with its characteristic fauna, is also exposed in this second cut.

It is the upper portion of the Brannon with its highly contorted or bouldery layers that is so characteristic, and it is this portion which furnishes most of the chert to its weathered out crop.

When freshly exposed the Brannon is very firm and hard, and requires blasting to remove it. It furnishes a good water bearer, and consequently its outcrop is generally marked by presence of springs. The Big Spring at Versailles is at this horizon, as also what were known as the Maxwell, or "sinking springs" at Lexington.

The Big Spring at Spring Station is also near this horizon. It is also pre-eminently the formation occurring in the numerous sinks found in this quadrangle. This latter association may be due to its tendency to resist destruction for a time, especially by solution and coming to form therefore the roofs of caverns. Later, on being brought near to the surface by denudation it goes

to pieces rapidly being decomposed into chert, the roof of the cavern falls in and a sink results.

There are instances of where this dropping in of the roof of a cavernous space has taken place suddenly, in one case known to the author entrapping grazing stock.

As might be inferred from the way this formation behaves under the influence of weathering natural exposures of the firm layers are rare. The best exposures are in railroad cuts and other artificial excavations and in sinks of probably rather recent development.

As localities where the formation may be seen out-cropping in a fairly good state of preservation may be mentioned the following:

1. Q. and C. R. R. cut at Lottie Street overhead bridge, Lexington, also at and below track level in the yards at the Lexington Station.

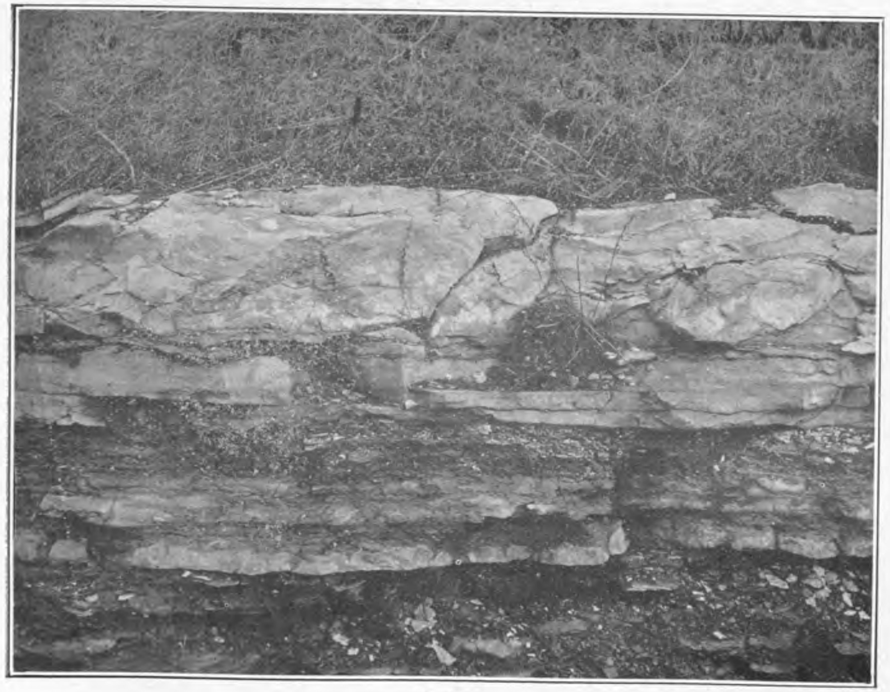


Plate. I.

Upper Brannon, showing contorted layer.
Q. & C. R. R. cut at Lottie St. Bridge, Lexington, Ky.

2. Louisville Southern R. R. cuts near the Cahill Place, about one and one-half miles from the Lexington Station. The rims of the sinks here also show it.

3. Q. & C. R. R., first cut south of Greendale Station. The exposure here is at the bottom of the cut.

4. At the level of the Big Spring, head of Glenn's Creek Ravine, Versailles.

5. In a sink on the south side of the pike and north side of the Louisville Southern R. R., about half-way between Pisgah and Versailles.

6. In sinks, mainly on the south side of the road, on the Parker's Mill Pike about half way between the intersection with the Versailles-Lexington Pike and the first fork of the pike.

7. In a sink on the Midway and Spring Station pike, about one mile from Spring Station.

8. At top of the quarry at the entrance to the Pythian Home on the Lexington and Harrodsburg Pike near the intersection with the Clay's Mill Pike; also above the bed of the 940 contour in the bed of the stream, head of Wolf Run, which runs by this quarry. Here the stromatocerium horizon shows below.

9. About two miles further on, near where the Clay's Mill pike intersects with the Stone road, in the bed of a small stream crossing the pike: Stromatocerium occurs at the base of this bed at elevation of 942 feet above sea level.

The Brannon is a fossil sponge horizon. Several species occur here; the most common probably is Strobilospongia aurita.

In Franklin County, at only two known localities, this bed has yielded the rare fossil Brachiospongia digitata.

The Brannon in most instances forms the base of the richest phosphate deposits of the region. It appears on account of its relatively impervious nature to have supplied a condition necessary for the reconversion of downward moving, soluble phosphate into insoluble phosphate. The soluble phosphate has even penetrated the material of the bed itself, giving rise in its weathered condition to phosphatic chert.

For the remainder of the Flanagan above the Brannon we propose the name "Woodburn," from the name of the celebrated Alexander estate, in Woodford County. where it may be said to be very typically developed, especially as regards its most distinctive feature, the possession of phosphate. The Woodburn consists of about 30 to 40 feet of thin bedded, granular, phosphatic limestone. Its most conspicuous fossil is the coral, Columnaria halli. It is commonly found in a silicified condition weathered out from its matrix and found loose in the deep dark red soil formed from the decay of the limestones at this horizon. Another very common fossil in this formation is the very small gastropod, Cyclora minuta. This fossil occurs only as phosphatic casts of the inside of the shell, and its presence in association with the more phosphatic phases of the rock suggests strongly that the animal which formerly inhabited the shell played an important part in the original segregation of the phosphate of lime from the sea water. This original segregation of the phosphate has in no case however given deposits rich enough to be commercially valuable. The latter deposits have resulted from the weathering of the deposits of the first concentration. Though concentrated as the result of weathering, we do not believe that the facts of occurrence warrant the explanation that in weathering the "carbonate of lime has been dissolved out leaving the phosphate of lime behind" —that in other words it is simply a residual product due to the leaching out of a more soluble constituent.

Were the latter the case it should be possible to find many instances of deposits of unleached phosphate where the amount of phosphate in the same volume of deposit equals that we do now find in the weathered commercial deposits. The same amount of phosphate should be there plus the original amount of carbonate of lime; but in no instance is this the case. On the contrary, all the facts point to an actual concentration of the phosphate into less volume as the result of a process of replacement. We have here the same phenomenon as is illustrated by certain iron ore deposits. Water with iron in solution is checked in its downward descent by meeting relatively impervious stratum. Under these conditions the saturated stratum (commonly a limestone) immediately above the relatively impervious stratum is altered by replacement; iron replaces calcium, the latter being finally carried away in the form of bicarbonate by the water.

So in the case of concentrated phosphate of lime deposits: insoluble tricalcium phosphate acted upon by organic acids in the superficial layers of rock waste has its phosphorus rendered soluble ("available"). Entering into solution in the form of phosphoric acid, it passes downward to the lower "rottenstone" and bed rock layers. Here the phosphorus "reverts" to its original tricalcium phosphate condition, replacing the nonphosphatic or relatively nonphosphatic limestone.

The final theoretical reaction is expressed by the following equation:

$$Ca.\ H_4\ (PO_4)_2 + 2\ Ca.\ CO_3 = (PO_4)_2 + 2H_2O + 2\ CO_2.$$

The Woodburn also abounds in sinks.

PERRYVILLE.

Thickness 10 feet, areal outcrop 3.86 square miles.

The term "Perryville," derived from the village of this name in Boyle County, Kentucky, proposed in a former report by the author, to include those divisions of the Upper Lexington (Trenton), which were originally referred to by Linney under terms descriptive of their lithological characters.

It comprises in ascending order the Faulconer, Salvisa and Cornishville. The lowermost division is a gastropod horizon. In western Woodford and adjacent portions of Franklin County the shells of these gastropods, mainly Bellerophon troosti, Lophospira medialis and Oxydiscus subacutus, are massed together into a ledge of limestone 5 or 6 feet in thickness. This bed is locally quarried for use as steps to doorways and as gate posts for front entrances to country seats. Prof. Foerste has given to this bed the name Faulconer from a station on the Q. & C. R. R. in Boyle County.

The Faulconer in its massive condition is found at its proper horizon in the western and southwestern portions of the Quadrangle south of South Elkhorn. In this region it borders two separated areas of the Cynthiana, the formation next above the Perryville. The northernmost of these areas lies west of the Versailles-Midway pike and south of the old Frankfort pike. It is crossed

by a connecting pike called the "Shipp pike." In this area the Faulconer is immediately overlaid by the Salvisa member of the Perryville.

The southernmost area lies south and southeast of Versailles, extending into the corporate limits of the town. The Faulconer is here not separated from the Cynthiana by any overlying Salvisa.

The former presence of this formation over all that portion of the Quadrangle lying west of South Elkhorn Creek can plainly be traced by the existence of outliers of it and a "gastropod chert" waste in the soil. Even outside of this area as far as the eastern and northern portions of the Quadrangle, traces of the former extent of the Faulconer horizon can be obtained from the presence of this "gastropod chert." It is not massive enough in these portions, however, to make a distinctive border to the Cynthiana areas as it does in the western portion.

SALVISA.

The next member of the Perryville, as has been indicated above, is the Salvisa. This formation takes its name (here proposed for the first time) from Salvisa in northern Mercer County. Linney, following the prevailing custom of his day, gave to this formation a term descriptive of its lithological peculiarities, referring to it as a "dove colored" limestone which possessed "birdseye" characteristics. To distinguish it from it a lower formation with similar characteristics, which we now call the Tyrone Formation, he designated this upper formation the "Upper Birdseye." The formation is dove colored to white where typically developed in Mercer and Boyle Counties. Northward it does not always possess these characteristics. It is fine grained and usually exhibits a conchoidal fracture.

Fresh surfaces show scattered facets of calcite giving it an appearance of which the term "birdseye" is suppose to be descriptive. In his report on Mercer County, Linney included in his "Upper Birdseye" the overlying Cornishville and underlying Faulconer as well, but in his report on Garrard County he did not include them.

In the region about Perryville this formation has a maximum thickness of about 15 feet. In passing north and east from that locality it thins steadily, so that where it enters the Quadrangle in the region referred to above, it has diminished to only five feet in thickness. In all other points in the Quadrangle it is wanting at the horizon where due.

The most characteristic fossils of the Salvisa are the ostracods, Isochilina jonesi and Leperditia caecigena and also the brachiopod Orthorhyncula linneyi.

THE CORNISHVILLE BED.

This, the top member of the Perryville, named by Prof. Foerste from a village in Mercer County, and previously recognized by Linney as a "few thin beds of concretionary limestone" above his "Upper Birdseye," is entirely wanting within the Georgetown Quadrangle.

CYNTHIANA.

Thickness 45 feet, areal outcrop 21.62 square miles. This formation in whole or in part has received many designations in Kentucky Geology since Linney first described it under the name "Lower Hudson."

Campbell, in his report on the Richmond Quadrangle, called it "Winchester," including under this term some of the Eden. He never defined accurately its upper limits.

The author of this present report has in previous publications referred to it sometimes as Winchester, sometimes as Catheys, identifying it with the latter from Ulrich's report on the Columbia Quadrangle of Tennessee. Foerste has at times used the term Catheys in about the same sense as the above. It is now definitely decided as the result of Ulrich's own investigations in both fields that the Catheys of Tennessee as originally defined reaches down in the Kentucky scales to the base of the Flanagan and includes from there to the base of the Eden.

The term Catheys, therefore, except for correlation purposes is dropped from Kentucky Geological Classification.

We have at times used the term Greendale as synonymous with lower Winchester. We now, however, adopt Foerste's term, Cynthiana, as a more inclusive term.

Ulrich has always insisted that the whole of the Catheys belongs to the Mohawkian. It has always appeared to the Kentucky Geologists however, beginning with Linney, that what we now know as Upper Catheys, or Cynthiana, is rather Cincinnatian in its affinities.

The Cynthiaia, named from the county seat of Harrison County, Ky., consists of very fossiliferous limestone, impure from the presence of clay and interbedded with clay or shale. The limestone has generally a peculiar "rubbly" appearance on weathering and assumes a yellowish red appearance. The soil formed from it is more yellowish than that made from the underlying Flanagan, but not so yellow as from the overlying Eden. Like the Eden, under the influence of freezing and thawing, this formation tends to "slough" where it appears in embankments and cuts, and gives much trouble to the section bosses along stretches of railroad cutting through this formation.

The most characteristic fossil of the formation here, as in the upper portion of the Catheys of Tennessee, is the gastropod Cyclonema varicosum.

A classified list of the fossils of the Cynthiana in Central Kentucky is here appended:

Coelenterata—

Anthozoa—
- Columnaria alveolata (Gold.) (C. stellata of some authors.)

Hydrozoa—
- Stromatocerium sp.?

Molluscoidea—

Bryozoa—
- Eridotrypa briareus, (Ul.)
- Eridotrypa mutabilis, (Ul.)
- Constellaria fischeri, (Ul.)
- Constellaria emaciata, (Ul.)
- Escharopora maculata, (Ul.)
- Peronopora milleri, (Nichols.)
- Heterotrypa parvuliopra, (Ul. and Bass.)
- Petigopora sp.?
- Proboscinia sp.?

Brachiopoda—
Hebertella sinuata (Hall), or a closely allied form.
Rafinesquina alternata, (Emmons), or a closely allied form.
Zygospira modesta, (Hal.)
Platystrophia colbyensis, (Ul.), or a closely allied form.

Mollusca—
Lamellibranchiata.
Allonychia flanaganensis.
Byssonchia sp.?
Orthodesma sp.?

Gastropoda—
Cyclonema varicousum, (Hall.)

Cephalopoda—
Orthoceras sp.?

Arthropoda—
Trilobita.
Calymmene sp.?
Isotelus sp.?

The Cynthiana is the surface formation in a number of distinct localities in the quadrangle. Named in the order of their size the more important are located as follows:

The first and largest is in the northwestern portion, adjoining the Eden area on the south and southeast.

The second is in the region south and southeast of Versailles, where it is bordered by the Faulconer bed.

The third is in the Greendale neighborhood. The formation at the latter locality lies at a lower elevation than would be given it by the normal dip in this direction from north to south. It appears to lie in a synclinal trough, a continuation of the faulted strip to the southeast which in the northwestern portion of the quadrangle is occupied by the Eden.

The fourth is in the middle of the western portion of the quadrangle, where it is bordered by the Perryville, which here exhibits its two lower members, the Faulconer and Salvisa.

The fifth is on the watershed between Cane Run and North Elkhorn Creek in the region of Donerail. It here

occurs in separate patches, the presence in most of which is not evidenced by outcrop. It is outlined on the map from contours.

The sixth is in the extreme southeastern portion, where it occupies the highest land in the quadrangle.

The seventh is in the region north of Georgetown, where is consists of tongues and separate patches of a more continuous area outside of the limits of the map in this direction.

EDEN.

Thickness (including about 10 feet of Garrard Sandstone) 130 feet. Areal outcrop 8.1 square miles.

The name "Eden" was first applied by Prof. Orton, of Ohio, in 1873 to that portion of the Cincinnatian at Cincinnati which began at about 50 to 75 feet above low water in the Ohio River and extended to about 300 or

Plate II.

Eden Shale at Oldham's Mill, North Elkhorn Creek.

325 feet above. The series was well exposed in the Eden Park Hill. On account of the predominance of shale in the formation, Orton generally referred to it as the "Eden Shale."

The formation consists in Central Kentucky of alternating layers of shales and thin limestones, becoming sandy towards the top (Garrard Sandstone). The predominance of shale in the series causes it to erode readily and Eden Shale topography is one characterized therefore by narrow ridges and steep slopes.

Cultivation of the slopes still further facilitates the tendency to wash. Deprived of its protective covering of grass or forest, rain washes the soil off the slopes and freezing and thawing during the winter months works the slabs of thin limestone out upon the surface. Many hillsides in this region, therefore, present a very unpromising agricultural prospect.

The base of the formation begins with wavemarked layers of finely crinoidal limestone, consisting of the stem plates of the crinoid Ectenocrinus simplex. These basal layers commonly exhibit frond like patches of lighter color and different texture from the remainder of rock, which, though they show no trace of organic texture, are probably of organic origin. Afew feet from the base, traces of the brachiopod, which has been identified as Plectambonites rugosa (Meek) incorrectly identified heretofore as P. sericeus by some authors, begins to make its appearance, and soon comes to cover completely the surfaces of the layers.

Other Brachiopods which are characteristic of the Eden, but not abundant, are Clitambonites diversus (Shaler) and Plectorthis rogerensis (Foerste).

The Eden is rich in Bryozoa. The most characteristic of these is probably Dekayella ulrichi (Nich).

Others that may be listed are:

Amplexopora petasiformis, (Nich.)
Calopora nodulosa, (Nich.)
Calopora sigillaroides, (Nich.)
Calopora communis, (James.)
Batostomum implicatum, (Nich.)
Escharopora falciformis, (Nich.)
Peronopora vera, (Ulrich.)

Of the Trilobites abundant traces of Trinucleus concentricus (Eaton) can usually be found in the basal layers, and occasional specimens of Calymmene senaria (Conrad) occur throughout the series.

The Eden in this quadrangle is confined in surface outcrop to the northwestern portion, where faulting accounts for its presence. It is there mostly included between two parallel faults—a primary and secondary, having the general trend of North forty-five degrees West. The more northerly of the two faults is the primary. It is quite evident that the Eden was once continuous over the whole of the Cynthiana, and the Cynthiana over the whole of the Lexington, of this Central Blue Grass Region. These formations have been removed from this area by atmospheric and stream denudation except where portions have been protected by being let down to lower levels through synclinal folding or through faulting.

On account of the effect on topography of the Eden Shale it does not require a geological map of the region to locate in fairly precise manner the boundaries of its outcrop. A good twenty foot contour map, such as the base used for the accompanying geological map, serves to indicate the presence of Eden Shale by a closer crowding together of the contours.

The tenaceous yellow clay soil of the Eden, inferior in quality to the less tenaceous yellowish red of the Cynthiana or the mellow deep red of the Woodford, with which soils it is brought into juxtaposition by sharp folding or by faulting, exhibited a contrast so marked that it did fail to attract the attention of the early settlers of this region. Nor in the absence of geological knowledge did the difference fail to draw from them a naive explanation.

To a faulted Eden strip just outside of the limits of this quadrangle to the east, the one in which the Lexington Reservoir lies, they gave the name of the "Old Buffalo Trail," explaining in this way to their satisfaction the greater poverty of soil along a comparatively narrow north and south strip.

In the light of what we know of early attempts to explain the Lexington-reservoir-poor-strip of land, it seems significant that such names as "Great Crossing" and "Stamping Ground" should apply to localities so close to this Eden Shale strip in the northwestern portion of the Georgetown Quadrangle. May it not be here as in the former case we have a tradition based on an erroneous inference, rather than that the buffalo were ever really observed to "cross" North Elkhorn Creek, near where the village of Great Crossing is now situated, or that they ever were known to have "stamped" near the present village of Stamping Ground?

A small patch of Paint Lick (Garrard) Sandstone, not large enough to map, occurs within this Eden area on top of the bluff overlooking North Elkhorn at Oldham's Mill, where the Woodlake-Stamping Ground pike crosses the creek.

STRUCTURAL GEOLOGY.

We have already referred to the prevailing dip of the rocks at the rate of about ten feet to the mile to the northwest, and to the indication that the axis of the Cincinnati Anticline passes a little to the east of the quadrangle. The general uniformity of gentle dip to the northwest has been interfered with in places by disturbances which have resulted for the most part in faults. Most of these are of very limited extent in the surface outcrop of the fault plane and of slight vertical throw. Regardless of their extent, however, they are all, so far as they have been located, double: that is, they consist of two parallel faults, one of which may be considered the "primary" and the other the "secondary" fault. Or the second might be termed a "compensatory" fault.

They are all "tension" and hence "normal" faults. They all exhibit a relatively wide "drag zone" and for this reason the "stratigraphic" throw is great as compared with the "vertical."

The two faults which include the Eden strip, already described, and which bear the relations primary and secondary as defined are the "North Elkhorn" and the "Switzer." They exhibit their greatest amounts of displacement in Franklin County outside the limits of the Georgetown Quardangle. Within the quadrangle the maximum stratigraphic throw for the primary, or North Elkhorn Fault, is in the neighborhood of Oldham's Mill,

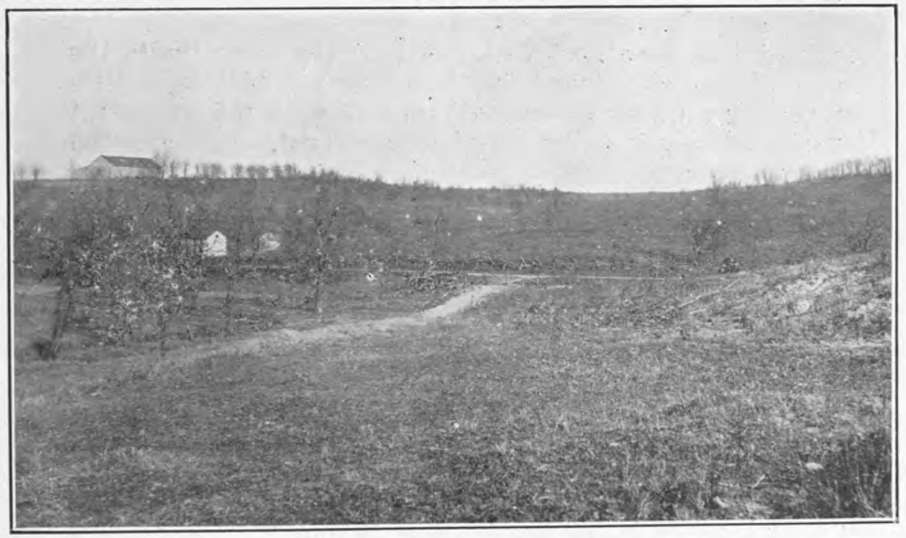


Plate III.

Eden Shale Topography.
North Elkhorn Fault Strip.

Plate IV.

Eden Shale Topography.
Lcoking north at Oldham's Mill.

where it is about 200 feet. Within the same limits the secondary or Switzer Fault has died out until it is little more than a sharp "buckle" bounding on the southwest rocks steeply dipping to the northeast. It loses the break character before it reaches the Georgetown and Frankfort pike in the neighborhood of White Sulphur, though it continues on as the crest of a fold, perhaps as far as the Greendale neighborhood, as perhaps does also the North Elkhorn Fault after it crosses the same aforementioned pike.

The smaller faults which have been located are as follows: One in Georgetown crossing the Q. & C. railroad in the first cut north of the station. This the primary fault has its hade, which is nearly vertical, beautifully shown in this cut, and the drag zone on the downthrow side to the southwest is pronounced. The strike of the fault is N. 53 degrees W. It displaces Woodford on the Stromatocerium horizon of Bigby at the fault line, and brings Cynthiana down on a level with the Stromatocerium horizon of Bigby at the south end of the drag zone at that end of the cut.

Two secondary or compensatory faults, each with a throw of five feet, are to be seen in a quarry situated between the railroad and North Elkhorn Creek to the east.

Another fault crosses the Mt. Vernon pike about a mile and a half south of its junction with the old Frankfort pike. The trend is northwest and southeast with the downthrow side on the southwest. It displaces Cynthiana on Woodford.

A line or belt of disturbance crosses the Parker's Mill pike, where it crosses South Elkhorn Creek. Signs of disturbance continue for a quarter of a mile to the southwest. The trend of the dipping rocks (the strike) is here northwest and southeast.

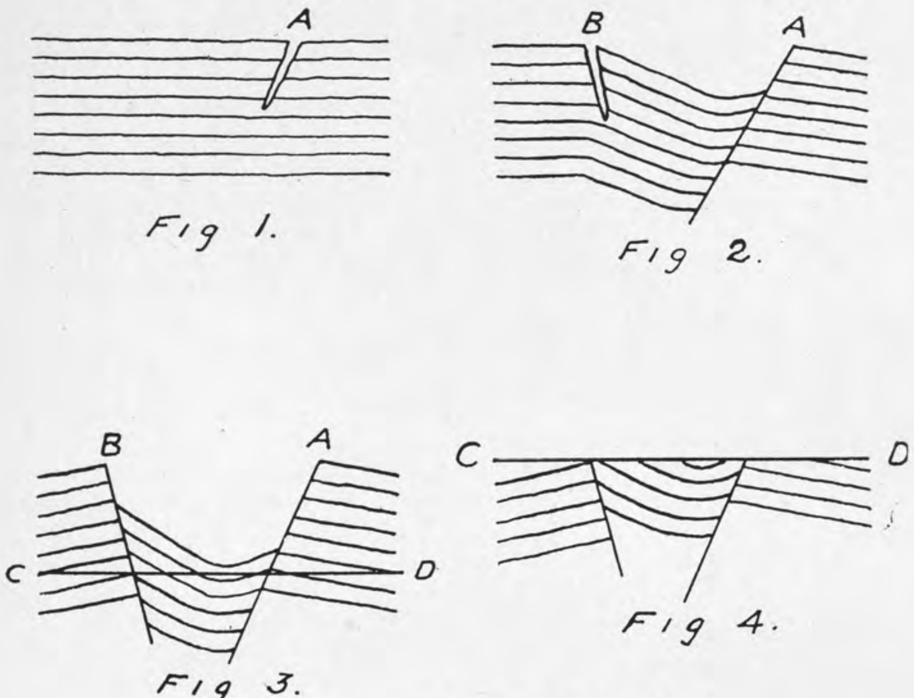
The explanation of how the slipping of strata in a primary fault tends to produce a secondary fault the hade of which slopes toward the primary is set forth in the first three of the accompanying four diagrams.

Fig. 1 shows strata in which tension is beginning to produce a crack at A.

Fig. 2 shows the same after further tension, aided by gravity, has produced a fault at A. (Primary Fault.) A crack produced by tension is beginning to form at B.

Fig. 3 shows the same with the crack widening at B until gravity has caused a slipping along it also, producing a secondary fault hading toward the primary.

Fig. 4 shows appearance after erosion has truncated the surface down to line C. D of Fig. 3.



Illustrating production of a Secondary Fault.

MINERAL VEINS.

There are a number of Barite Veins occurring within the Quadrangle.

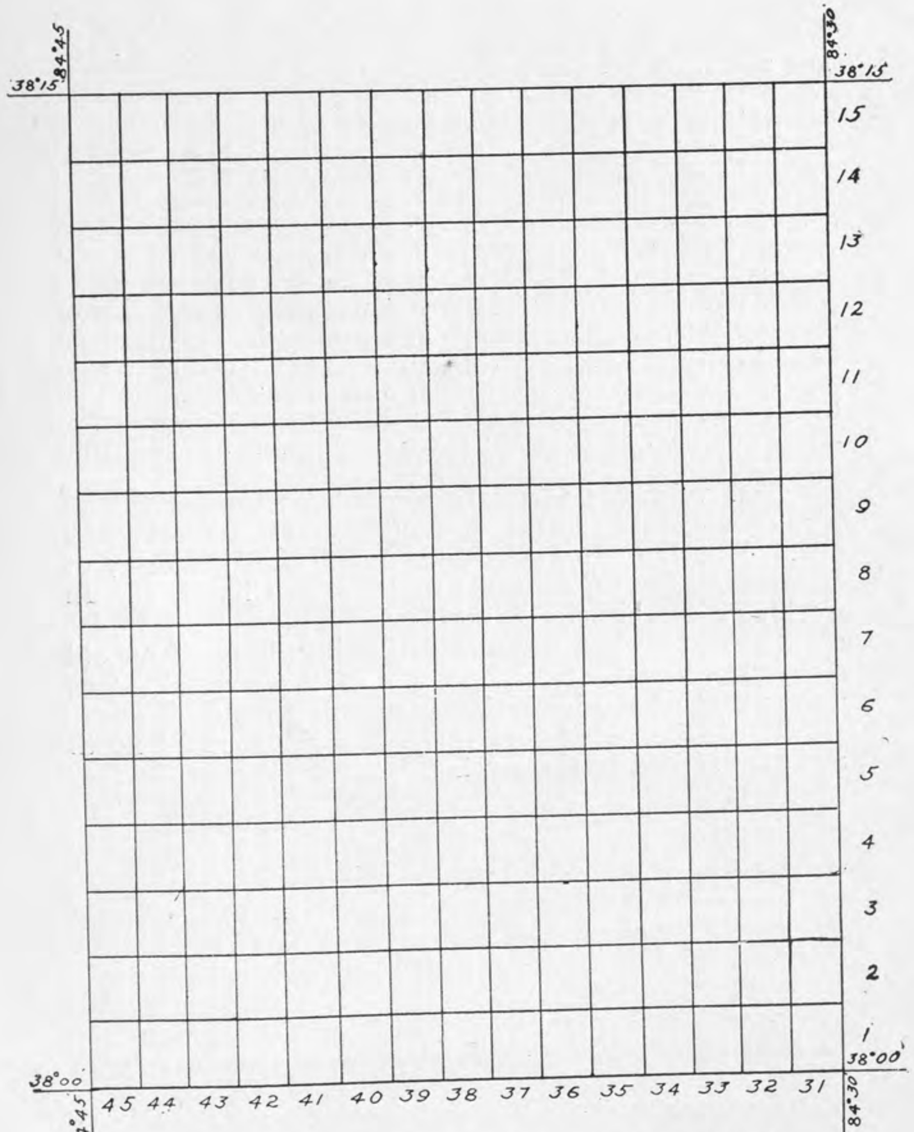
Twelve of these have been located and their strikes plotted on accompanying map.

All of these traverse Lexington Limestone and appear to be fillings of tension cracks in the limestone which had been widened by solvent action of water. These veins may sometimes penetrate the overlying Cynthiana though never the Eden—probably because the latter is too shaly to permit of the formation of fissures in it. The barite in these veins carries some sphalerite (sulphide of zinc) and galenite (sulphide of lead). The former is generally more abundant in the upper part of the veins. It has been found also that in passing downward below the bottom of the Lexington Limestone the barite gives way to calcite as the vein filler.

The evidence then points to the Lexington Limestone as the source of the barite in a disseminated condition. This was gathered by circulating underground waters and carried by them in solution ultimately to the fissures, where the material was deposited by chemical precipitation. The veins are not wide, being seldom over 18 inches thick, but by reason of the multiplicity of uses which has been found for barite in recent years and consequently a greatly increased demand for it, it is probable that the supply offered by these veins will all be drawn upon before many years.

The most convenient and accurate way of referring to the locations of these veins on the map is by a system of co-ordinates, made by drawing the lines marking the minutes of latitude and longitude on the map. The columns thus constituted are each designated by a number which is the same as that of the line of longitude bounding it on the west in case of those extending vertically, and the same as that of the line of latitude bounding it on the north in the case of those extending horizontally.

None of these veins are being worked at the present writing, but on one just to the east of this sheet in Fayette County work is being actively pushed. The vein in question is located about one-half mile from the Russell Cave pike at the crossing of North Elkhorn and is on the Louis Haggin land. The work is being done by the Evans Chemical Co., of Nicholasville, Ky., of which company Mr. W. J. Weinman is superintendent. The strike of this vein is nearly north and south and a shaft has been sunk to a depth of 355 feet. There is an adit at a depth of 100 feet and another at 140 feet and a cross-cut 200 feet below the top. The vein ranges in width from two to seven feet, is vertical for the first 50 feet and after that dips at an angle of about 45 degrees westward. The gaugue is principally barite and calcite with some fine galena and very little sphalerite.



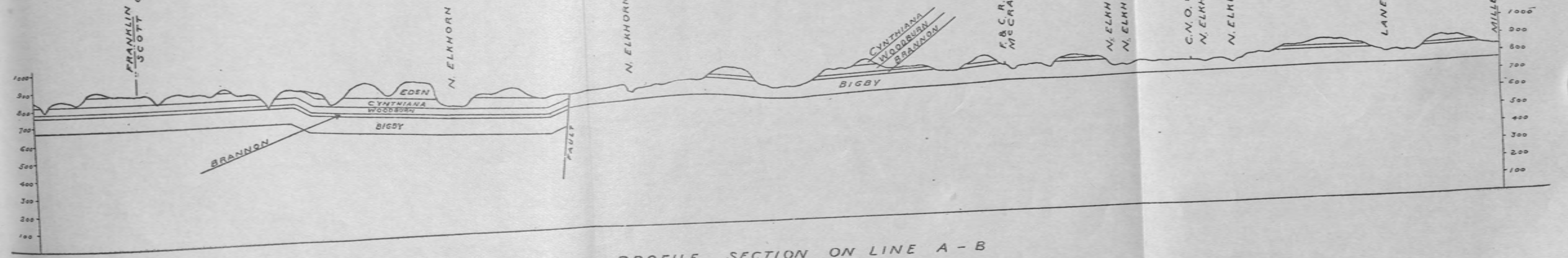
TO ILLUSTRATE METHOD OF NOTATION.

Beginning on the eastern side of the map, these veins and their locations are as follows (The first number indicates the vertical column):

Crumbaugh Vein, in	31—14;	Strike North 8 degrees East
Downing Vein, in	31— 8;	Strike North 30 degrees East
Petit Vein, in	31— 7;	Strike North 30 degrees West
Lexington Vein, in	31— 3;	Strike North 10 degrees West
J. L. Lisle Vein in	32—11;	Strike North 5 degrees East
Vein in	32— 8;	Strike North 20 degrees East
R. Lisle Vein, in	32— 4;	Strike North 17 degrees West
Haggin Vein, in	34— 9;	Strike North 5 degrees West
Crenshaw Vein, in	34— 8;	Strike North 20 degrees West
Dolan Vein, in	36— 8;	Strike North 10 degrees West
Bosworth Vein, in	37— 4;	Strike North 20 degrees East
Graves Vein, in	38—15;	Strike North 53 degrees West
McConnell's Run Vein, in	40—15;	Strike North about 5 degrees West

This vein was formerly worked for the barite and lead contained. These products were refined and smelted at the Kissinger Barite and Lead Works, at Kissinger Station, on the Frankfort & Cin. R. R. In working this vein some interesting tapir remains were discovered in what was evidently the filling of an old sink. The best preserved portion of these remains was a fragment of the lower jaw containing teeth.

It will be noted that there is a pronounced north and south trend to these veins.



PROFILE SECTION ON LINE A - B

SOILS.

References have been made to the quality of the soils formed from the decay of the rocks of the different formations outcropping within the quadrangle.

The best soils of the area are those bedded on the various members of the Lexington Limestone, and in particular those bedded on the most phosphatic of these—the Woodburn. Where typically developed—in the stretch of country lying between Versailles and Midway—these soils are very deep, loose textured, dark red and highly phosphatic. The silicified fossil, Columnaria halli, may generally be found weathered out in this soil.

The second class of soils found within the area are those bedded on the Cynthiana Formation. These are yellowish-red in appearance, less pervious to moisture, less phosphatic and in general less fertile than those in the first class. They show some tendency to wash on steep slopes.

The third class of soils are those bedded on the Eden Formation. These are yellow, tenacious on account of the prevalence of clay, and lacking phosphorous. They form the poorest soils within the area. They tend to wash badly on steep slopes, but if kept in grass, form excellent grazing land. It is unfortunate that any of these lands were ever brought under cultivation at all.

TIMBER.

In timber growth there are differences to be noted on these different soils.

The most characteristic trees on the Lexington Limestone, extending up on to the Cynthiana are the Bur Oak and the Hackberry. The most characteristic tree on the Eden is the White Oak. In the Eden areas to the north of the quadrangle also belong the sassafras, the persimmon and the beech. The latter tree seems never to have gotten a foothold within the quadrangle, no native beeches being known here.

While the region has suffered much from deforestation, it is not probable that any tree species originally here has been rendered entirely extinct.

The following is a list of the trees which have been observed within the quadrangle.

OAKS—The most characteristic of these, on Lexington Limestone soil, as has been stated, is the Bur Oak. The Chinquapin Oak is also quite common and characteristic. Other common oaks are the White and Black. The Laurel Oak occurs sparingly.

HICKORIES—The Little and Big Shell-bark Hickory and the Pignut Hickory are fairly common.

WALNUTS—The Black Walnut is a very common tree. The White Walnut or Butternut is comparatively rare.

MAPLES—The Sugar Maple is common in some sections. The Water Maple abounds along streams.

The Box-elder and the Black Willow also are common along streams.

The Sycamore grows well in all sections and is not confined to stream courses.

The Tulip Tree is fairly common.

The White Ash and the Kentucky Coffee Tree are very common.

The Black Gum, or Tupelo Tree, is occasional.

Along fence rows the most common trees are the Black Locust, Honey Locust, Hackberry, Wild Cherry and White Elm, as well as the Black Walnut already listed.

Other fairly common trees are the Linden, Ohio Buckeye and Red Mulberry.

The Persimmon has not been noted growing native, though it is due on the Eden Shale land.

Under the head of small trees and shrubs may be listed The Haw (several species—Cockspur, Dotted and Scarlet), Wild Goose Plum, Black Haw, Pawpaw, Dogwood, Serviceberry, Redbud, Witch Hazel, Burning Bush, Ironwood, Hop Hornbeam, Spicebush, Redberried Sumach.

The Red Cedar is probably the only evergreen indigenous to the region. It is found on steep, rocky slopes and cliffs.

APPENDIX.

Location of the Stromatocerium outcrop at top of Bigby, using the system of coordinates previously defined. The numbers appended indicate elevation in feet above sea level.

		Elevation.
31— 8	In bed of Cane Run	870
31— 6	In Quarry on Downing Place (faulted down here)	944
32—15	In water pool by roadside	860
32—12	In quarry by roadside	850
32—10	Natural exposure near Cane Run (Evidence of faulting near)	870
32—10	Below pond dam	870
32— 9	In quarry, W. side of Cane Run	870
32— 9	Iron Works Pike exposure	870
32— 9	Lane exposure	870
32— 7	In quarry, E. of Georgeton Pike	885
32— 2	In bed of Wolf Run	940
33—15	Natural exposure	850
33—14	Natural exposure by N. Elkhorn	851
33—14	By roadside	860
33—14	R. R. cut (Q. and C.) Fault	850
33—13	R. R. cut (G. & P. R. R.)	875
33—12	By roadside (Lemon Mill Pike)	870
33—11	R. R. cut (Q. and C.)	880
33—10	By Iron Works Pike	875
33— 9	Branch Bed, by Georgetown Pike	860
33— 7	Pond by roadside	830
33— 2	In bed of lane	940
33— 1	In bed of branch	942
34—14	R. R. cut (Q. and C.)	845
34—13	R. R. cut (G. & F. R. R.)	860
34—13	In field, E. of Georgetown Pike	860
34—13	In field, W. of Georgetown Pike	865
34—11	In road, Valley of Cane Run	854
34—10	In road, Valley of Cane Run	875
34—10	By Iron Works Pike	870
35—15	By Long Lick Pike	861
35—13	Top of N. Elkhorn Bluff	855
35—12	Bed of private lane	850
35—12	Bed of private lane	845
35— 9	In roadway (sink)	910
35— 9	Natural exposure above quarry	950
37—14	By roadside, Stamping Ground Pike	840
37—11	By side of R. R. (Georgetown and Midway)	870
38—14	By roadside, Stamping Ground Pike	840
38—12	By roadside	877
38—11	Old quarry, near Georgetown and Midway R. R.	865
38—13	In field, S. of No. Elkhorn	830
38— 1	Old Quarry, N. side of Military Pike	925
39— 1	Old Quarry, S. of Shannondale	925
40—10	R. R. Cut (Georgetown and Midway)	845

		Elevation.
40— 9	R. R. Cut (L. and N. R. R.)	850
41—10	R. R. Cut (Georgetown and Midway)	845
42—12	By roadside	785
42—11	In road	800
42— 6	By roadside	870
43— 7	In old quarry	847
43— 1	Natural exposure N. of Pike	880
44—15	In branch bed	780
44—11	By roadside (Leestown Pike)	820
45—13	By roadside (Spring Station, Woodlake)	770

Dips calculated from the data given in foregoing table.

From Stromatocerium in 33-13 (875) to Stromatocerium in 45-13 (770), across the northern portion of the map in a nearly due west direction the drop in 11 miles is 105 feet or 9.5 feet per mile.

From Stromatocerium in 33-12 (870) to Stromatocerium in 42-12 (785), across the northern portion of the map a little further south than the above, in nearly a due west direction, the drop in 8.3 miles is 85 feet or 10.2 feet per mile.

From Stromatocerium in 33-7 (930) to Stromatocerium in 43-7 (847), across the middle portion of the map in a nearly due west direction the drop is 83 feet in 8.7 miles, or 9.5 feet per mile.

From Stromatocerium in 33-1 (942) to Stromatocerium in 43-1 (880), across the southern portion of the map the drop is 62 feet in 8.8 miles, or 7 feet per mile.

From Stromatocerium in 33-1 (942) to Stromatocerium in 33-14 (850), across the eastern side of the map in a nearly due north direction the drop is 92 feet in 15.8 miles, or 5.8 feet per mile.

From Stromatocerium in 35-2 (950) to Stromatocerium in 35-13 (855), across the eastern portion of the map a little further west than the section next preceding, in a nearly due north direction the drop is 95 feet in 13.2 miles, or 7.2 feet per mile.

From Stromatocerium in 38-1 (925) to Stromatocerium in 38-14 (840), across the middle portion of the map in a nearly due north direction the drop is 85 feet in 14.9 miles, or 5.7 feet per mile. The northern end of this stretch, however, involves a reversal of the dip, as it crosses the southeastern extension of the synclinal fault strip of North Elkhorn.

For the first 11 miles the drop is from 925 to 865, or at the rate of 5.4 feet per mile. For the next 2.3 miles it is from 865 to 877, a reversal at the rate of 5.2 feet per mile, and from here across the syncline it is from 877 to 840 in 2.2 miles, or at the rate of 16.8 feet per mile.

From Stromatocerium in 43-1 (880) to horizon of Stromatocerium in 43-11 (800) across the western portion of the map in a nearly due north direction, the drop is 80 feet in 12 miles, or 6.6 feet per mile.

From Stromatocerium in 33-2 (940) to Stromatocerium in 45-13 (770), diagonally across the map from southeast to northwest (N. 45 degrees W.), the drop is 170 feet in 17.3 miles, or 10 feet per mile.

TABLE SHOWING DISTANCES IN MILES BY NEAREST PUBLIC HIGHWAYS BETWEEN PLACES WITHIN THE GEORGETOWN QUADRANGLE.

	Donerail	Duvall	Elkchester	Faywood	Fort Spring	Georgetown (C. H.)	Great Crossing	Greendale	Lexington (C. H.)	Midway	Paynes Depot	Pisgah	Hillenmeyer (Sandersville)	Shannondale	Spring Station	Versailles (C. H.)	Wallace	White Sulphur	Yarnallton
Donerail		10.95	9.7	9.95	13.55	4.75	7.85	4.5	8.85	10.55	6.5	12.6	6	16.65	14.15	15.95	12.6	10.4	5.95
Duvall	10.95		17.75	14.3	21.45	6.2	3.1	14.35	19.20	13.3	10.8	18.	16.85	23.55	17.7	20.5	15.5	6.85	12.25
Elkchester	9.7	17.75		3.35	3.7	11.95	15.05	8.2	8.7	8.3	6.85	2.9	7.2	5.8	11.05	7.75	6.85	14.5	4
Faywood	9.95	14.3	3.35		6.5	7.2	11.25	8.7	8.15	5.	3.5	4.2	7.7	8.6	7.7	6.95	3.6	11.25	4
Fort Spring	13.55	21.45	3.7	6.5		19	22.1	9.55	6.55	10.95	10.45	2.6	8.65	2.1	13.15	5.4	9.05	17.10	7.7
Georgetown (C. H.)	4.75	6.85	11.95	7.2	19.		3.1	8.15	12.45	10.9	6.75	13.10	10.1	17.4	15	16.3	13.1	8.1	7.95
Great Crossing	7.85	3.1	15.05	11.25	22.1	3.1		11.25	15.55	8.3	7.7	14.05	13.2	24.2	12.4	18.35	10.5	5.1	11.5
Greendale	4.5	14.35	8.2	8.7	9.55	8.15	11.25		4.85	10.75	7.5	11.1	2.2	11.65	14.85	14.95	11.8	14.3	4.2
Lexington (C. H.)	8.85	19.20	8.7	8.15	6.55	12.45	15.55	4.85		12.45	10.35	9.15	3.55	8.65	15.85	12.45	11.75	17.95	6.9
Midway	10.55	13.3	8.35	5.	10.95	10.9	8.3	10.75	12.45		3.9	7.85	11.9	12.	4.1	7.7	2.2	6.15	7.55
Paynes Depot	6.5	10.8	6.85	3.5	10.45	6.75	7.7	7.5	10.55	3.9		6.35	7.5	10.65	8.	9.55	6.1	9.2	4.45
Pisgah	12.6	18.	2.9	4.2	2.6	13.10	14.05	11.1	9.15	7.85	6.35		10.1	4.3	10.55	4.85	6.45	14	6.9
Hillenmeyer (Sandersville)	6.	16.85	7.2	7.7	8.65	10.1	13.2	2.2	3.55	11.9	7.5	10.1		10.75	15.4	14.05	11.3	15.10	5.35
Shannondale	16.65	25.55	5.8	8.6	2.1	17.4	24.2	11.65	8.15	12.	10.65	4.3	10.75		13.9	7.1	9.8	18.1	9.8
Spring Station	14.65	17.7	11.05	7.7	13.15	15.	12.4	14.85	15.85	4.1	8	10.55	15.4	13.9		9.6	4.1	6.7	11.65
Versailles (C. H.)	15.95	20.5	7.75	6.95	5.4	16.3	18.35	14.95	12.45	7.7	9.55	4.85	14.05	7.1	9.6		5.5	13.85	11.55
Wallace	12.6	15.5	6.85	3.6	9.05	13.1	10.5	11.8	11.75	2.2	6.1	6.45	11.3	9.8	4.1	5.5		8.35	7.6
White Sulphur	10.4	6.85	14.	11.25	17.10	8.1	5.1	14.3	17.95	6.15	9.2	14	15.10	18.15	6.7	13.85	8.35		12.7
Yarnallton	5.95	12.25	4.5	4.	7.7	7.95	11.5	4.2	6.9	7.55	4.45	6.9	5.35	9.8	11.65	11.55	7.6	12.7	

GEOGRAPHIC POSITIONS WITHIN THE GEORGETOWN QUADRANGLE.

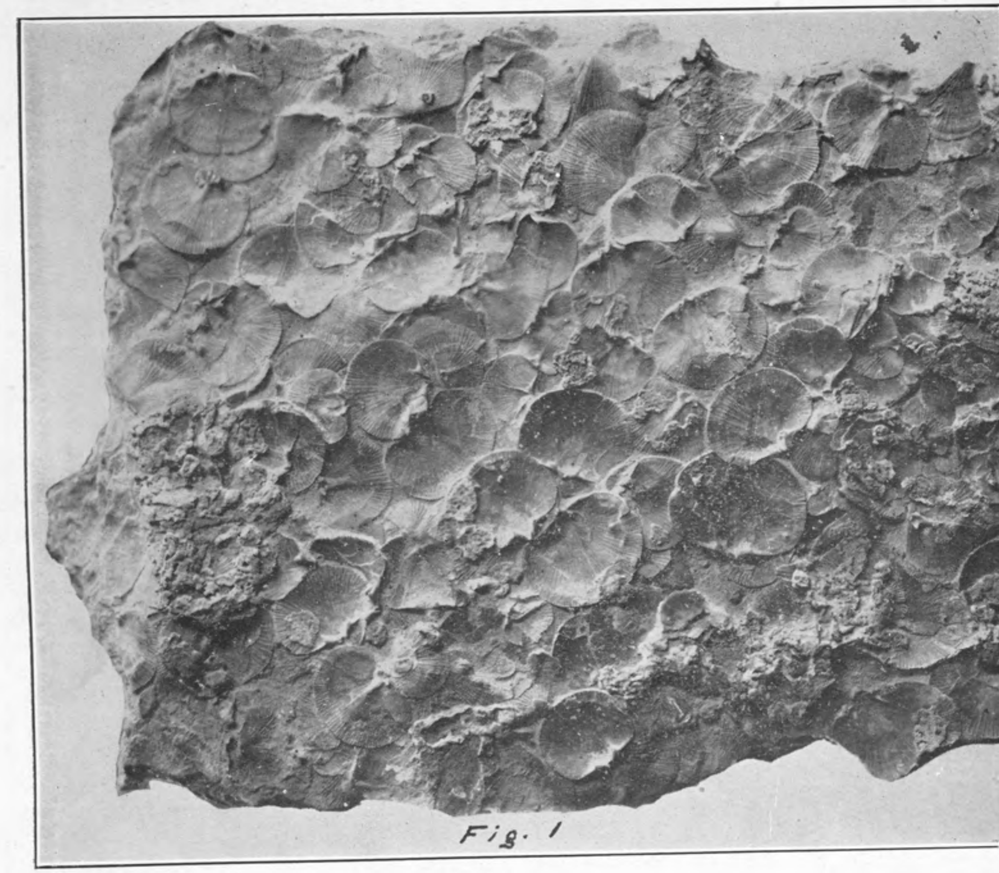
	Latitude. °	′	″	Longitude. °	′	″
Q. and C. R. R. Mile Post 271, near private road crossing	38	15	10	84	33	21.5
Q. and C. R. R. Semaphore No. 65d, near private road crossing	38	14	24.4	84	33	23.8
Q. and C. R. R. private road crossing	38	13	34.7	84	33	11.8
Q. and C. R. R.. overhead crossing 0.5 miles north of Georgetown Station	38	13	00.4	84	32	54.4
Georgetown, bench mark post stamped "Prim. Trav. Sta. No. 17" in vacant lot owned by Mrs. T. B. Sinclair; (southeast corner of Sinclair's store bears north 35 degrees 30 minutes E. distant 5.7 feet; northeast corner Catherine Conley's house bears S. 4 degrees 30 minutes E., distant 23.3 feet; cross cut in north foundation stone to water tank bears S. 24 degrees 55 minutes E., distant 152.2 feet)	38	12	27.5	84	32	53.5
Q. and C. R. R., road crossing 850 feet south of Georgetown Station	38	12	06.1	84	32	58
Q. and C. R. R., Mile post 266	38	10	56.1	84	32	31.1
Q. and C. R. R., road crossing under Trestle No. 21	38	10	11.7	84	32	31.9
Q. and C. R. R., north and south road crossing one mile north of Donerail	38	09	51.	84	32	27.4
Q. and C. R. R., north and south road crossing at Donerail	38	08	58.7	84	32	09.8
Q. and C. R. R., pike crossing, N. W. and S. E.	38	07	59.2	84	31	52.1
Q. and C. R. R. Overhead north east and south west road crossing	38	07	36.7	84	31	48.7
Q. and C. R. R., road crossing at Greendale	38	06	20.6	84	31	33.6
Q. and C. R. R., road crossing under trestle at Hillenmeyer	38	05	11.4	84	31	12.8
Louisville Southern R. R., road crossing under trestle No. 859	38	03	11.8	84	31	50.9
Louisville Southern R. R., old stone house near private road	38	03	29.7	84	32	34.1

	Latitude. °	′	″	Longitude. °	′	″
Louisville Southern R. R., road crossing northwest and southeast 600 feet east of Payne Station	38	03	28.7	84	33	39.
Louisville Southern R. R. Van Meter station board	38	03	38.	84	35	23.
Louisville Southern R. R., private road crossing at mile post 82	38	03	52.	84	35	45.6
Louisville Southern R. R., Elkchester; hole drilled in top of limestone post 36 by 5 inches, on property owned by C. C. Patrick,, opposite railroad station: (S. W. corner sta. bears N. 53 degrees 25 minutes E., distant 66.7 feet; cross cut on north east corner foundation to wagon bridge bears S. 54 degrees 30 minutes W., distant 138.4 feet.)	38	04	18.4	84	37	09.
Louisville Southern R. R., private road crossing under bridge	38	04	00.	84	37	43.9
Louisville Southern R. R., north and south road crossing at Milepost 78	38	03	24.5	84	39	20.9
Louisville Southern R. R., Versailles: road crossing at waiting shed	38	03	30.2	84	41	20.6
Louisville Southern R. R., north east and south west road crossing 0.75 mile east of Versailles	38	03	38.9	84	43	05.7
Versailles, bench mark post stamped "Prim. Trav. Sta. No. 20," on land owned by Belle Hunter: (north corner post to lot bears N. 16 degrees W., distant 12.7 feet; nail in Boise d'Arc tree bears S. 43 degrees E., distant 4.4 feet; top to automatic gate bears N. 1 degree 15 minutes E., distant 25.6 feet).	38	03	23.9	84	43	50.8
Louisville Southern R. R. crossing McCracken Pike at Versailles	38	03	22.9	84	43	52.4
Louisville Southern R. R., east and west road crossing 1 mile west of Versailles	38	03	11.5	84	44	40.0
Frankfort and Cincinnati R. R., pike crossing north and south at Duvall Station	38	14	49.3	84	48	27.6
Frankfort and Cincinnati R. R., road crossing, north and south under trestle	38	14	29.8	84	37	28.2

	Latitude. °	′	″	Longitude. °	′	″
Frankfort and Cincinnati R. R., pike crossing at Johnson Station	38	14	25.6	84	35	48.9
Frankfort and Cincinnati R. R., private road crossing, east and west	38	13	35.9	84	35	05.5
Frankfort and Cincinnati R. R. private overhead north and south road crossing	38	13	15.3	84	34	16.7

ELEVATIONS IN FEET ABOVE SEA LEVEL OF SELECTED POINTS WITHIN THE GEORGETOWN QUADRANGLE.

	Feet.
Donerail, on the pike	855
Donerail, on the Q. and C. R. R.	888
Duvall, crossing of the Frankfort and Cincinnati R. R.	840
Elkchester, crossing of the Louisville Southern R. R.	835
Faywood, Store	820
Faywood, Church, east side of S. Elkhorn	858
Fort Spring, Bridge over South Elkhorn	870
Georgetown, Court House	845
Georgetown, Q. & C. Station	866
Georgetown, top of Cemetery Hill	915
Great Crossing, Bridge over N. Elkhorn	770
Greendale, B. M. on Q. & C. R. R.	936
Lexington, Q. & C. Station (U. S. G. S.)	955
Lexington, Q. and C. R. R. (Railroad survey)	965
Midway, L. and N. tracks	810
Midway, Upper town level	855
Payne's Depot, L. and N. R. R. crossing	847
Pisgah, Church	935
Pisgah, Louisville Southern Crossing	863
Hillenmeyer, B. M. on Q. and C. R. R.	939
Shannondale, Pike intersection	888
Spring Station, (crossing of L. and N. R. R.)	816
Versailles, Court House	895
Versailles, Intersection of Shryocks Ferry and Clifton pikes	900
Versailles, Crossing of Louisville Southern and McCracken pike	921
Wallace, pike crossing	870
White Sulphur, intersection of Georgetown and Frankfort and Iron Works pikes	873
Yarnallton, crossing of L. and N. R. R.	850



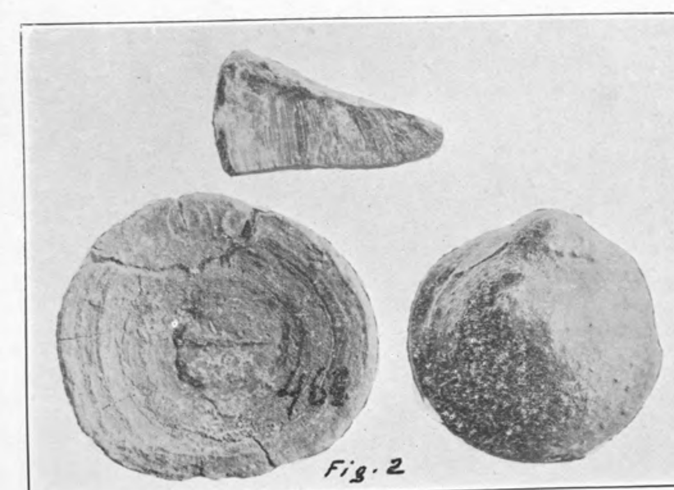


Plate V.

Characteristic Fossils of the Wilmore

Fig. 1. Dalmanella bassleri (Foerste.)

Fig. 2. Prasopora simulatrix (Ulrich.)

geo. 12.

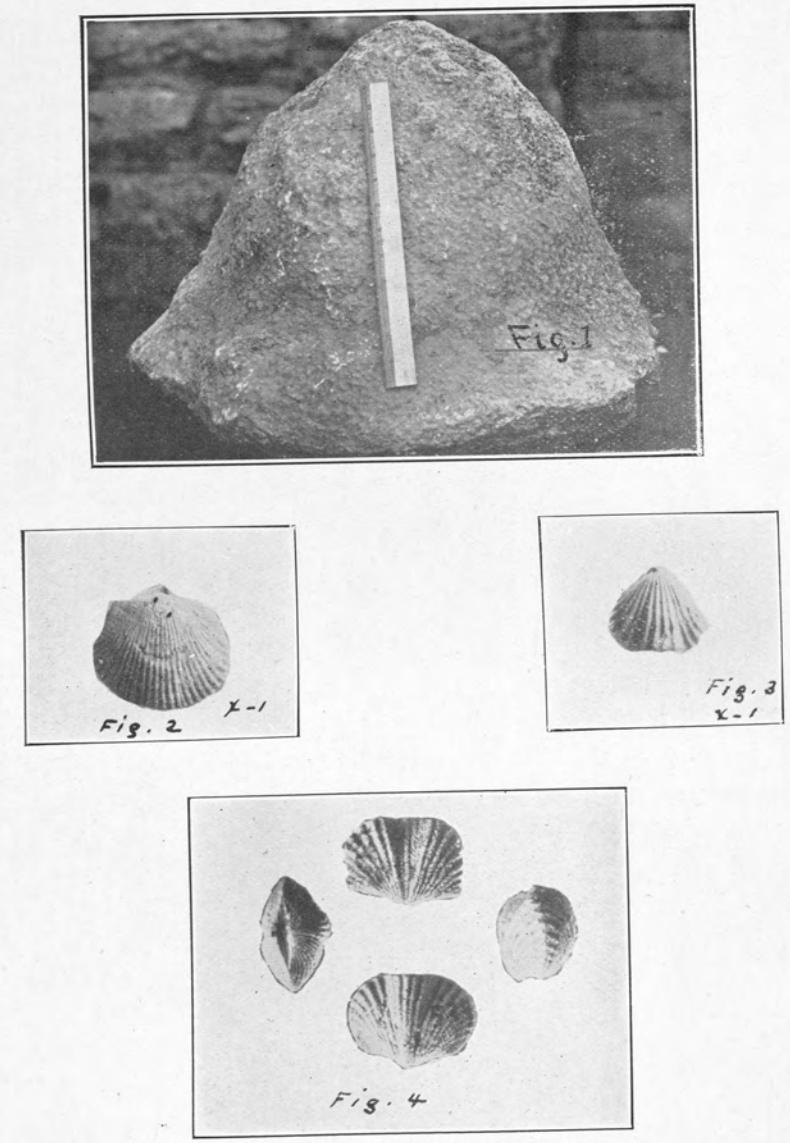


Plate VI.

Characteristic Fossils of the Bigby.

Fig. 1. Stromatocerium rugosum (Hall.)
Fig. 2. Hebertella frankfortensis (Foerste.)
Fig. 3. Rhychotrema inaequivalve (Cast.)
Fig. 4. Platystrophia colbyensis (Foerste.)

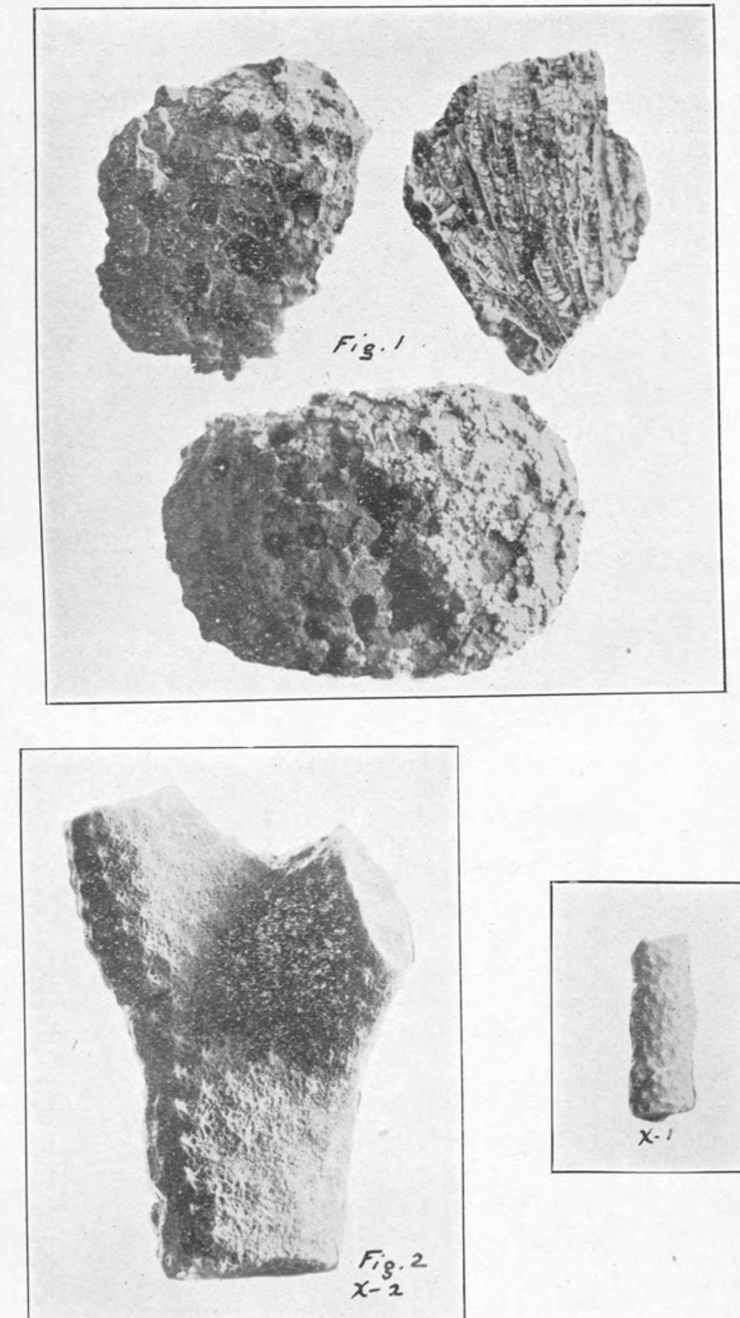
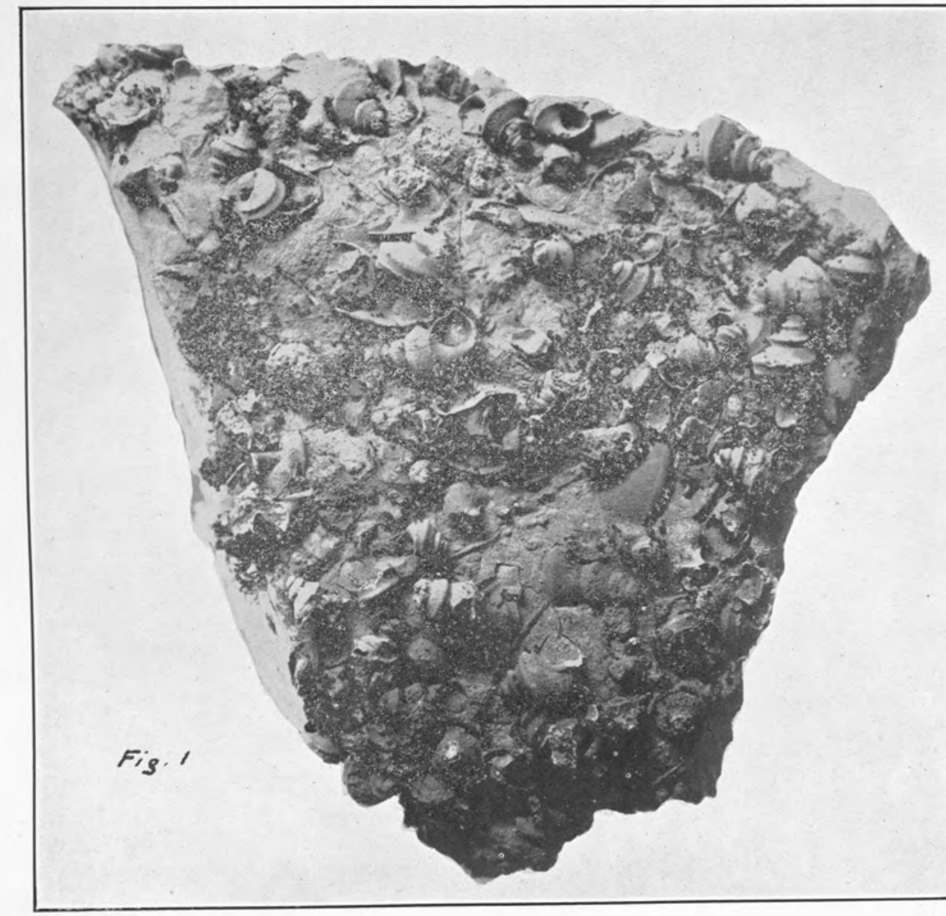


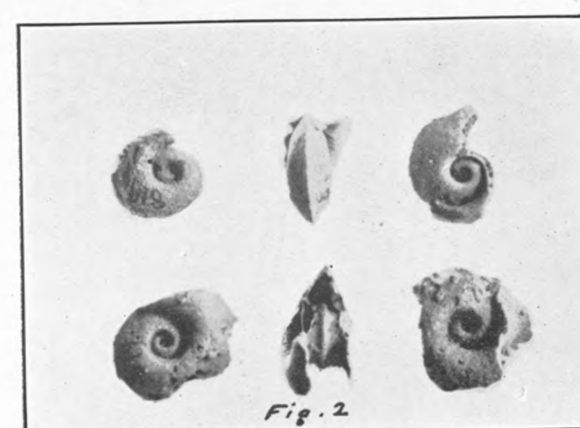
Plate VII.

Characteristic Fossils of the Woodburn.

Fig. 1. Columnaria halli (Nich.)

Fig. 2. Constellaria teres (Ul. and B.)





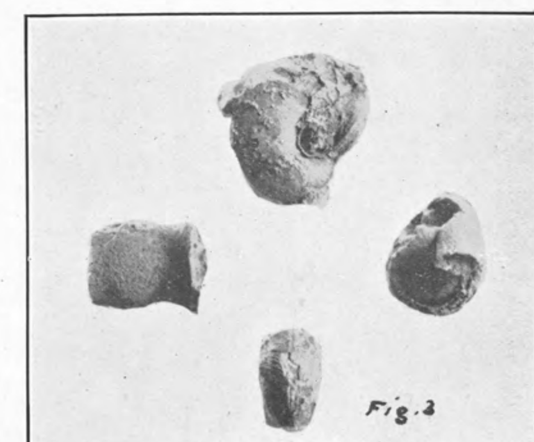


Plate VIII.

Characteristic Fossils of the Faulconer.

Fig. 1. Lophospira medialis (U. and S.)

Fig. 2. Oxydiscus subacutus (Ul.)

Fig. 3. Bellerophon troosti (Saf.)

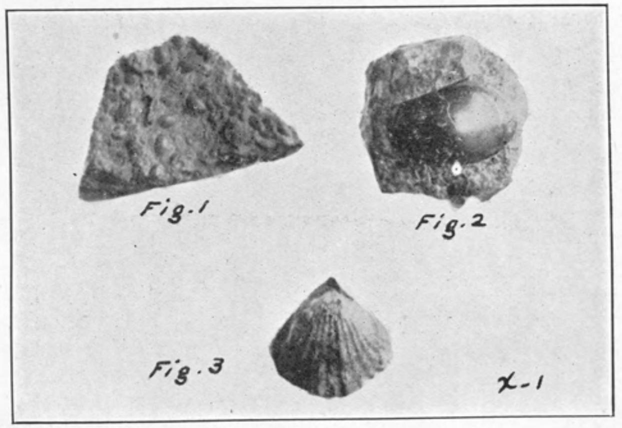


Plate IX.

Characteristic Fossils of the Perryville.

Fig. 1. Leperditia caecigena (Miller.)

Fig. 2. Isochilina jonesi (Weth.)

Fig. 3. Arthorhyncula linneyi (James.)

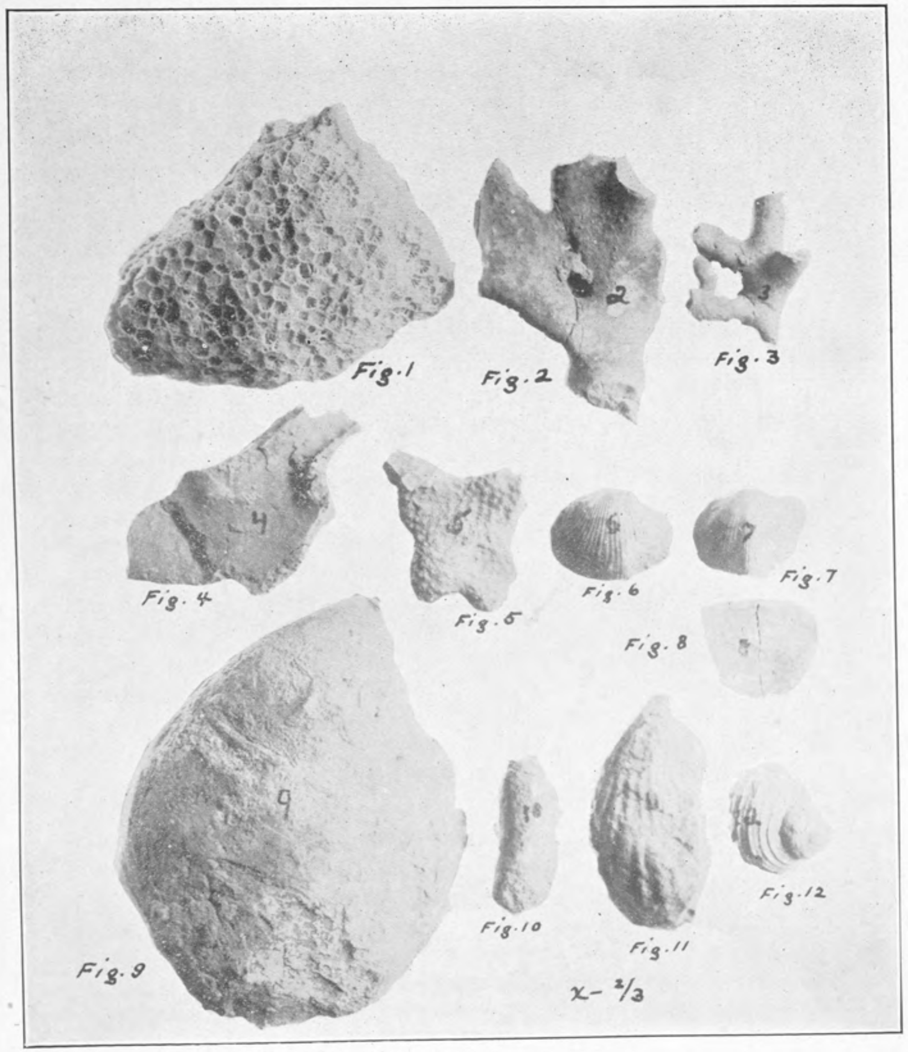


Plate X.

Characteristis Fossils of the Cynthiana

Fig. 1. Columnaria alveolata (Goldfuss.)
Fig. 2. Heterotrypa parvulipora (U. and P.)
Fig. 3. Eridotrypa briareus (Nich.)
Fig. 4. Peronopora milleri (Nickles.)
Fig. 5. Constellaria fischeri (Ulrich).
Fig. 6. Hebertella sinuata (Hall.)
Fig. 7. Hebertella maria (Billings.)
Fig. 8. Rafinesquina alternata (Emmons.)
Fig. 9. Allonychia flanaganensis (Foerste.)
Fig. 10. Orthodesma sp.?
Fig. 11. Byssonychia sp.?
Fig. 12. Cyclonema varicosum (Hall.)

THE IDENTIFICATION OF TRENTON AND LOWER GEOLOGICAL HORIZONS.

BY A. F. FOERSTE.

While the identification of geological horizons during field work is based largely upon lithological characteristics, nevertheless the more exact correltion of strata at different localities requires some knowledge of the contained fossils. There is not the slightest doubt that the prospector acquainted with the characteristic fossils, and their vertical and geographical distribution gains from this knowledge greatly in the facility with which he can trace strata. Owing to this fact, it is unfortunate that no detailed lists of the fossils characteristic of the various formations in the State are at hand. It is for the purpose of supplying this demand that the following lists are submitted. To these lists the following observations are added.

Stromatocerium, Strophomena vicina and Dinorthis ulrichi, associated with *Hebertella frankfortensis, Platystrophia colbiensis, and Rhynchotrema increbescens,* are characteristic of two horizons in Central Kentucky, the upper part of the Benson or Bigby and the Cornishville beds. Lithologically the rocks look very similar at the two horizons, and the means of distinguishing the latter is chiefly by examining the underlying and overlying strata. In the case of the Cornishville layer, the immediately underlying rock consists of a very fine-grained whitish or dove-colored limestone, not exceeding 7 feet in thickness, usually with few fossils but locally containing a few ostracoda; the overlying strata contain the very characteristic fauna belonging to the Catheys. In the case of the *Stromatocerium, Strophomena vicina* and *Dinorthis ulrichi* horizons at the top of the Benson or Bigby bed, the overlying strata consist not of the Catheys, but of the Brannon layer, from 40 to 70 feet of Trenton strata intervening before the Catheys is reached; moreover, beneath the horizons mentioned, instead of very fine-grained and very hard whitish or dove-colored limestone, there is a considerable thickness, often 20 to 30 feet, of coarse-grained limestone, below which there are finer grained limestones in which *Dalmanella* and *Prasopora* are more or less common.

From the preceding remarks it is evident that whenever the *Stromatocerium-Strophomena-Dinorthis* horizon is overlaid by a considerable thickness of strata containing *Hebertella frankfortensis* or *Rhynchotrema inaequivalve,* it must be the lower horizon that is exposed. It must be the lower horizon also if the overlying beds, some distance further up, so as to make allowance for the thickness of the Brannon bed, contain *Columnaria alveolata,* since the latter fossil is quite abundant locally at certain horizons in the Woodford bed.

In making these correlations by means of fossils the following facts should be observed. *Dinorthis ulrichi and Strophomena vicina* can be safely recognized by the beginner in the study of fossils only by looking for specimens exposing the muscular scars on the interior of the pedicel valves. There is no known reason why these fossils should not occur also at various levels in the Woodford bed, but judging from past experience they must be rare in the Woodford strata, if they occur there at all. *Hebertella frankfortensis* may be readily distinguished by its smaller size, the simple plications on its exterior surface, usually without the presence of intercalated plications, and the long hinge area. In *Platystrophia colbiensis* the plications are bolder, fewer in number, and there is a conspicuous elevation along the middle of one valve, and a corresponding depression along the middle of the other valve. From *Rhynchotrema or Orthorhynchula* it may be distinguished by the long hinge area. *Rhynchotrema increbescens* may be identified usually by means of its narrow, acute beak, there being no hinge area. It may be confused, however, with *Orthorhynchula linneyi,* which is a larger shell and has a small hinge area, usually not well exposed. Since *Orthorhynchula linneyi* occurs not only in the Perryville bed, locally, but also much more abundantly in the Catheys, it is important that the distinctions between *Orthorhynchula linneyi* and *Rhynchotrema increbescens* be carefully observed.

Columnaria is present also locally in the Catheys, but only as occasional specimens, and not in the abundance seen in the Woodburn division of the Trenton. It is the so-called honey-comb coral. A form of *Columnaria* occurs also in the Catheys, but it is quite rare and usually does not occur in masses more than two inches in diameter.

Stromatocerium occurs at so many horizons that the mere occurrence of a single specimen or two does not establish the geological horizon. Specimens occur not only in the upper part of the Benson bed and in the Cornishville layer, but also in the Catheys and at many other horizons. In the Trenton of Central Kentucky the specimens often attain large size. Most of them appear to be closely related to *Stromatocerium canadense* or belong to the variety described by Prof. W. A. Parks as *minimum.* The upper surface frequently presents a large number of rather low and wide elevations or mamelons which can be detected even in the case of specimens broken across so as to show the interior structure. This interior structure consists chiefly of numerous lamellae following each other in close succession and building up hemispherical masses often more than a foot in diameter. The thin vertical pillars uniting these lamellae often can not be detected readily, usually on account of failure of preservation during fossilization.

At the Brannon horizon, the bases of sponges belonging to the genus *Pattersonia,* are quite frequent. These resemble more or less twisted, thick but short strands or bundles formed of numerous long but very fine spicules.

The most important single work including many descriptions and illustrations of fossils belonging to the Trenton and Stones River formations in Central Kentucky, is Volume III of the Minnesota Geological Survey, which discusses the Paleontology of the Ordovician horizons not only of Minnesota and neighboring States, but also of Kentucky. Other descriptions and illustrations are scattered through many publications, including the Journal of the Cincinnati Society of Natural History, Volume VIII. of the Paleontology of New York, and the Bulletin of Denison University.

LISTS OF FOSSILS FOUND IN THE LOWER ORDOVICIAN FORMATIONS IN CENTRAL KENTUCKY.

Cornishville Division of Perryville Formation—

Stromatocerium rugosum, Hall.
Dinorthis ulrichi, Foerste.
Hebertella frankfortensis, Foerste (borealis of some writers.)
Platystrophia colbiensis, Foerste.
Rhynchotrema increbescens, Hall (inaequivalve, of some writers.)
Strophomena vicina, Foerste.

Salvisa Division of Perryville Formation—

Isochilina jonesi, Wetherby.
    subnodosa, Ulrich.
Leperditia appressa, Ulrich.
    linneyi, Ulrich.

Faulconer Division of Perryville Formation—

Buthotrephis succulens, Hall.
Cylindrocoelia danvillensis, Ulrich.
Saccospongia danvillensis, Ulrich.
Stromatocerium
Tetradium columnare, Hall.
    fibratum, Safford.
Prasopora.
Rhinidictya neglecta, Ulrich.
Clitambonites multistriata, Foerste.
Dalmanella.
Hebertella.
Orthorhynchula linneyi, James.
Rhynchotrema increbescens, Hall.
    procteri, Ulrich.
Zygospira recurvirostris, Hall.
Bellerophon bilineatus, Ulrich.
    troosti, Safford.
    troosti—burginensis, Ulrich.
Bucania micronema, Ulrich.
    nana, Ulrich.
    nana-subspatula, Ulrich.
    rugatina, Ulrich.
    subangulata, Ulrich.
    sublata, Ulrich.
Bucanopsis carinifera, Ulrich.

Faulconer Division of Perryville Formation—Continued.

Carinaropsis cumulae, Hall.
    cymbula, Hall.
Clathrospira conica, Ulrich.
Cyclora minuta, Hall.
    parvula, Hall.
Cyrtolites retrorsus, Ulrich.
Eunema arctatum, Ulrich.
    obsoletum, Ulrich.
Holopea parvula, Ulrich.
Hormotoma salteri, Ulrich.
    salteri-nitida, Ulrich.
Liospira micula, Hall.
    mundula, Ulrich.
    vitruvia, Billings.
Lophospira decursa, Ulrich.
    elevata, var. Ulrich and Scofield.
    humilis, Ulrich.
    medialis, Ulrich and Scofield.
    medialis—burginensis, Ulrich.
    pulchella, Ulrich and Scofield.
    sumnerensis, Safford.
Oxydiscus subacutus, Ulrich.
Stenotheca unguiformis, Ulrich.
Strophostylus textilis, Ulrich and Scofield.
Trochonema subcrassum, Ulrich and Scofield.
    umbilicatum, Hall.
Ctenodonta hartsvillensis, Safford.
    regia, Ulrich.
    retrorsa, Ulrich.
Cyrtodonta grandis, Ulrich.
    grandis-germana, Ulrich.
Lyrodesma intermedium, Ulrich.
Matheria cf. tenera, Billings.
Modiolodon patulus, Ulrich.
Modiolopsis cf. nais, Billings.
Vanuxemia hayniana, Safford.
    nana, Ulrich.
Actinoceras milleri, Foerste.
Halliella sculptilis, Ulrich.
Leperditia caecigena—frankfortensis, Ulrich.
    tumidula, Ulrich.
Conocardium cf. immaturum, Billings.
Pterygometopus, Hall.

Woodburn Bed—

Saccospongia danvillensis, Ulrich.
rudis, Ulrich.
Columnaria alveolata, Goldfuss.
Constellaria emaciata, Ulrich.
teres, Ulrich and Bassler.
Cyphotrypa frankfortensis.
Dekayella foliacea, Ulrich and Bassler.
Heterotrypa cf. parvulipora, Ulrich.
Mesotrypa echinata, Ulrich and Bassler.
Phylloporina granistriata, Ulrich.
reticulata, Hall.
Glyptocrinus cf. ramulosus, Billings.
Clitambonites sp.
Hebertella frankfortensis, Foerste.
Lingula procteri, Ulrich.
procteri—versaillesensis, Foerste.
Orbiculoidea lamellosa, Hall.
Platystrophia colbiensis, Foerste.
Rhynchotrema increbescens, Hall.
Triplesia sp.
Zygospira recurvirostris, Hall.
Bellerophon clausus, Ulrich.
Bucania frankfortensis, Ulrich.
Carinaropsis cymbula, Hall.
Clathrospira conica, Ulrich and Scofield.
Cyclora minuta, Hall.
parvula, Hall.
Cyrtolites retrorsus, Ulrich.
Liospira micula, Hall.
Lophospira bicincta, Hall.
decursa, Ulrich.
medialis, Ulrich and Scofield.
medialis—burginensis, Ulrich and Scofield.
obliqua, Ulrich.
pulchella, Ulrich and Scofield.
Microceras indornatus, Hall.
Colpomya constricta, Ulrich.
Proetus sp.

Brannon Bed—

Brachiospongia digitata, Owen.
Chirospongia wenti, Miller.
Pattersonia aurita, Beecher.
tuberosa, Beecher.

Benson or Bigby Bed—

Pattersonia, basal spicule bundles.
Stromatocerium rugosum, Hall.
canadense—minimum, Parks.
Cyphotrypa frankfortensis, Ulrich and Bassler.
Dekayella trentonensis, Ulrich.
Eridotrypa mutabilis, Ulrich.
Hallopora multitabulata, Ulrich.
Prasopora nodulosa, Ulrich.
simulatrix, Ulrich.
Dinorthis ulrichi, Foerste.
Hebertella frankfortensis, Foerste.
Platystrophia colbiensis, Foerste.
Rafinesquina alternata.
Rhynchotrema increbescens, Hall.
Strophomena vicina, Foerste.
Zygospira recurvirostris, Hall.
Cyclora Minuta, Hall.
Primitia nitida, Ulrich.
Proetus.

Wilmore Bed—

Hindia parva, Ulrich.
Solenopora compacta, Billings.
Atactoporella.
Cyphotrypa acervulosa, Ulrich.
Eridotrypa mutabilis, Ulrich.
trentonensis, Nicholson.
Eurydictya multipora, Hall.
Hallopora (Callopora) multitabulata, Ulrich.
(=kentuckiensis, James).
Homotrypella granulifera, Ulrich.
mundula, Ulrich.
Mesotrypa angularis, Ulrich and Bassler.
Monticulipora arborea, Ulrich.
Pachdictya acuta, Hall.
Phacelopora constricta, Ulrich.
Prasopora falesi, James.
nodosa, Ulrich.
simulatrix, Ulrich.
Rhinidictya neglecta, Ulrich.
Dalmanella bassleri, Foerste.
Hebertella frankfortensis, Foerste.
Rafinesquina alternata, Conrad.
Rhynchotrema increbescens, Hall.
Schizocrania filosa, Hall.
Zygospira recurvirostris, Hall.
Conradella compressa, Conrad.

Wilmore Bed—Continued.
- Cyrtolites retrorsus, Ulrich.
- Fusispira angusta, Ulrich and Scofield.
  - angusta—subplana, Ulrich and Scofield.
  - subfusiformis, Hall.
- Holopea appressa, Ulrich and Scofield.
- Liospira mundula, Ulrich.
  - vitruvia, Billings.
- Lophospira obesa, Ulrich.
- Lyrodesma intermedium, Ulrich.
- Ceratopsis, intermedia, Ulrich.
- Pterygometopus, callicephalus, Hall.

Logana or Hermitage Bed—
- Tetradium minus, Safford.
- Mesotrypa quebecensis, Ami.
- Prasopora hemispherica, Ulrich.
- Dalmanella fertilis, Ulrich.
- Heterorthis clytie, Hall.
- Lingula coburgensis, Billings.
  - covingtonensis, Hall and Whitfield.
  - modesta, Ulrich.
  - riciniformis, Hall.
- Plectambonites.
- Rafinesquina alternata, Hall.
- Trematis ottawaensis, Billings.
  - punctostriata, Hall.
- Archinacella simulatrix, Ulrich and Scofield.
- Cyrtolites retrorsus, Ulrich.
- Liospira micula, Hall.
- Protowarthis pervoluta, Ulrich and Scofield.
- Ctenodonta socialis, Ulrich.
- Eurymya subplana, Ulrich.
- Modiolodon oviformis, Ulrich.
  - oviformis—amplus, Ulrich.
- Modiolopsis parva, Ulrich.
- Ceratopsis intermedia, Ulrich.
- Primitia.
- Trinucleus concentricus, Eaton.

Curdsville Bed—
- Receptaculites occidentalis, Salter.
- Streptelasma profundum, Conrad.
- Columnaria carterensis, Safford.
- Aesiocystites priscus, Miller and Gurley.
- Amygdalocystites florealis, Billings.
  - huntingtoni, Wetherby.
  - radiatus, Billings.
- Apiocystites.

Curdsville Bed—Continued.
- Astroporites ottawaensis, Lambe.
- Ateleocystites.
- Belemnocystites wetherbyi, Miller and Gurley.
- Blastoidocrinus carcharidens, Billings.
- Calceoocrinus kentuckiensis, Miller and Gurley.
- Carabocrinus ovalis, Miller and Gurley.
  - radiatus, Billings.
- Castocrinus articulosis, Billings.
- Cleiocrinus sculptus, Springer.
- Comarocystites.
- Cupulocrinus jewetti—kentuckiensis, Springer.
- Dendrocrinus acutidactylus, Billings.
- Edrioaster bigsbyi, Billings.
- Glyptocrinus mercerensis, Miller and Gurley.
  - priscus, Billings.
  - ramulosus, Billings.
- Hybocrinus conicus, Billings.
  - tumidus, Billings.
- Hybocystites eldonensis, Parks.
  - problematicus, Wetherby.
- Palaeocrinus angulatus, Billings.
- Pleurocystites mercerensis, Miller and Gurley.
  - cf. squamosus, Billings.
- Porocrinus conicus, Billings.
  - kentuckiensis, Miller and Gurley.
- Retiocrinus alveolatus, Miller and Gurley.
- Homotrypa minnesotensis, Ulrich.
- Dalmanella.
- Dinorthis pectinella, Emmons.
- Orthis tricenaria, Conrad.
- Plectambonites curdsvillensis, Foerste.
- Plectorthis plicatella, Hall.
- Archinacella cingulata, Ulrich.
- Bellerophon subglobulus, Ulrich.
- Bucania elliptica, Ulrich and Scofield.
  - halli, Ulrich and Scofield.
- Clathrospira subconica, Hall.
- Conradella similis, Ulrich.
- Gyronema pulchellum, Ulrich and Scofield.
- Liospira angulata, Ulrich.
  - progne, Billings.
  - vitruvia, Billings.
- Lophospira bicincta, Hall.
  - helicteres—wisconsinensis, Ulrich and Scofield.
  - notabilis, Ulrich.
  - obliqua, Ulrich and Scofield.

Curdsville Bed—Continued.

oweni, Ulrich and Scofield.
Omospira alexandra, Billings.
Protowarthia cancellata, Hall.
pervoluta, Ulrich.
Raphistomina denticulata, Ulrich.
Salpingostoma buella—kentuckiensis, Ulrich.
Tetranota bidorsata, Hall.
obsoleta, Ulrich and Scofield.
Trochonema beachi, Whitfield.
Conularia quadrata, Walcott.
Ctenodonta subrotunda, Ulrich.
Cyrtodonta, obesa, Ulrich.
rotulata, Ulrich.
subovata, Ulrich.
Plethocardia umbonata, Ulrich.
Vanuxemia cardinata, Ulrich.
gibbosa, Ulrich.
hayniana, Safford.
umbonata, Ulrich.
Colpoceras clarkei, Wetherby.
Ormoceras tenuifilum, Hall.
Orthoceras (Spyreceras) bilineatum—frankfortensis, Foerste.
Triptoceras planoconvexum, Hall.

Tyrone or Lowville Bed—

Phytopsis tubulosa, Hall.
Cylindrocoelia endoceroidea, Ulrich.
Dermatostroma tyronensis, Foerste.
Stromatocerium rugosum, Hall.
Columnaria halli, Nicholson.
Streptelasma profundum, Conrad.
Tetradium cellulosum.
halysitiforme.
Heterocrinus milleri, Wetherby.
Escharopora angularis, Ulrich.
Escharopora libana, Safford.
ramosa, Ulrich.
Helopora spiniformis, Ulrich.
Homotrypa arbuscula, Ulrich.
Orbignella wetherbyi, Ulrich.
Phyllodictya frondosa, Ulrich.
labyrinthica, Hall.
Rhinidictya nicholsoni, Ulrich.
Camarella panderi, Billings.
Dalmanella hamburgensis, Walcott.
Dalmanella subaequata—circularis, Winchell.
Dinorthis deflecta, Conrad.

Tyrone or Lowville Bed—Continued.

Hallina saffordi, Winchell and Schuchert.
Orthis tricenaria, Conrad.
Rafinesquina minnesotensis, Winchell.
Strophomena incurvata, Shepard.
Zygospira recurvirostris.
Cyrtospira bicurvata, Ulrich.
Clathrospira subconica, Hall.
Eccyliopterus beloitensis, Ulrich.
Helicootoma granosa, Ulrich.
Hormotoma angustata, Hall.
Liospira abrupta, Ulrich.
angulata, Ulrich.
vitruvia, Billings.
Lophospira obliqua, Ulrich.
oweni, Ulrich.
perangulata, Hall.
serrulata, Salter.
Subulites nanus, Ulrich.
parvus, Ulrich.
regularis, Ulrich.
Tetranota bidorsata, Hall.
Trochonema ubilicatum, Hall.
Pterotheca attenuata, Hall.
Cameroceras.
Ormoceras tenuifilum, Hall.
Orthoceras tyronensis, Foerste.
Triptoceras planodorsatum, Whitfield.
Cyrtodonta huronensis, Billings.
subovata, Ulrich.
Drepanella crassinoda, Ulrich.
Eurychilina aequalis, Ulrich.
longula, Ulrich.
obesa, Ulrich.
Isochilina armata, Walcott.
Krausella arcuata, Ulrich.
Leperditia fabulites, Conrad.
Leperditella sulcata, Ulrich.
sulcata—ventricornis, Ulrich.
tumida, Ulrich.
Macronotella scofieldi, Ulrich.
Primitiella constricta, Ulrich.
Schmidtella near umbonata, Ulrich.
Tetradella quadrilirata, Hall and Whitfield.
simplex, Ulrich.
Bathyurus extans, Hall.
spiniger, Hall.

Camp Nelson Bed—

Mitoclema cinctosum, Ulrich.
Dalmanella subaequata, Conrad.
Dinorthis deflecta, Conrad.
Hebertella bellarugosa, Conrad.
Orthis tricenaria, Conrad.
Protorhyncha australis, Foerste.
Rafinesquina minnesotensis, Winchell.
Rhynchotrema.
Strophomena incurvata, Shepard.
Ctenobolbina subcrassa, Ulrich.
Drepanella ampla, Ulrich.
  elongata, Ulrich.
  nitida, Ulrich.
Eurychilina aequalis, Ulrich,
  granosa, Ulrich.
Leperditella aequlatera, Ulrich
  inflata, Ulrich.
  mundula, Ulrich.
Primitiella constricta, Ulrich.

A CHEMICAL STUDY OF THE TRENTON AND STONE'S RIVER ROCKS IN CENTRAL KENTUCKY.

By A. F. FOERSTE.

No chemical survey of the rocks of the state of Kentucky has ever been attempted. The writer, however, has had this long in mind, and, with the permission of the director, has collected samples from various localities with the idea of contributing toward such a survey. While the search for phosphatic deposits was in progress, a series of samples of Trenton and underlying strata was collected in Central Kentucky, not only with the idea of making a thorough search for phosphatic material at all horizons, but also for the purpose of contributing toward this general chemical survey.

It was believed that most of the earlier analyses having this object in view were misleading since they were based on chunks of rock, and not on a systematic collecting of chips representing every individual layer in its proper proportion throughout the entire rock mass being sampled. When it is learned that the collecting of three samples may occupy fully half a day, it may be easily understood why chunk collecting usually is allowed to pass under the name of sampling, although chunk collecting may give a very wrong impression as to the chemical characteristics of the general run of the rock.

HIGH BRIDGE.

The lowest strata in the state were studied at High Bridge. These include all the strata formerly included in the High Bridge or Stone's River group. Recently it has been learned that the upper division of this High Bridge limestone, the Tyrone, corresponds to the Leray of New York, and, as the latter has been included in the Black River of New York, it has been desirable to separate also the Tyrone of Kentucky from the High Bridge.

That part of the Camp Nelson limestone which was sampled at High Bridge, includes only the upper 150 feet of the total section. It contained 89.4 per cent of calcium carbonate, 4.43 per cent of magnesium carbonate, 3.84 per cent of silica, and 0.05 per cent of alumina.

The Oregon bed, long known as the Kentucky marble, has so long been regarded as a strongly magnesian horizon that the chemical analysis presented by the chemist of the survey, of the general run of this bed, 33 feet thick, was received with surprise. This general sample gave 81.5 per cent of calcium carbonate, 0.8 per cent of magnesium carbonate, 5.54 per cent of silica, and 3.55 per cent of alumina.

Only the upper part of the Tyrone, 50 feet thick, was sampled. This gave 86.5 per cent of calcium carbonate, 6.3 per cent of magnesium carbonate, 6.38 per cent of silica, and only 0.23 per cent of alumina.

FRANKFORT.

The total thickness of the Curdsville bed at Frankfort is approximately 23 feet. At present, the section is best exposed south of Frankfort, at the water works, on the western bank of the Kentucky river. The analysis of the general run of the bed gave 82.8 per cent of calcium carbonate, 2.5 per cent of magnesium carbonate, 11.88 per cent of silica, and only 1.54 per cent of alumina. Most of the rock consists of coarse grained limestone.

MILLVILLE.

At Millville, the total thickness of the Logana bed is about 22 feet. It is well exposed along the railroad immediately south of the station. The fine grained limestone forms only about half of the section, the remainder consisting of the interbedded clay. A sample including only the limestone part of the section gave 77.8 per cent of calcium carbonate, 1.07 per cent of magnesium carbonate, 17.18 per cent of silica, and 0.38 per cent of alumina. The interbedded clay contained 41.2 per cent of calcium carbonate, 0.95 per cent of magnesium carbonate, 44.98 per cent of silica, and only 2.21 per cent of alumina.

SOUTHWEST OF OLD CROW DISTILLERY, AT GLENN CREEK STATION.

The exposures along the steep road, ascending the hill southwest of the Old Crow distillery, were used for collecting samples from some of the Trenton and underlying horizons.

The lowest strata here sampled form the lower part of the Wilmore bed; they include 23 feet of granular limestone characterized by the great abundance of *Dalmanella fertilis*, especially toward the base. The same fossil is abundant locally also in the underlying Logana bed, but the latter consists of very fine grained and rather even bedded siliceous limestones, more or less alternating with clay, and characterized by the presence of *Heterorthis clytie*. This part of the Wilmore section contains 92.5 per cent of calcium carbonate, and 1.13 per cent of magnesium carbonate, with 3.48 per cent of silica as the chief impurity.

The next section sampled included the 58 feet of limestone extending from 23 to 81 feet above the base of the Wilmore. The rock here is fairly well bedded, contrasting with the lower rock which weathers into smaller fragments or rubble. *Prasopora simulatrix* is common at various levels. *Hebertella frankfortensis* usually is rather rare at this level. These strata also belong to the Wilmore. The rock contains 95.7 per cent of calcium carbonate, 1.18 per cent of magnesium carbonate, and 2.02 per cent of silica.

Overlying the second section sampled is a rather fine grained limestone, somewhat resembling the Logana lithologically, only five and a half feet thick, which was not analyzed.

The next section investigated consisted of 33.5 feet of limestone extending from 86.5 to 120 feet above the base of the Wilmore. The lower part of this section, about 5 feet thick, consists of massive limestone. The middle part, about 13 feet thick, weathering to argillaceous rubble limestone, contains *Prasopora* near the top. The upper part, about 16 feet thick, consists of softer limestones than the overlying part of the Benson or Bigby bed, and contains an abundance of *Dalmanella bassleri* at the top. This part of the section, therefore, still is included in the Wilmore, although it evidently is a transition stage to the Benson. This agrees also with the original definition of the term Wilmore, and with the general practice of both Prof. Miller and myself to draw the line there where strata with an abundance of *Dalmanella bassleri* were overlaid by coarser grained strata in which *Hebertella frankfortensis* and *Rhynchotrema increbescens* were more abundant. Sampling this part of the section, 33.5 feet thick, as a whole, the rock was found to consist of 93. per cent of calcium carbonate, and 3.44 per cent of magnesium carbonate, with 2.44 per cent of silica as the chief impurity.

The lower part of the Benson or Bigby bed, 16.5 feet thick, consists of massive, rather coarsely crystalline, gray limestone, in which *Dalmanella* is present, but no longer forms a conspicuous part of the fauna; in fact, it usually is rare. The rock consists of 96.3 per cent of calcium carbonate, 2.02 per cent of magnesium carbonate, and only one per cent of silica.

Above this part of the section there are 8 feet of strata poorly exposed, overlaid by 10 feet of rather fine grained limestone containing *Strophomena vicina* and and *Platystrophia colbiensis*. Five and a half feet above the latter, a large specimen of *Stromatocerium* is present, and it is supposed that this horizon corresponds to the *Stromatocerium* horizon found near the top of the Benson bed near Brannon Station. The immediately overlying limestone, a foot and a half thick, is massive. *Rhynchotrema increbescens* is common at the top. For an interval of 38 feet the exposures are poor, and within the lower part of this section the equivalents of the Brannon bed should occur. Between 2 and 8 feet above this 38-foot section *Columnaria* is present, and 5 feet farther up residual blocks of the "gasteropod layer, referred to the Flanagan division of the Perryville, occur. They probably have been let down by weathering to a position below their original level.

HULETT STATION.

No adequate study of the chemical characteristics of the Brannon layer have been made at any locality. In order to give some approximate notion, the following analysis has been inserted. Hulett Station is about a mile northeast of Brannon, along the traction line from Lexington to Nicholasville. Stop No. 11 lies directly northward. Here the Brannon rock, near its base, consisted of 84.8 per cent of calcium carbonate, 5.65 per cent of magnesium carbonate, and 7.7 per cent of silica. Of alumina there is only 0.23 per cent, so that the rock certainly cannot be called an argillaceous limestone, although that is its physical appearance, and the term argillaceous limestone was employed in all field notes.

VERSAILLES.

The unweathered coarse-grained limestone, forming the characteristic part of the Woodburn bed, was studied at the deep railroad cut in Versailles, along the new line leading to Frankfort. Here the lowest strata investigated, not the lowest strata in the Woodburn section, however, extended from 27 to 35 feet below the top of the Woodburn limestone, and contained 89 per cent of calcium carbonate, 5.9 per cent of magnesium carbonate, and 3.96 per cent of silica. The overlying part of the section, 2.5 feet thick, contains only 32.63 per cent of calcium carbonate, 1.80 per cent of magnesium carbonate, with 2.80 per cent of silica; it is one of the great phosphatic horizons, containing 55.5 per cent of calcium phosphate in a rock apparently not at all weathered. This is overlaid by 7 feet of rock with 85.6 per cent of calcium carbonate, 6.59 per cent of magnesium carbonate, 5.68 per cent of silica, and 9.39 per cent of calcium phosphate. Immediately above is a 9.5 foot section, containing 83.7 per cent of calcium carbonate, 6.20 per cent of magnesium carbonate, 7.58 per cent of silica, and 6.12 per cent of calcium phosphate.

MRS. BEN WILLIAMS' FARM, TWO MILES SOUTH OF GLENN STATION.

The road leading up the steep hill southwest of Glenn Creek station, exposing the Trenton section described on the preceding pages, passes the Mrs. Ben Williams farm, two miles southward. The farm house is a considerable distance east of the road. Northwest of the house is a shallow quarry exposing a very hard, fine grained blue limestone containing *Orthorhynchula linneyi, Lophospira medialis, Lophospira bowdeni, Ischo-ilina jonesi, Orthoceras milleri,* and a variety of *Hebertella* with more numerous radiating plications than *Hebertella frankfortensis.* This horizon evidently belongs to the Perryville. Lithologically it most resembles the darker limestone underlying the Salvisa horizon, between Nevada and Cornishville, in the western part of Mercer county. Farther eastward, between Harrodsburg and Danville, this lower horizon becomes richly fossiliferous, gasteropoda being abundant, especially in the lower strata, at the *Tetradium* horizons. This lower horizon also appears present on the Mrs. Ben Williams' farm, occurring just beneath the level of the quarry, and forming the so-called gasteropod layer. Locally, for instance a mile southwest of Frankfort, on the Louisville pike, representatives of the Salvisa layer occur. The fine grained limestone forming the upper part of the Faulconer section, at the Mrs. Ben Williams' quarry, contains 35.3 per cent of calcium carbonate, 22.39 per cent of magnesium carbonate, 38.10 per cent of silica, and 4.81 per cent of calcium phosphate. Its chemical composition differs altogether from that of any part of the Perryville section studied farther southward.

CORNISHVILLE.

Cornishville is situated on Chaplin river, about 8 miles west of Harrodsburg. The representative of the Faulconer section at this locality is comparatively unfossiliferous. This is in striking contrast with the section west of Nevada, where corresponding strata, lithographically identical, contain very well preserved fossils, weathering out beautifully in the residual clays. Toward Danville and Harrodsburg, the rock becomes extremely fossiliferous, whiter in color, and slightly coarser in grain, although still fine grained. The Faulconer rock which was chemically investigated therefore belonged to the western representative of this bed. It contained 89.4 per cent of calcium carbonate, 2.53 per cent of magnesium carbonate, 2.54 per cent of silica, and 2.68 per cent of alumina. The Salvisa layer, at the same locality, contained 95.5 per cent of calcium carbonate, 1.04 per cent of magnesium carbonate, and 2.74 per cent of silica, with only a trace of alumina.

The Salvisa is the very fine grained and very hard, whitish limestone, which most nearly resembles the Tyrone, or Birdseye, as exposed in Central Kentucky. It is overlaid by about 5 or 6 feet of granular limestone, containing a typical Trenton fauna. This upper Trenton horizon has been called the Cornishville bed. At Cornishville, it contains 87.7 per cent of calcium carbonate, 0.36 per cent of magnesium carbonate, 3.14 per cent of silica, and 3.19 per cent of alumina. At the deep railroad cut, southeast of Harrodsburg, the calcium carbonate content has dropped to 66.4 per cent, and the magnesium carbonate has risen to 12.23 per cent.

DEEP RAILROAD CUT, SOUTHEAST OF HARRODSBURG.

At the deep railroad cut, a mile and a half southeast of Harrodsburg, the Cornishville limestone, 5 feet thick, forms the base of the quarried section. The lower part of the overlying Catheys section, 7 feet thick, consists of fine grained limestone, having an argillaceous appearance. Part of the layers are soft, and have a shaly appearance. A sample giving the general run of this part of the Catheys section, gave 70.9 per cent of calcium carbonate, 1.16 per cent of magnesium carbonate, 22.62 per cent of silica, and only 1.46 per cent of alumina. The overlying part of the Catheys section, 12 feet thick, consists of coarser grained, richly fossiliferous limestone, and contained 70.9 per cent of calcium carbonate, 2.72 per cent of magnesium carbonate, 15.9 per cent of silica, and only 1.13 per cent of alumina.

GENERAL COMMENTS ON THE CHEMICAL COMPOSITION OF TRENTON AND LOWER ROCKS IN CENTRAL KENTUCKY.

Perhaps the most striking result of the chemical analysis here presented is the small per centage of alumina. Of course, this was expected in the case of the coarser grained, crystalline limestone, which evidently consisted very largely of calcium carbonate, but it was not expected of some of the finer grained strata, such as the Logana, nor of those rubbly limestones in the Wilmore which have a strongly argillaceous appearance. As a matter of fact, however, the analysis so far presented contain no case in which the per centage of alumina exceeds 3.55 per cent, and this per centage was presented by the Oregon bed, a horizon in which magnesium carbonate was expected to be very prominent.

It was expected that at the so-called argillaceous horizons, the alumina would be combined with silica, forming a considerable per centage of clay. As a matter of fact, however, the silica, even where quite abundant, could not have been present combined in the form of clay. The question is, in what form could it have existed? Apparently only in the form of free silica. Evidently in most cases this silica must have been present in the form of finely divided particles, and may have been brought in as silt from some distant shore. Silica is abundant in the Logana clay, and forms a considerable per centage even of the Logana limestone. A part of the silica present in the Curdsville limestone, usually in large part in the form of silicified fossils, may have originated to a great extent in the overlying Logana, and have been concentrated at lower levels owing to silicification accompanying weathering.

The per centage of silica is high again in the Catheys as exposed southwest of Harrodsburg. Here it also probably occurs as minute grains brought in as silt from some distant shore. The great per centage of silica in the Perryville section on the Mrs. Ben Williams' farm, two miles south of Glenn Creek station, is noteworthy when contrasted with the various analyses of Perryville strata secured near Cornishville. It does not follow from the numerous silicified fossils in the lower Perryville, between Danville and Harrodsburg, that silica once formed a large per centage of the rock. At these localities the silica probably has replaced the fossils as the result of conditions accompanying weathering, and the origin of this silica may have been as far up as the Catheys. Even the silica in the Woodburn bed may have been derived in part by the disintegration of overlying strata.

The Brannon layer, when more carefully examined, probably will prove another of the siliceous horizons in

which the silica is present in the free state in the form of very minute granules.

There is only one conspicuous clay horizon in the entire series of strata here under discussion, and this horizon, three or four feet thick, immediately overlies the Tyrone, at High Bridge. It consists of 56.13 per cent of silica, all chemically combined, and 23.79 per cent of alumina and the oxide of iron, the latter evidently only forming an inconsiderable part. This clay evidently could not have originated as the result of the decay of any strata now exposed in Central Kentucky, and must have been washed in as silt from some more remote locality.

The per centage of magnesium oxide exceeds 3.14 per cent only in the case of two analyses. In the Cornishville layer at Harrodsburg it equals 6.3 per cent, and in the Perryville outlier on the Mrs. Ben Williams' farm, it equals 10.66 per cent. The latter analysis is in violent disagreement with strata at the same horizon and having a similar lithological appearance, seen at Cornishville, farther southward. In general, it may be stated, therefore, that the Trenton and underlying strata, in Central Kentucky, form a remarkably pure limestone section, and are not at all dolomitic except very locally, and at very limited horizons. Judging from former analyses, there must be several layers of dolomitic limestone in the Oregon bed, but these limestone probably do not form any considerable part of the total section.

TABLE OF ANALYSES OF SAMPLES INDICATING THE CHIEF CHEMICAL CHARACTERISTICS OF TRENTON AND UNDERLYING FORMATIONS.

HORIZONS AND LOCALITIES.	Laboratory Numbers.	Moisture at 100° C.	Ignition (CO^2, Etc.)	Silica.	Alumina.	Ferric Oxide.	Calcium Oxide (Lime.)	Magnesium Oxide.	Phosphoric Acid (P_2O_5.)	Total.	Calcium Carbonate.	Magnesium Carbonate.	Calcium Phosphate.	Calcium Fluoride.
Upper Catheys, at Harrodsburg	3462	0.09	36.14	15.94	1.13	1.28	42.00	1.77	0.57	98.92	75.00	2.72	....	....
Lower Catheys, at Harrodsburg	3461	0.14	33.70	22.62	1.46	1.12	39.70	0.55	0.84	100.13	70.90	1.16	....	....
Cornishville, at Harrodsburg	3463	0.08	29.90	4.54	0.94	1.44	47.84	6.30	9.16	100.20	66.40	13.23	....	....
Cornishville, at Cornishville	3459	0.08	36.54	3.14	3.19	0.80	52.89	0.17	3.18	99.93	87.71	0.36	....	....
Salvisa, at Cornishville	3458	0.02	42.54	2.74	Trace	0.48	53.48	0.49	0.31	100.06	95.50	1.04	....	....
Faulconer, at Cornishville	3460	0.03	42.91	2.54	2.68	0.32	50.06	1.21	0.34	100.09	89.40	2.53	....	....
Faulconer, 2 miles south of Glenn's Station	3419	0.40	27.30	38.16	1.00	1.04	19.77	10.66	2.20	100.53	35.30	22.39	4.81	....
Woodburn, from 8 to 17.5 feet below top, at Versailles	3431	0.20	37.90	7.58	0.76	0.80	46.87	2.95	2.80	99.86	83.70	6.20	6.12	....
Woodburn, from 17.5 to 24.5 feet below top, at Versailles	3429	....	38.54	5.68	0.42	0.72	47.94	3.14	4.30	100.74	85.60	6.59	5.39	....
Woodburn, phosphate layer, unaltered rock, 24.5 to 27 feet below top, at Versailles	3455	0.18	15.40	2.80	0.70	1.12	50.96	0.86	25.40	99.66	32.63	1.80	55.50	4.62
Woodburn, from 27 to 35 feet below top, at Versailles	3426	0.06	40.32	3.96	0.10	0.64	49.84	2.81	1.40	99.22	89.00	5.90	3.06	....
Brannon, at Hullett Station	3413	0.18	40.46	7.70	0.23	0.64	47.49	2.69	1.30	100.69	84.80	5.65	2.84	....
Benson or Bigby, from 9 to 25.5 feet below Gleen Creek bed, at Glenn Creek Station	3445	....	43.26	1.00	Trace	0.48	53.93	0.96	0.42	100.05	96.30	2.02	....	....
Upper Wilmore of Miller, from 25.5 to 59 feet below Glenn Creek bed, at Glenn Creek Station	3452	0.12	42.62	2.44	0.05	0.48	52.08	1.64	0.51	99.94	93.00	3.44	....	....
Middle Wilmore of Miller, from 63 to 121 feet below Glenn Creek layer, at Glenn Creek Station	3453	0.28	42.40	2.02	0.16	0.48	53.59	0.56	0.74	100.23	95.70	1.18	....	....
Lower Wilmore of Miller, lower 23 feet, at Glenn Creek Station	3451	0.16	41.64	3.48	0.33	0.32	51.80	0.54	0.77	99.04	92.50	1.13	....	....
Logana limestone, at Millville	3433	0.34	35.50	17.18	0.38	1.28	43.50	0.51	1.20	99.59	77.80	1.07	....	....
Logana clay, at Millville	3432	1.34	20.70	44.98	2.21	3.84	25.88	0.45	1.85	101.25	41.20	0.95	....	....
Curdsville, at Frankfort	3456	0.08	37.22	11.88	1.54	0.80	46.37	1.19	1.46	100.54	82.80	2.50	....	....
Tyrone, at High Bridge	3450	0.22	41.00	6.38	0.23	0.48	48.44	3.00	0.11	99.86	86.50	6.30	....	....
Oregon, at High Bridge	3457	0.08	43.26	5.54	3.55	0.48	45.64	0.38	0.19	99.12	81.50	0.80	....	....
Camp Nelson, at High Bridge	3443	0.10	42.32	3.84	0.05	0.48	50.06	2.11	0.25	99.21	89.40	4.43	....	....

THE

PHOSPHATE DEPOSITS IN THE UPPER TRENTON LIMESTONES OF CENTRAL KENTUCKY.

TABLE OF TRENTON AND OTHER ORDOVICIAN FORMATIONS MENTIONED IN THIS REPORT.

Catheys	40 feet	Winchester and Cynthiana of former reports.	Granular limestone, predominating in upper half, argillaceous limestone and clay predominating in lower half of section. **Cyclonema varicosum.**
Perryville	35 feet	Cornishville, 5 feet	Granular limestone. Upper **Strophomena vicina**, **Dinorthis ulrichi** and **Stromatocerium** zone.
		Salvisa. (Name proposed by A. M. Miller.) 9 feet.	Very dense white limestone. Fossils usually extremely rare, but locally with **Isochilina jonesi** and **Leperditia linneyi** common.
		Faulconer, 20-25 ft.	Fine grained limestone, grayish or bluish brown, usually with numerous gasteropods, **Vanuxemia hayniana** and **Tetradium** Locally underlaid by coarser grained gray limestone with **Cyrtodonta grandis.**
Flanagan	60-70 ft	Woodburn. (Name proposed by A. M. Miller.) 50-60 feet.	Granular limestone, frequently phosphatic, but only locally of commercial value. **Columnaria alveolata.**
		Brannon. (Name proposed by A. M. Miller.) 7-10 feet.	Fine-grained argillaceous limestone, equivalent to typical Flanagan chert horizon, but the overlying Woodburn section was also mapped as Flanagan by Marius Campbell. **Strophomena vicina**, **Brachiospongia**, spicule bundles of **Pattersonia.**
Bigby	35 feet	Benson, 35 feet. (Doubtfully identified with Bigby of Tennessee.)	Granular limestone, occasionally phosphatic at the top. **Strophomena vicina**, **Dinorthis ulrichi** and **Stromatocerium** in upper third of section.
Wilmore	70 feet.	Wilmore, 70 feet.	Limestones, frequently argillaceous and usually interbedded with thin clay layers and weathering to rubble. **Herbertella frankfortensis** and **Rhynchotrema increbescens** range from lower part of Wilmore to top of Perryville. **Dalmanella bassleri** is common near top of Wilmore **Dalmanella fertilis** is sommon at base.
Logana	22 feet.	Equivalent to Saltillo and Hermitage of Tennessee.	Fine grained limestone alternating with clay layers of similar thickness; locally with granular limestone layers at top. **Heterorthis clytie** and **Dalmanella fertilis.**
Curdsville	23 feet	Equivalent to Kirkfield crinoid beds, extending from 40 to 100 feet above top of Black River in Ontario.	Granular limestones, interbedded with finer grained layers toward the base locally. **Dinorthis pectinella**, **Orthis tricenaria**, **Plectambonites curdsvillensis**, **Streptelasma corniculum**, **Dalmanella.**
Tyrone	80 feet	Equivalent to Lowville of New York and regarded by some as iower part of Black River.	Very fine grained, hard, massive limestone, breaking up into irregular blocks on quarrying; with richly fossiliferous layers, chiefly in the upper horizons, locally, and readily detected only where the rock is strongly weathered.
Oregon	30 feet	Doubtfully indentified with the Carters Creek bed of Tennessee.	Fine grained limestone, often readily quarried, and usually of a darker color than the Tyrone.
Camp Nelson	exposed 285 feet	Including Lebanon and Ridley beds of Tennessee.	Fine grained limestone, very hard and similar to that of the Tyrone.

THE PHOSPHATE DEPOSITS IN THE UPPER TRENTON LIMESTONES OF CENTRAL KENTUCKY.

BY AUGUST E. FOERSTE.

EARLIER DISCOVERIES OF PHOSPHATE ROCK IN CENTRAL KENTUCKY.

The presence of phosphate in the limestones of Central Kentucky was brought to the attention of the agricultural public by Dr. Robert Peter, in the Albany Cultivator, of New York, as early as April, 1849. Twenty-seven years later, while riding along the Newtown turnpike, north of Lexington, the attention of Dr. Peter was attracted to a somewhat friable, bluish-gray limestone fragment, brownish on the weathered surface, containing many minute gasteropod shells belonging to the genus *Cyclora,* which had been thrown out on a pile for road making, and which was found to consist of as much as 31.8 per cent of phosphoric acid, equivalent to 69.45 per cent of tribasic phosphate of lime. This limestone fragment had been quarried on the McMeekin farm, three miles north of Lexington. Four years later, ten samples from the same quarry were analyzed, but of these the six best samples averaged only 27 per cent of phosphate. In the mean time phosphatic limestone had been discovered also on the Randall Haley farm, much nearer Lexington, about half a mile beyond the first toll-gate, the five samples collected ranging from 12.2 to 17.6 per cent of phosphoric acid. Investigations were resumed eight or nine years later, and the known area of phosphatic limestone was somewhat extended. Within the city limits of Lexington itself, along the side of South Limestone street, near the Agricultural Experiment Station, thin layers were found varying from 29.73 per cent of phosphoric acid, equivalent to 64.93 per cent of phosphate of lime, down to 3.84 per cent of phosphoric acid. At the Winton farm, seven miles north of

Lexington, along the same Newtown pike, previously mentioned, only 3.136 per cent of phosphoric acid was detected in a softer layer between some of the harder layers of limestone. The failure of these discoveries to develop into any commercial enterprises may be readily understood when it is learned that nowhere were any of the richer layers found more than a foot in thickness, and, indeed, at only one locality had even this thickness been detected. As a rule, the samples consisted of very thin layers, often not exceeding half an inch in thickness, interbedded among much thicker layers of granular limestones in which the phosphatic content was very small.

Although these earlier investigations did not result in the discovery of phosphatic rock in sufficient quantity to make possible its sale as a commercial product, its value agriculturally was readily recognized. In his report published as chemist of the Kentucky Geological Survey, in 1890, Dr. Robert Peter states that the great durable fertility of the region occupied by the Trenton limestone, in Fayette and neighboring counties, is largely due to the phosphoric acid and other fertilizing materials which exist in notable proportions in this limestone. This was indicated by many analyses made by him from different layers of limestone from different localities in Fayette county, but the layer in one of the Newtown pike quarries, reputed to have had a thickness of one foot, still remained the maximum thickness known.

Interest in phosphatic limestones was enormously aroused in 1896 by the publication by Charles Willard Hayes of a report on the phosphatic limestones of western Tennessee. It was soon recognized that the richest deposits of phosphate rock in Maury County, in Tennessee, were of Trenton age, and had at least approximate stratigraphical equivalents in central Kentucky. Prof. Arthur M. Miller, of the State University, at Lexington, made numerous qualitative tests of the strata exposed in Fayette and neighboring counties and demonstrated the wide spread of phosphatic strata in the upper part of the Trenton section, but did not find phosphatic sections of sufficient thickness to warrant the quarrying of the rock for their phosphatic content.

Aside from the various Ordovician strata, found to be phosphatic in western Tennessee, rich phosphate deposits, though of comparatively small thickness, had been found also in the Devonian strata immediately underlying the Chattanooga Black shale. This led to a trip down the Cumberland river, in southern Kentucky, from Burnside to Burksville, during which Prof. Miller and the writer made numerous studies of the geological sections exposed along the steep cliffs. Prof. Miller gave especial attention to the phosphatic content of the strata at the base of the Devonian black shale section, and found numerous indications of phosphatic ingredients, but nothing of commercial value.

In his report on the Lead and Zinc Bearing Rocks of Central Kentucky, published in 1905, Prof. Miller identified as Bigby all the strata included in both the Bigby and Flanagan of the present publication. As forming the very top of the Bigby in many localities, especially in the counties of Woodford and Franklin, he placed the "gasteropod layer", now known as the northern equivalent of the Faulconer layer. In the immediately underlying strata, recognized as the principal phosphate horizon, and at present referred by him to the Woodburn beds, he found *Columnaria alveolata,* associated with *Constellaria teres,* a very abundant and characteristic fossil, occurring as silicified masses in the deep red soil resulting from the decomposition of the limestones at this horizon. The base of the section at that time regarded as Bigby is well established by the statement that, in western Woodford and in adjoining Anderson and to some extent in Franklin county, there is developed in the Trenton section, about 60 feet above the base of the Bigby, an argillaceous limestone bed having a maximum thickness in one place of 29 feet. Above this comes in the same locality about 30 feet of granular phosphatic limestone. This is the first identification, in geological literature, of the Trenton phosphate horizon to a definite division of the Trenton section. It is evident that the argillaceous limestone mentioned by Prof. Miller is the horizon to which he now gives the name Brannon, while the overlying granular phosphatic limestone belongs to that part of the section to which he applies the term Woodburn. The various changes in the terms used to designate the various strata discussed were necessitated by discoveries made in more recent years. Between five and ten feet below the base of the Brannon bed Prof. Miller found a horizon at which *Stromatocerium,* in large hemispherical masses, often weighing several hundred pounds, ranged from Fayette into Scott and Franklin counties. *Hebertella frankfortensis* and *Rhynchotrema increbescens* were noticed to be fairly abundant from the base of the Benson to the top of the Woodburn beds, as defined in the present paper. Subsequent investigation has shown the presence of the latter fossils in abundance in the Cornishville layer, and occasional specimens occur within 20 feet of the base of the Wilmore bed. With these and other fossils as guides, Prof. Miller, during the summer of 1905, greatly extended his observations on the phosphatic limestones of Central Kentucky, and discovered the field which has since resulted in the only commercial operations so far undertaken. This is the territory lying between Versailles and Midway.

The phosphatic rock occurs here in the form of thin, rather porous-looking, yellowish brown plates, evidently the result of weathering of the upper layers of the Trenton limestone. The horizon, now known as Woodburn, was sufficiently identified by the presence of *Columnaria alveolata.* It was found that there is hardly a locality where this horizon has been exposed in upland situations, as the result of slow denudation of the overlying beds, where thin plates of this phosphate rock can not be found. Samples were collected from a locality in Woodford County, about three quarters of a mile east of Wallace station, running as high as 33 per cent of phosphoric acid, equivalent to 72 per cent of calcium phosphate. The samples first collected consisted of plates of leached limestone, from half an inch to an inch and a half in thickness, and weighing from one to three pounds. These lay scattered very thickly over the surface of a roadside slope, and, on digging down, were found disseminated through the soil nearly to the bed-rock—here from one to two feet below the surface. The locality was regarded as of very promising character, and is in the first district mentioned by Prof. Miller as

among those favorable for further prospecting. It should be noted in this connection that the phosphate rock at present quarried, southeast of Wallace station, lies less than three-quarters of a mile west of the locality which Prof. Miller recognized as warranting further prospecting. Had his services not been diverted during the summers of 1906 and 1907 to a study of the Lower Coal Measures of the Eastern Coalfield of Kentucky, and during 1908 to a study of the soils of south-central Kentucky, the commercial value of the phosphate fields near Wallace would no doubt have been recognized much earlier.

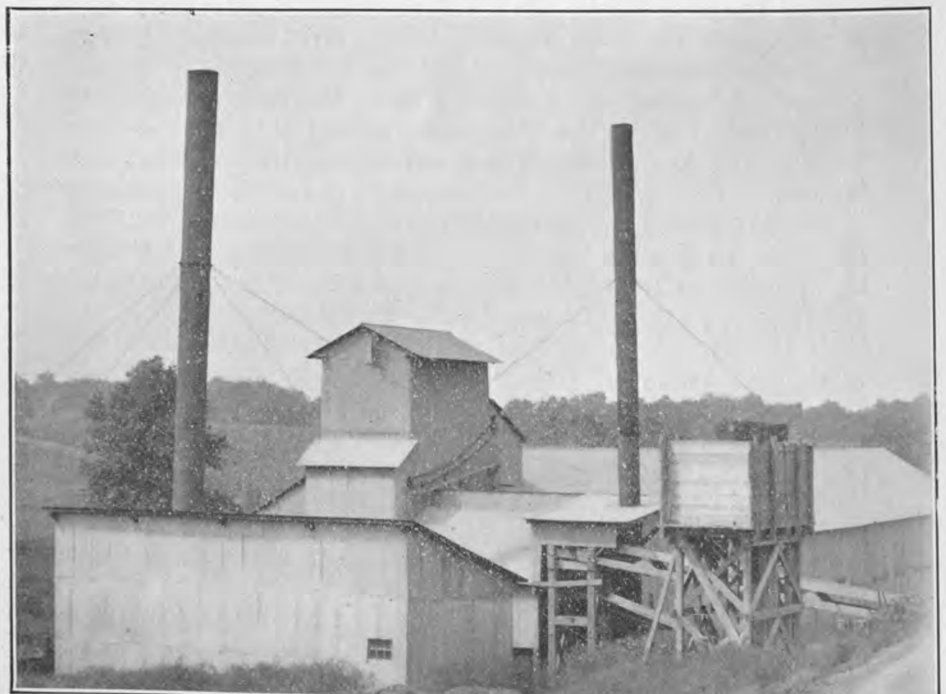
In the meantime, the phosphate fields in Maury and neighboring counties of southwestern Tennessee were being rapidly exhausted and the various companies there interested were searching for new territory. Various men familiar with the Tennessee phosphate rock began visiting the phosphatic areas of Central Kentucky. It is notable that all of these prospectors began operations in the Wallace area to which Prof Miller had attracted attention in his preliminary report, an extract of which was published in the Report on the Progress of the Survey for the years 1904 and 1905. From this central area, their investigations extended in all directions, resulting in the discovery of promisng localtes between Wallace staton and various points about a mile and a half eastward, and also several promising deposits between two and two and a half miles northwest of Midway. During the summer of 1910 and the spring of 1911 these investigations had advanced far enough to cause considerable excitement. Leases were being taken in every direction, and on June 11, 1911, the Lexington Phosphate Company was formed, by three men from Birmingham, Alabama.

In the meantime the writer had entered upon a special investigation of the field. The numerous notes and maps collected by Prof. Miller, and a special report on the Geology of Woodford Cunty, were placed at his command, Prof. Miller accompanying him on various trips through the territory under consideration. From the preceding notes it will be seen that the general data had already been established, and only the more detailed work remained to be done.

RECENT INVESTIGATIONS OF THE TRENTON PHOSPHATE DEPOSITS OF CENTRAL KENTUCKY—WOODFORD COUNTY.

THE LEXINGTON PHOSPHATE COMPANY PROPERTY, SOUTHEAST OF WALLACE.*

More attention has been given to the property worked by the Lexington Phosphate Company, on the Davis farm, southeast of Wallace station, because this is the only locality at which phosphate rock is quarried at present for commercial purposes.



Phosphate Mill at Wallace, Ky.

It is favorably situated as regards transportation. The farm lies immediately east of the branch of the Southern railroad running from Versailles to Midway. A switch leaves the railroad a short distance south of the

*Now Central Kentucky Phosphate Co.

station at Wallace, and enters the western margin of the farm. A plant has been erected at the end of the switch, several hundred yards south of the pike, within easy reach of the diggings, and here the phosphate rock is ground for use as a fertilizer, without further treatment.

There is nothing striking topographically about the farm. Most of the land is comparatively flat, sloping westward toward the broad and very shallow valley followed by the railroad. This slope is rather gradual, but gradual slopes are regarded as much more favorable for the development of valuable phosphate deposits than steep slopes. There is a more uniform disintegration of the overlying limestone, and a more uniform concentration of the phosphatic material at approximately the same level beneath. Where the slopes are gradual there is a greater uniformity in the amount of disintegration shown by the layers in which the phosphatic material has been concentrated. This is a matter of great importance, since the readiness with which the phosphate rock can be worked depends not only on the ease with which the overlying rock and soil can be removed, but also upon the amount of disintegration which the phosphatic layers beneath have undergone. The leaching out of calcium carbonate not only increases the relative amount of calcium phosphate, as determined by comparing the weight of the contained calcium phosphate with the total weight of the rock, but also softens the phosphate rock, and makes it more readily worked. However, if softened too much, the rock crumbles into a friable mass, not readily handled, locally but incorrectly called *matrix* by the operators.

It has been observed, also, that when the slope is comparatively small, the vertical thickness of the section in which the phosphatic material has been concentrated usually is greater, probably owing to the slower circulation of underground waters.

The original exploration of the farm was done by means of pits. These were vertical, rectangular openings sufficiently large to enable the digger to wield his pick and shovel readily. In all cases these were sunk until the solid rock beneath the phosphatic layers was struck.

On the Davis farm, the phosphatic rock was found immediately above the solid rock, and usually had a thickness of only two or three feet, excepting where weathering had causd disintegration along certain lines between masses of comparatively solid rock, which after the removal of the phosphatic material remained behind as large irregular limestone masses or "horses."

The limestone above the phosphate horizon had disintegrated chiefly into clay, more or less gritty with the siliceous matter which had been present during the later stages of the limestone. The grit was often richly fossiliferous, the fossils consisting chiefly of *Hebertella frankfortensis* and *Rhynchotrema increbescens*. Two of the pits were allowed to remain open until the beginning of summer, in 1911. One of these was located in the wheat field now occupied by the diggings, fairly well down the western slope of the land, about 200 yards south of the pike. This pit was close to the western margin of the workable phosphate horizon. Here a phosphatic section, apparently 6 feet thick, was exposed below 4 feet of overburden. Southeast of this pit about 300 yards, nearer the top of the hill-land, a second pit exposed a phosphatic rock section, apparently 5 feet thick, beneath an overburden of about 7 feet. In both pits, the diggings had struck places where phosphatic material occurred in the spaces between horses. Subsequent developments upon this farm have shown the danger of estimating the workable thickness of phosphate deposits from such selected pits left for the information of strangers, since it is practically certain that only the most promising pits will be permitted to remain open, and these pits almost always are those that have struck the thicker phosphate deposits between horses. Such pits suggest a greater workable thickness of phosphate rock than actually exists on the average. Even when the sides of the horses are exposed along the walls of the pits, the stranger is likely to regard the horses as occasional instead of frequent. The notable thicknesses of phosphatic material obtained in the depressions between the horses may be very misleading in determining the value of the phosphate field commercially.

The fallacy of estimating a phosphate field from such data was noticed during the later operations on this farm. A strip 50 feet wide and several hundred yards long was uncovered along the western margin of the workable deposits of phosphate rock, during the late summer. Here horses were encountered every 3 to 5 steps. An idea of the frequency of these horses may be secured from the following data, in which the single numbers indicate the number of steps taken from the middle of one, not very broad, horse to the middle of the next one. In these cases the width of the horses usually equals about one-third of the width of the intervening spaces, the latter being filled with phosphatic rock.

View in Phosphate Mine at Wallace, Ky., showing limestone "horses."

When two numbers occur united by a dash, the horses dicates the number of steps taken as a measure of the space between two horses, while the second indicates the width of the next following horse. Each step indicates a distance of approximately two and two-fifths feet. The measurements were made while going from south to north along the western margin of the second strip of overburden removed by the diggers, or 50 feet east of the western margin of the first strip. This was the richest part of the field so far uncovered. The numbers of encountered were much wider; the first number then insteps taken, in accordance with the preceding explanations, was as follows: 5, 4, 3, 5, 4—5, 3, 2, 4, 3—4, 3—2, 5, 4, 4, 5, 5, 6, 8, 7, 2—4, 4, 3, 2—3, 2—3, 2, 4—4, 1—7, 2—4, 2—2, 1. From this it will be seen that 29 horses were encountered in a length of 143 steps or an estimated distance of 343 feet. It is estimated that the horses occupied at least one-fifth of this length measured lineally. It is when the large total area occupied by these horses is considered, and when the difficulty of digging in such narrow quarters is taken into account, that the significance of the presence of great numbers of these horses is best understood.

Along the first 50-foot wide strip uncovered along the western margin of the field, the overburden was from 2 to 4 feet, while the thickness of the underlying phosphatic rock section down to the level of the top of the horses, varied from two and a half to three feet. This thickness, of course, was increased between the horses. It should be noted, however, that in all cases the phosphatic strata could be seen to sag between the horses, drooping like festoons, in vertical section, from the crest of one horse to the crest of the next. Near the middle of these festoons the phosphatic rock fragments evidently are more loosely arranged, while on the crests of the horses they are more densely packed together. From this it is estimated that an average thickness of phosphatic rock not exceeding 3 feet was ample to account for all parts of the field exposed at that time. It will be remembered that the two pits which were allowed to remain open for the longest time, of course by no means the poorest exposures uncovered, since it was desired to interest capital, gave estimates of 5 and 6 feet of phosphatic rock instead of scarcely three feet. From this it may be seen how far it is possible to go astray from estimates based on exposures made by pits. The significance of such an error in the estimation of the value of a field needs no further elucidation. It should be stated that the Lexington Phosphate Company understood this point perfectly and was not satisfied with the data received from pits.

Very soon after it was determined to open the field commercially, the company inaugurated a system of prospecting substituting long trenches at varying inter-

vals for the scattered pits. These trenches were arranged as follows: The western part of the farm slopes rather gently toward the west, and the richer phosphatic layers were expected near mid-slope along the hillside, judging from previous prospecting by means of pits. The trenches were dug, about two and a half feet wide, in an east and west direction, up the slope of the hill. This caused them to cut across the western margin of the most richly phosphatic horizon. Beginning at the fence at the rear of the garden plot surrounding the farm house, the distance to the first ditch, southwards, was 19 steps; 7 steps farther south a single sample pit had been dug; 34 steps farther there was cut a second ditch or trench; 60 steps farther south there was a third trench, and at one point this trench was carried down to a depth of 7 feet so as to expose the underlying rock; 50 steps farther south was located the lower one of the pits which was allowed to remain open, as stated earlier in this report. The top of this pit was about 840 feet above sea level. Since the overburden here was 4 feet, the phosphate rock occurred between 833 and 837 feet, except where it extended downward between the horses.

The first prospecting of this field, as already stated, had been done by means of pits; the second, by means of transverse trenches; the third, by entirely removing the overburden and thus uncovering the phosphate rock along strips 50 feet wide and several hundred yards long. The first strip began half way between the second and third transverse ditches, 230 feet south of the garden fence, and continued for a length of 575 feet southward. The uncovered phosphate rock, of course, was quarried out and used. Southward, beyond this uncovered strip, the prospecting was continued by a series of transverse ditches for a distance of 100 feet, exposing the character of the underlying phosphate rock. Along this first strip the overburden was found to vary between 2 and 4 feet, while the thickness of the available phosphate rock ranged from two and a half to three feet on an average, making allowance for the sagging of the phosphate rock in the spaces between the horses.

After the first strip of overburden had been removed, and the exposed phosphate rock collected, a second strip, also 50 feet wide, was begun. The quantity of phosphate rock exposed by this second strip did not appear to be quite equal to that uncovered by the first diggings, and this was true also of the third strip. When last visited, no extensive territory had been uncovered from any of the upper slopes of the hill. This, however, would be desirable to determine the maximum vertical section from which workable phosphate rock might be expected.

While the level of the phosphate rock uncovered in the lower pit mentioned first in this report was from 833 to 837 feet above sea level, that in the second pit, southeastward, along the upper slopes of the hill, extended from 865 to 870 feet above sea level. This suggests a vertical range of at least 37 feet within which commercially valuable phosphate rock may be found.

Numerous samples have been taken at various times from the exposures on the Davis farm, or the Lexington Phosphate Company plant as it is now known. In the first pit, dug 200 yards south of the fence around the garden plot, only the phosphate rock fragments were selected, the interbedded "matrix" or more completely decayed rock having been discarded. This sample contained 76.47 per cent of calcium phosphate. At the second pit, several hundred feet southeastward up the hill, the general run of the phosphatic part of the pit, including the matrix, was collected, and the sample was found to contain only 34.96 per cent of calcium phosphate. It is not safe from this to conclude that the matrix usually is devoid of commercially valuable phosphate. For instance, when twenty pounds of material, including both the phosphate rock and the matrix, were collected from about thirty localities within the first fifty-foot strip, between 300 and 600 feet south of the pike, the sample was found to contain 68.83 per cent of rock phosphate. The chief objection to an abundance of matrix in some cases is the difficulty in handling the material readily.

In a sample taken from the third ditch, about 280 feet south of the garden fence, 76 per cent of calcium phosphate was found. The rock occurred 7 feet below the top of the soil, and only the richer phosphate fragments were collected. Another sample was collected about 460 feet south of the fence around the garden plot, along the first strip exposed along the western edge of the phosphate diggings. Here two and a half feet of phosphate rock were found under two and a half feet of overburden. The sample consisted of the general run of material, including as much of the matrix as it was possible to secure by the method employed in sampling. Here the calcium phosphate equalled 73.74 per cent, again demonstrating that the richness of the matrix depends less upon its physical condition, and more on its origin. Where the matrix results from the decay of a richly phosphatic rock, the matrix also is richly phosphatic.

Seven hundred feet south of the fence around the garden plot, two and a half feet of phosphate rock were uncovered under three to four feet of overburden. Here no matrix was collected excepting such as happened to adhere to the phosphate rock chips. The sample contained 65.76 per cent of calcium phosphate.

WILLIAM STEEL FARM, A MILE EAST OF WALLACE STATION.

A little over a mile east of Wallace station, a lane leads northward from the pike to a farm house belonging to Mrs. M. B. Murray. Immediately opposite, on the south side of the pike, near the edge of the hill land, a pit was dug, exposing 5 feet of phosphate rock fragments under 7 feet of overburden. The pit had entered a space between horses. There was considerable sagging among the rather loosely arranged phosphate rock fragments into the depression between the horses. In one part of the pit, the fragments stood on edge, vertically, in another part the fragments had an inclination of about 45 degrees, and in a third part many of the fragments were horizontal, but evidently had sagged considerably beneath their former level. Notwithstanding these misleading conditions the pit demonstrated the presence of several feet of commercially valuable rock. A sample of the general run of the pit was attempted, but only a part of the matrix was secured. Since the sample contained 69.92 per cent of calcium phosphate, the matrix must have been fairly phosphatic also. The elevation of the phosphatic layers here extended from about 845 to 850 feet above sea level.

About an eighth of a mile west of the entrance to the lane leading to the home of Mrs. M. B. Murray, phosphatic rock fragments are exposed along the pike at an elevation of 860 feet above the sea level. The chips varied in thickness from a quarter of an inch to half an inch. Only the better looking fragments were selected, and these gave a sample containing 78.22 per cent of calcium phosphate. This is the richly phosphatic locality discovered by Prof. Miller in 1905.

Phosphatic rock was found also in a pit dug fully a quarter of a mile east of the lane leading to the home of Mrs. M. B. Murray, but on the south side of the pike, along the top of the hill land several hundred yards northeast of the home of William Steele. The pit was about 15 feet deep. Chips, half an inch thick, were selected from the material at the mouth of the pit. The sample contained 76 per cent of calcium phosphate. The phosphate rock horizon extended here for about 863 to 867 feet above sea level. Comparing the elevation of the phosphate rock in the pit northeast of the house on the Steele farm with that northwest of the house, opposite the Murray lane, there would appear to be a vertical range of at least 22 feet at which workable phosphate rock may be found. In other words, while the thickness of the phosphatic rock at any one locality in this area may not exceed 4 or 5 feet, the total vertical range of the phosphatic deposits as they are followed along the hill slopes may equal 22 feet.

Two and a quarter miles east of Wallace station, half a mile west of the Pisgah road, a little phosphatic material occurs in the form of very thin slivers of finer grained rock, picked out from between the ordinary gray crystalline limestone layers. The horizon was approximately 860 feet above sea level. Although the analysis of the sample collected gave 23.59 per cent of calcium phosphate, it must be remembered that these phosphatic slivers form a practically negligible part of the rock section here, and there is no doubt of their total lack of value commercially.

STARK FARM, A MILE AND A HALF SOUTH OF WALLACE, ON THE VERSAILLES PIKE.

A mile and a half southwest of Wallace, on the pike from Versailles to Midway, a quarry is located on the eastern side of the pike. The quarried rock consists of gray, granular limestone. Near the top of the quarry there are some finer grained, dark blue bands, sometimes very thin, which were sampled separately and were found to contain 64.57 per cent of calcium phosphate. Where this material is strongly weathered, it is dark brown in color and contains 75.38 per cent of calcium phosphate. This weathered material was found only in the upper parts of the quarry. It formed a section three to five feet thick. The original rock had weathered very irregularly. Some of the unweathered masses remained as bosses or horses, between which the weathered phosphatic layers sagged downward. This downward sagging of the weathered phosphate rock between the limestone horses is sufficient evidence of the shrinkage of the rock section, due to the leaching out of the calcium carbonate.

Directly west of the Stark quarry, on the Lister Witherspoon farm, there is a lane leading back to some farm houses. Along this lane, within 200 yards of the pike, there is an exposure of phosphate rock fragments. The fragments occur approximately on a level with the basal part of the Stark quarry. They are scattered over a vertical interval of two feet but evidently are not in place and formed but a small part of the original section. By selecting only the most promising material, a sample containing 80.8 per cent of calcium phosphate was obtained. Another sample, selected from material exposed on the south side of the small stream, nearly opposite the first locality, contained 65.99 per cent of rock phosphate. Neither sample gave the least promise of commercially valuable rock, since the phosphatic rock, no matter how rich, evidently formed only an inconsiderable part of the rock section. The misleading character of a sample selected from among the most promising chips occurring along a roadside or on a hill slope requires emphasis. Such sampling can not reach any practical results. For commercial results it is necessary to find not only richly phosphatic layers but also a sufficient total thickness of them, in a practically continuous vertical section, to make their commercial exploitation profitable. It was difficult to persuade some of the owners of properties from which samples rich in calcium phosphate had been secured, that the samples were worse than useless, since they did not take into account the relative amount of the phosphatic rock compared with the total section which it would be necessary to exploit. Thin phosphate layers selected from between ordinary limestone layers have practically no commercial value.

VERSAILLES.

The new line of railway from Versailles to Frankfort passes beneath the Frankfort pike by means of a deep vertical cut exposing the upper two-thirds of the Woodburn bed. Since this bed appears to be the one in which the phosphatic material of commercial value, in central Kentucky, originates, and since the cut at Versailles exposes an unusually large amount of unweathered rock, readily accessible, a special study of the phosphatic contents of this section was made. The commercially valuable phosphate rock appears to originate by the decay of the less phosphatic upper layers and the concentration of the phosphatic material at lower levels. At most localities, this concentration takes place at lower levels in the Woodburn bed itself, but locally also the upper part of the underlying Benson or Bigby bed become phosphatic.

The top of the Woodburn bed is exposed directly north of the depot at Versailles. Here the highest rock contains *Orthorhynchula linneyi*, a fossil indicating the presence of the Catheys formation at this locality. This fossil occurs only in the loose residual limestone fragments occurring immediately above the massive Woodburn limestone. Extending from the depot westward along the railroad, down grade, a total vertical thickness of 38 feet of medium or coarse grained limestone is exposed. Most of this limestone is of gray color, but here and there, and especially at the lower levels, layers of a darker color are interbedded, which, on chemical analysis, prove to be more or less richly phosphatic. Most

of these darker phosphatic layers are very thin, running like horizontal and more or less irregular seams through the ordinary limestone, but at one horizon, twenty-four and a half feet below the top of the Woodburn bed, the darker rock forms by far the greater part of a two and a half foot section, which evidently would give rise to commercially valuable rock, if weathered and brought nearer the surface by such natural agencies as were active in the Wallace area.

The following is an account of the results obtained by a study of this cut. The depot at Versailles is situated about four hundred feet east of the Frankfort pike. The Frankfort pike is supported, where crossing the railroad, by means of an arched concrete bridge, the arch being supported on each side of the cut by a high vertical wall or foundation of concrete lining the wall of the cut. That part of the arch which rests directly on the concrete foundation is here called the base of the arch.

The top of the Woodburn bed, at the depot, is 8 feet above the base of the arch at the bridge. The rock belonging to this 8 foot interval consists of granular limestone, but contains also some thin phosphatic layers. Along the northern side of the cut, these phosphatic layers have weathered out into fragments several inches broad and scarcely a quarter of an inch thick. Although rich in phosphate, these fragments form too small a part of the entire mass to have any commercial value.

The part of the rock section which extends from the base of the arch of the concrete bridge down to a level nine and a half feet lower is well exposed both east and west of the bridge. The unweathered rock was sampled on the western side (Sample 3431), and the chemical analysis indicated 6.12 per cent of calcium phosphate. This sample included all of the rock belonging to this part of the section, whether phosphatic or not. Equal quantities of rock were broken out from every vertical inch exposed at several localities along the cut where complete sections of this nine and a half foot interval were exposed. This is the only kind of sampling which can furnish any reliable information as to the general characteristics of any section, or part of a section. Isolated hand specimens often produce very misleading results. East of the concrete, between it and the depot, the coarser grained limestone rock has weathered away locally, or has left a residual red clay, in which the original thin phosphate layers remain as thin fragments of a brownish color, less than a quarter of an inch thick, containing 71.66 per cent of calcium phosphate. They represent too small a part of the original rock to have any commercial value.

That part of the rock section which extends from nine and a half feet beneath the base of the arch of the concrete bridge to a level 7 feet lower also was sampled west of the concrete bridge. The unweathered rock, including all of this part of the section, whether phosphatic or not, (Sample 3429) gave 9.39 per cent of calcium phosphate. Where the rock had weathered away, leaving only thin phosphate layers in a matrix of red clay, the phosphatic fragments contained 65.99 per cent of calcium phosphate. In that part of the Woodburn section so far described, twenty-four and a half feet thick, the richly phosphatic layers are thin, and, although rich, are so widely separated in the original rock by coarsely grained grayish limestone in which the phosphatic contents are small, that they can have no commercial value, as phosphate rock. Ground up for liming the soil, the additional phosphatic contents would have value, and ground limestone from this source should bring a higher price for liming purposes than ordinary ground limestone. The phosphatic ingredients would act as a fertilizer while the lime corrected the acidity of the soil.

Between sixteen and a half feet beneath the base of the arch of the concrete bridge and a level two and a half feet lower, there is a two and a half foot section in which the rock consists of light and dark gray limestone more or less interbedded. The quantity of the darker rock is so great at this horizon that in some parts of the long railroad cut this darker color readily distinguishes this horizon, even when viewed from a distance. The unweathered rock at this horizon was sampled, both the light and dark gray layers being included in the sample.

The sample (Sample 3425) was collected near the small overhead bridge located immediately west of the concrete bridge, and used only by a switch crossing from the main track of the railway leading to Lawrenceburg. The sample contained 27.31 per cent of calcium phosphate. The darker layers from this horizon (Sample 3455) contained 55.5 per cent of calcium phosphate, thus demonstrating again that it is chiefly the darker, finer grained rock in the Woodburn section which contains the richer deposits of phosphatic material, this fact being true of the rock even in its unweathered condition. Farther west in the same cut, where the overlying rock had been weathered to a red clay, and where the gray limestone layers interbedded with the darker layers at the two and a half foot horizon had suffered partial decay, the phosphatic darker layers contained 68.8 per cent of calcium phosphate, illustrating the increase in the relative percentage of calcium phosphate on the decay of the rock, due partly to the removal of the calcium carbonate at this lower horizon, and partly also to segregation of phosphatic material released by weathering from numerous higher layers and then concentrated in this narrow zone at a lower level. It is evident that if in the course of time the rock overlying this lower horizon were so strongly weathered as to be reduced chiefly to red residual clay, and if the lower horizon then were rendered readily accessible by the partial removal of this clay, resulting from the wash produced by rain falling upon its surface during many years, this lower horizon eventually might become a commercially valuable phosphate deposit. Something like this is supposed to have taken place in the Wallace area now being exploited.

Between 19 and 27 feet below the base of the arch of the concrete bridge, the rock is similar to that above the richly phosphatic horizon last mentioned. A sample including all of this part of the section, whether phosphatic or not (Sample 3426), contained 3.06 per cent of calcium phosphate. Farther west, where the rock was strongly weathered at this horizon, thin phosphatic fragments were secured which contained 74.01 per cent of calcium phosphate; however, these fragments formed such an insignificant part of the section that there is no doubt of their lack of commercial value.

The base of the section exposed by the railroad cut is a small thickness of rock, about two feet, similar to that above but not sampled.

It will be noticed that only a small part of the section at Versailles ever could have any commercial value, even if favorably exposed as regards the amount of overburden to be removed. Nevertheless, the study of this section is highly instructive. It indicates the general distribution of phosphatic material in the unweathered rock throughout the Woodburn horizon. It demonstrates that at most horizons the percentage of phosphatic material is low, the numbers varying from 3.06 to 9.39 per cent. The phosphatic material is concentrated chiefly along fine grained darker layers in the limestone, often less than a quarter of an inch thick, in fact frequently not exceeding a thirty-second of an inch in thickness. At some horizons, however, the quantity of the darker rock, rich in phosphate, is much greater. It is probable that these richer parts of the section vary in horizon, but so far they have been discovered chiefly in the lower part of the coarsely granular part of the Woodburn limestone bed. The darker rock usually is richly phosphatic even in the unweathered conditon, but proves much richer after weathering. At Versailles the dark rock at the lower horizon contained 55.5 per cent where unweathered, and 68.8 per cent where weathered. At the Stark quarry, three and a half miles north of Versailles, the corresponding percentages were 64.57 for the unweathered rock, and 75.38 per cent for the weathered rock. Perhaps the most important conclusion is this: If the unweathered finer grained dark blue rock represents the product of original deposition, and not of subsequent segregation, then original deposition has played a more important factor in the segregation of phosphatic materials in sufficient quantities for commercial purposes, in central Kentucky, than subsequent concentration resulting from decay. In other words, the richer phosphate deposits occur at those elevations, locally, where there was abundant phosphatic material even before weathering began to add to the relative percentage of phosphatic material present.

A mile north of Versailles, where the pike to Midway branches off from the pike to Frankfort, phosphatic rock fragments occur in the shallow ditch west of the road corner. Selected fragments, representing a small part of the total section, gave 69.26 per cent of lime phosphate. The elevation of the phosphatic rock here is about 874 feet above sea level. There are rumors of good phosphate rock having been found on the neighboring farms, west of the pike, but nothing indicating commercially valuable phosphate rock was found at the surface.

SLACK FARM, TWO AND A QUARTER MILES NORTHWEST OF MIDWAY.

The Slack farm is reached by going from Midway half a mile northward, to the Leestown pike, and then turning westward for a distance of nearly two and a half miles. The farm house is situated on the south side of the pike. Several sink holes, occupied by ponds, occur south of the farm house, and the nearest pit, which was kept open during the summer of 1911 in order to attract outside capital, was located southeast of the first large sink hole containing water. At this pit there was an overburden of 9 feet resting on phosphate rock said to have a thickness of 7 feet. Although the pit was open, there was no ladder for examining it closely. The phosphatic fragments at the mouth of the pit were thin, usually less than half an inch thick, but included excellent specimens of phosphate rock. A sample consisting of the better grade of material found at the mouth of the pit, gave 71.23 per cent of calcium phosphate. A second pit, also remainng open for the benefit of visitors, was located several hundred yards southeast of the more southern lime sink which contained water. It was located at the eastern edge of a large wheat field. Here the overburden of 9 feet rested on phosphate rock said to be 3 feet thick. The phosphate rock was sampled from the dump and none of the matrix was taken. It contained 82.37 per cent of calcium phosphate. These two samples compare very favorably with the selected samples from other localities, so that if the rock occurs with the thickness claimed by those who were interested in the property, namely 3 and 7 feet at different localities, this should prove a valuable area commercially.

At the first mentioned pit, the elevation of the phosphate rock extended from 826 to 833 feet above sea level. At the second pit, it extended from 837 to 842 feet. This gave a vertical range of 16 feet for the section within which phosphatic rock may be expected.

The Slack farm was very thoroughly explored by parties interested in the commercial development of the phosphate territory around Midway. Six hundred and fifty acres were tested on the Slack farm, and on the Thomas farm, immediately eastward. Sample holes, several inches across, were drilled every 200 feet in every direction, the field being blocked out in squares. This undoubtedly is the most intelligent prospecting on a large scale done so far in the State, but up to date it has not led to the opening of this part of the area commercially.

THE GEOLOGICAL POSITION OF THE COMMERCIALLY VALUABLE PHOSPHATE IN WOODFORD COUNTY—

WALLACE AREA.

Half a mile southwest of the Lexington Phosphate Company plant, southeast of Wallace, the base of the Brannon bed is exposed at an elevation of about 847 feet above sea level. At the road corner a mile east of the plant, the base of the Brannon bed occurs at 864 feet. A mile and a half north of the plant the base of the Brannon bed occurs at 815 feet. From these data it is evident that the diggings so far made by the Lexington Phosphate Company, at their plant southeast of Wallace, belong to the upper part of the Benson or Bigby bed, and not to the Woodburn bed. This is confirmed by the latest diggings made at the plant. Here the basal part of the Brannon bed was exposed about half way up the hillslope, above the level of the first three strips of phosphate rock, fifty feet wide, so far removed. Here *Dinorthis ulrichi* and *Stromatocerium* occurred in the upper part of the phosphate rock, beneath the base of the

Brannon layer, clearly indicating the geological horizon. The phosphate rock struck northeast of the house on the Steele farm, about a mile and a quarter east of Wallace station, however, belongs to the lower part of the Woodburn horizon.

It is evident that, locally, weathering away of the Woodburn bed has resulted in the concentration of phosphatic material at the top of the next underlying limestone, which in this case is the Benson or Bigby bed. It is interesting that, at the only locality at which so far any actual commercial development of the phosphate field has been undertaken, the only workable rock so far exploited should belong to the Benson and not the Woodburn horizon. Aside from this limited area in the neighborhood of Wallace, there are also other localities at which phosphate rock occurs in the upper part of the Benson bed, but by far the greater number of occurrences of phosphate deposits, taking the field as a whole, occur in the Woodburn bed, and this is especially true when the unweathered rock is taken into account. This suggests the origin of most of the phosphatic deposits in Central Kentucky in the Woodburn horizons, although locally concentration may have extended downward into the upper part of the Bigby.

The occurrence of *Strophomena vicina* in the phosphatic layers in the upper part of the Stark quarry, a mile and a half south of Wallace, suggests that these layers also belong to the upper part of the Benson section.

MIDWAY AREA.

A mile east of the Slack farm house, where the Leestown pike crosses a branch of South Elkhorn Creek, *Strophomena vicina* occurs between the 790 and 800 foot level above sea, and strata identified as Brannon occur eastward along the road. Since the general dip of the strata here is westward, it is evident that the area of phosphate rock discovered on the Slack and Thomas farms, belongs to the lower part of the Woodburn bed.

VERSAILLES AREA.

Strophomena vicina is abundant along the railroad a short distance west of where the Southern Railroad crosses the new line to Frankfort by means of a lofty trestle. The Brannon bed is poorly exposed at various points at a higher elevation, nearest the trestle. It is evident that all of the rock in the deep cut eastward belongs to the Woodburn horizon. The small exposure at the forks of the Midway and Frankfort pikes belongs to the same horizon.

FOUR MILES NORTHWEST OF VERSAILLES, ON THE FRANKFORT PIKE.

McKee's crossroads, five miles northwest of Versailles, is stop 51 on the traction line to Frankfort. About a mile nearer Versailles, phosphate rock is exposed in a cut made for the traction line. The locality is between stops 46 and 47, an eighth of a mile east of a school house on the south side of the pike and a quarter of a mile west of the Harris farm. Only the phosphate chips were collected; no attempt was made to include the matrix. The sample gave 68.39 per cent of calcium phosphate. The material was collected at a point where the cut gave a good exposure of the section as far as it could be exposed by the cut, the latter amounting to about three or four feet in depth. Although the phosphate chips were numerous, they were not in sufficient quantity to have commercial value; however, better deposits might exist in neighboring areas.

The elevation of this locality is from 852 to 857 feet above sea level. The presence of *Columnaria* and *Platystrophia colbiensis* indicates that the horizon belongs in the Woodburn bed. The *Strophomena vicina* horizon, indicating the presence of the upper part of the Benson or Bigby bed, is exposed at a locality reached by going from McKee's crossroads, three-quarters of a mile southwest, and then westward by a second road.

THREE MILES SOUTH OF VERSAILLES, ALONG THE NICHOLASVILLE PIKE.

Half a mile south of the road corner where the Pinckard pike leaves the Nicholasville road, a limesink occurs on the eastern side of the road, and a corresponding depression is seen on the western side. On the lower part of the hill slope north of the depression west of the road, phosphatic chips, picked out in thin slivers from among the normal grayish crystalline limestone, gave 71.67 per cent of calcium phosphate. These phosphatic fragments have not the slightest value commercially since they form an almost inappreciable part of the total volume of the rock with which they were inbedded. The horizon is doubtfully referred to the upper part of the Benson or Bigby horizon, owing to the presence of *Stromatocerium* and *Platystrophia colbiensis* at the quarry several hundred yards westward, the immediately overlying strata at the quarry being regarded as the base of the Brannon bed. Characteristic exposures of the Woodburn bed, with *Columnaria*, occur along the roadside, a little over a mile northward.

FRANKLIN COUNTY.

FRANKFORT.

On the reservoir hill, along the road from Frankfort to Bridgeport, the top of the Woodburn bed is exposed only a short distance above the level of the pike, at the point where it turns westward on reaching the top of the hill. East of the road, just before it turns westward, as stated, the upper part of the Woodburn bed contains *Columnaria*, between 6 and 9 feet below the base of the immediately overlying Catheys. Between 6 and 20 feet below the top of the Woodburn bed, the limestone is coarse grained, and contains, at various intervals, thin slivers of phosphatic rock, forming an insignificant part of the total section, and, therefore, having no commercial value. The analysis of selected fragments of this phosphatic material contained 38.67 per cent of calcium phosphate.

FOUR MILES NORTH OF SPRING STATION, IN THE SOUTHEASTERN CORNER OF FRANKLIN COUNTY.

Where the pike leading north from Spring Station strikes the pike from Georgetown to Frankfort, a quarry is located north of the road junction. Here phosphatic rock fragments are abundant in the upper foot of the section and between the limestone horses beneath. They are abundant also in the washed material on the surface of the dump, owing to the removal of the part of the residual clay by rain. The percentage of phosphate rock, when compared with the original section from which it has weathered out, however, is small. A sample including only the phosphate fragments contained 70.34 per cent of calcium phosphate. The horizon is not definitely known but is regarded as low in the Woodburn bed.

SCOTT COUNTY.

GEORGETOWN.

Near the western edge of Georgetown, a street was opened recently south of the Frankfort pike, about a quarter of a mile east of the point where the pike approaches Elkhorn creek. At this locality the rock contains some large specimens of *Stromatocerium*. The top of the exposure is at 862 feet above sea level, and phosphatic fragments occur in the upper 7 feet of the section. They form an inconsiderable part of the total section. A sample of selected specimens gave 67.3 per cent of calcium phosphate. There is no prospect of finding phosphate rock in commercial quantities in this vicinity. Half a mile west of Georgetown, *Dinorthis ulrichi* and *Strophomena vicina* occur on the southern side of the pike between 831 and 836 feet above sea level. From this it is probable that the phosphatic exposures in the western edge of Georgetown belong to the Woodburn bed. The occurrence of *Stromatocerium* is not sufficient to identify a horizon as upper Benson or Bigby. It is known to occur also in the Woodburn section, a considerable distance above the Brannon horizon.

TWO AND A HALF MILES EAST OF GEORGETOWN.

Two and a half miles east of Georgetown, on the Newtown pike, is the home of Harrison Smith, south of the pike. A pit was dug south of the house, in the yard. The base of the pit was 860 feet above sea level. A small quantity of thin phosphatic chips were found near the base of the pit, but these evidently formed an insignificant part of the total section. An analysis of selected fragments contained only 17.78 per cent of calcium phosphate. Nearly a quarter of a mile west of the Harrison Smith house, at a cave spring, a barites vein runs approximately north and south through rock containing *Dalmanella* and *Prasopora*, and evidently belonging to the Wilmore bed. The level here is approximately 830 feet. It is assumed that the pit near the Harrison Smith house has penetrated some of the lower strata belonging to the Woodburn bed.

FAYETTE COUNTY.

LEXINGTON.

Along South Limestone street in Lexington, in front of the State University grounds, phosphatic limestone fragments may be found approximately at the level of the upper part of the Benson or Bigby bed. In putting down sewers at the northwestern angle of the grounds the same phosphatic horizon was struck. These occurrences have long been known. They were recorded by Dr. Peters more than thirty years ago. The same strata underlie many parts of Lexington. While digging the cellar for the foundation of the new power plant erected in 1911, on North Broadway street, in Lexington, phosphate rock, two feet thick, and of good quality, was discovered 24 feet below the level of the belt line which crosses Limestone street a short distance northward. The associated rock is comparatively unfossiliferous, and alternations of gray granular limestone with darker, bluish, fine grained rock occur as in the railroad cut at Versailles. The elevation is 1016 feet above sea level. Since the base of the Brannon layer along the Queen and

Crescent railroad is approximately 960 feet, the phosphatic horizon at the new power plant is probably in some part of the Woodburn bed. From a commercial standpoint the rock, although rich in phosphate, was covered by too great an overburden to be available.

NEWTOWN PIKE, NORTH OF LEXINGTON.

A former quarry, once known as the McMeekin quarry, long abandoned, is located three miles north of Lexington, on the western side of the Newtown pike, a quarter of a mile south of the point where the pike turns sharply toward the left. The limestone is granular. The phosphatic material occurs in the form of very thin slivers between the much larger thicknesses of ordinary limestone. By long search enough fragments of phosphatic rock were secured to form a sample, and this contained 59.87 per cent of calcium phosphate, evidently having no commercial value.

About a mile north of the McMeekin quarry, and the same distance south of the Ironworks pike, is the home of G. C. Gorham. Southwest of the house there is a large quarry, worked by the Randolph brothers. The top of the quarry lies 10 feet below the level of the pike. Four feet below the top of the quarry is the *Stromatocerium* layer, and about a foot lower *dinorthis ulrichi* and *strophomena vicina* are seen. The quarry evidently belongs to the top of the Benson or Bigby horizon, suggesting that the McMeekin quarry may belong to approximately the same horizon.

About seven miles north of Lexington, north of the entrance to the Walnut Hall stock farm, also known as the Harkness farm, thin phosphatic chips are exposed along the eastern side of the pike. Here a sample gave 63.37 per cent of calcium phosphate. Although this was a fairly rich sample, it formed only an insignificant part of the section, and there is no evidence of commercially valuable phosphate rock in this vicinity.

J. P. HEADLEY FARM, HALF A MILE NORTH OF LEXINGTON.

The Headley farm is located east of the Russell Cave pike, half a mile northeast of the railroad crossing at the northern edge of Lexington. A quarry is in operation east of the pike. Phosphatic rock is found at several points in the upper part of the quarry, occurring also between the limestone horses. Locally, in this quarry, the phosphatic fragments are abundant, filling a section of three feet between the horses. One sample of selected specimens gave 71.45 per cent of calcium phosphate, while a second sample, including also the matrix, gave 54.62 per cent. The presence of *Dinorthis ulrichi* in the phosphatic rock suggests the upper part of the Benson horizon.

H. P. HEADLEY FARM, FIVE MILES EAST OF WALLACE STATION.

Two miles east of Faywood, where the Frankfort pike crosses Elkhorn creek, is the home of H. P. Headley. A short distance westward, on the southern side of the pike, phosphatic fragments were exposed by the wash of the soil. Their vertical range was five feet, but only a small part of the section was formed by the phosphatic material. An analysis of selected specimens gave only 74.29 per cent of calcium phosphate. The elevation was approximately 890 feet above sea level.

JESSAMINE COUNTY.

HULETT STATION.

Hulett Station is at stop 12 on the traction line from Lexington to Nicholasville. A short distance north, half a mile north of the county line, is stop 11. Northwest of the road crossing is a long cut from which clay was removed for making fills along the right of way. The top of the exposed section, for a distance of four feet, consists of soil and residual clay, much altered by burrowing insects and earthworms. The underlying residual clay, 5 feet thick, contains only 8.3 per cent of calcium phosphate. Below this level, the residual clay encloses fragments of phosphate rock, and a general run of a section four and a half feet thick gave 35.05 per cent of calcium phosphate. A similar section, beneath this, six feet thick, gave only 26.65 per cent of calcium phosphate. The unweathered rock at the base of the section gave only 2.84 per cent of calcium phosphate, the interbedded limestone lenses containing 3.27 per cent. The horizon of the unweathered rock undoubtedly is that of the Brannon bed, and the overlying part probably represents the base of the Woodburn bed, since *Columnaria* is common. At Hulett Station it may be seen that the *Columnaria* horizon is not in, but several feet above the phosphatic section, as here exposed.

South of stop 12 the limestone below the Brannon bed is phosphatic at the top, down to the *Stromatocerium* horizon, but the quantity of phosphatic material is too insignificant to have commercial value.

CLARK COUNTY.

Pine Grove, Eight Miles West of Winchester.

The Brannon bed is well exposed along the long cut west of Pine Grove station, where the residual clay was removed to make a fill along the railroad. A hundred yards east of the railroad station, on the northern side of the railroad, about 6 inches of phosphatic rock overlies coarse grained limestone assumed to belong to the Woodburn bed. The phosphatic rock consists of loose chips half an inch to three-quarters of an inch in thickness. The analysis of a sample consisting of selected material gave 76.04 per cent of calcium phosphate.

At the eastern end of the railroad siding, at mile post 12, phosphatic fragments in the residual clay within two feet of the top of the limestone, contained 69.92 per cent of calcium phosphate.

Better material 18 inches thick, is said to have been found by Mr. P. B. Winn about 200 yards southeast of the last locality, in an open field, on the J. D. Gay farm. He did his sampling with a soil auger, and apparently secured better phosphate rock and a thicker section than was possible by confining observations to open exposures. I am convinced from studies elsewhere in the field, that prospecting by examining open exposures must be considered merely preliminary and that much more can be learned by means of the soil auger, following these explorations, first by open pits, and later by transverse trenches.

Becknerville and Flanagan.

The upper part of the Benson or Bigby bed, characterized by the presence of numerous specimens of *Dinorthis ulrichi and Strophomena vicina,* is exposed at numerous localities around Becknerville. At the northern end of the Bowyer farm, this horizon is seen to be overlaid by the Brannon bed and along the pike bordering the western margin of the farm the equivalent of the Woodburn bed is exposed in a quarry.

The top of the Benson bed is exposed both south and north of Flanagan station, along the railroad. The Brannon layer is best exposed along a road north of the station. The full section of the Woodburn bed is seen still farther north, along the railroad.

Nowhere, in these parts of Clark County, were sufficient evidences of phosphatic rock seen to merit chemical analysis.

BOURBON COUNTY.

In the railroad cuts in the northern part of Paris, the limestone contains *Dinorthis ulrichi,* indicating the presence of the upper part of the Benson bed. No phosphatic rock was seen.

HARRISON COUNTY.

At Lair station, eight miles north of Paris, the limestone is rather thin bedded for about 4.5 feet above the railroad track. Within the immediately overlying rock, a foot and a half thick, *Strophomena vicina* occurs, suggesting the presence of the upper part of the Benson bed. If this is the case, the Brannon bed does not extend this far northeastward, and only a thickness of 17.5 feet of the Woodburn bed remains. The Woodburn section here consists of rather thin bedded limestone, cross bedded near the base. No phosphatic layers were observed.

At the northern edge of Cynthiana, west of the Louisville and Nashville railroad, there is a quarry, east of the pike. By selecting the very thin phosphatic slivers between the granular limestone layers, enough material was secured to give a sample containing 47.41 per cent of calcium phosphate. Since *Strophomena vicina* occurs somewhere in this quarry, as shown by loose blocks, it is probable that not only the Woodburn but also the Benson horizon is exposed here, with no indication of the Brannon layer.

MADISON COUNTY.

At the southwestern edge of Valley View, along the railroad, the presence of the upper part of the Benson or Bigby bed is indicated by the fossils *Strophomena vicina* and *Dinorthis ulrichi*. Eastward, there is exposed an overlying section of coarse grained limestone, referred to the Woodburn horizon. There is no evidence of the Brannon layer, nor has any phosphatic material been found.

The chief object in recording these observations from the more eastern counties is to emphasize the fact that no phosphatic deposits of value are likely to be found there. When it is not possible even to secure enough phosphatic material for a so-called sample, the quantity must be extremely small.

It is quite evident that the unweathered rock does not promise any extension of the phosphate areas of Central Kentucky at any other horizon than the Woodburn and the immediately underlying part of the Benson or Bigby. The percentage of phosphoric acid in the analyses exceeds two per cent only in the case of the Woodburn bed and Cornishville layer. The latter is so limited in the number of exposures in which it weathered so as to have any commercial value, that it may be stated with confidence that all possible exposures have been visited and the absence of valuable phosphate deposits at this horizon definitely determined.

As far as mere location is concerned, the Woodburn and top of the Benson may be richly phosphatic in sufficient quantity at localities as yet undiscovered, although as investigation goes on the probabilities of the discovery

of new fields is lessening. Not much prospecting remains to be done of the kind which makes use of open exposures along creeks, roads, railroad cuts, or quarries. Soil drills, reaching depths of ten to fifteen feet, followed by open trenching, might result in new discoveries, but such expensive methods are beyond the financial means of the Survey.

PROSPECTING FOR PHOSPHATIC ROCKS IN CENTRAL KENTUCKY.

As stated on the preceding pages, most of the phosphatic rock giving any prospect of commercial value is found in the Woodburn bed or in the upper part of the Benson or Bigby bed. Since these two beds are separated by the Brannon layer, and the latter offers an easy reference mark, the aereal distribution of the latter assumes importance. With these facts in mind, it may be stated that the Woodburn bed forms the upper part of most of the hill land or upland in the area covered by the Georgetown quadrangle.

A KNOWLEDGE OF THE DIP AS A GUIDE IN PROSPECTING.

Estimating the elevation of the base of the Brannon bed along the Queen and Crescent railroad in the southwestern part of Lexington at 960 feet above sea level and that at Versailles as 860 feet, there is a westward dip of nearly 8 feet a mile. In the same manner, estimating the elevation of the *Stromatocerium* horizon a mile west of Greendale at 910 feet, and that of the base of the Brannon bed half a mile south of Wallace as 850 feet, a dip of about 7 feet per mile results. Again, estimating the level of the *Stromatocerium* horizon a mile southeast of Georgetown as 870 feet, and that a mile and a half south of White Sulphur as 810 to 820 feet, a dip of about 7 feet again results. From this it is not intended to infer that the rate of dip westward is quite uniform. As a matter of fact, there either are local variations of dip or small faults of moderate throw, which interfere with this uniformity, but the general moderate westward dip is established within this area.

Estimating the base of the Brannon layer three miles south of Versailles at 890 feet, and the corresponding horizon a mile and a half south of White Sulphur at 820 feet, a northward dip of about five and a half feet per mile results. Estimating the base of the Brannon bed southeast of Shannondale as 920 feet, and the *Stromatocerium* horizon along the railroad three miles northeast of Midway at 860 feet, a northward dip also of about five and a half feet per mile results. A mile and a half north of Nicholasville, the base of the Brannon layer occurs at 1035 feet above sea level; southwest of the depot, along the Queen and Crescent railroad at Lexington it occurs at 960 feet, suggesting a northward dip of 8 feet per mile, and this dip continues as far as the *Stromatocerium* exposures southeast of Georgetown.

The maximum dip, of course, is northwestward, amounting to 12.5 feet between stop 19, a mile and a half north of Nicholasville, and Versailles, and nearly 12 feet between Lexington and the *Strophomena vicina* locality two miles northwest of Midway.

Owing to the dip of the strata, the Woodford bed is not exposed for any distance south of the Georgetown quadrangle excepting along the area toward Nicholasville, and here the phosphatic material is not very rich and has weathered to the so-called matrix.

West of the Georgetown quadrangle many of the hill-lands are high enough to include the Woodford bed almost as far west as the Kentucky river. West of the Kentucky river, owing to the strong westward, or rather southwestward dip of the strata, the Woodford bed is soon overlaid by stratigraphically higher strata, belonging to the Catheys and the Eden.

Estimating the base of the Brannon layer two miles northwest of Midway at 800 feet above sea level, and that the B. B. Graves farm, three miles southwest of Frankfort, along the Lawrenceburg pike as 715 feet, there is here a westward dip of nearly 7 feet. The Brannon layer may be traced westward to Bridgeport, thence northwestward three miles to the famous *Brachiospongia* locality on Big Benson creek, and it is seen also along the railroad about a mile west of Benson station. None of the localities west of the Kentucky river, however, give the least

promise of phosphatic rock either above or immediately below the Brannon layer.

North of the Georgetown quadrangle, the northward dip of the strata soon brings the Woodford bed below the covering of Catheys and Eden strata. There is not the slightest indication of commercially phosphatic rock in this direction.

East of the Georgetown quadrangle, the Woodford bed may be traced toward Paris, Millersburg and Lair, but there is no indication of phosphatic rock in even sufficient quantities to make sampling of selected material interesting anywhere east of Elkhorn creek.

A fault brings in the Eden beds a short distance east of Lexington. Southeastward, however, in the area covered by the Richmond sheet, the Brannon and the overlying Woodford beds are well exposed as far east as Flanagan. If the elevation of Pine Grove station, on the line to Winchester, is 942 feet, the base of the Brannon layer there must be approximately 930 feet. At Flanagan, it is approximately 890 feet. This suggests a southeastward dip in this area. There is no doubt of the southward or southeastward dip in the vicinity of Becknerville.

None of the area south of the Kentucky river, in Garrard, Mercer, and Boyle counties, need require any consideration whatever. There is no indication of phosphatic rock in commercial quantities anywhere in that area.

AREAS WORTHY OF FURTHER INVESTIGATION.

The only areas worthy of further investigation are those extending from the vicinity of the Russell Cave pike near Lexington northward along the Newtown pike, thence westward along the Ironworks pike to its junction with the pike from Georgetown to Frankfort, following the latter pike toward Frankfort. Southeast of Lexington the area worth searching is soon limited by the fault which brings in the Eden. Although phosphatic material occurs along the Nicholasville pike, it is not very promising and the area southwestward is limited by South Elkhorn creek. Westward from Lexington no promising territory was noticed south of the pike to Versailles, nor was any noticed directly west of Versailles.

Within the area as here limited, phosphatic rock in commercial quantities was noticed only east and southeast of Wallace, and northwest of Midway, although promising territory was seen also northwest of Versailles, and at several localities north of Elkhorn creek, a number of miles northwest of Midway. While there may be some valuable phosphate rock near Lexington, it is not likely that owners will be willing to have their lands worked over for the sake of a few feet of phosphate rock.

THE USE OF GROUND PHOSPHATE ROCK.

Regarding the general availability of ground phosphate rock, untreated by acid, there need be no question. This subject has been investigated too thoroughly to be longer in doubt. Ground phosphate rock has been tested not only in many other progressive States with satisfactory results, but it has been tested by S. C. Jones at the Agricultural Experiment Station, at Lexington, Kentucky, and he is enthusiastic as to its availability. Moreover, he is thoroughly acquainted with the methods of Dr. Hopkins, of the Illinois Experiment station, under whom he studied, who also is an enthusiast as to the availability of ground phosphate rock.

Of course, the chemically treated phosphate rock will give more immediate results. No one has attempted to deny this fact. But it can be asserted with equal confidence that the chemically treated phosphate rock is not worth the additional expense. When the great price of the chemically treated phosphate rock is considered, it seems a lack of good judgment for a farmer raising the ordinary crops to pay a large price for the chemically treated phosphate rock when he could get so much more phosphate rock for a more moderate expenditure of money which will give equally good results in the long run, under proper treatment.

The proper treatment of the ground up phosphate rock is the matter of chief importance. For this reason, the theory of its use should be understood. In the form of calcium phosphate, the phosphate is not readily soluble, and this is the reason why it has been customary to

treat it by means of acids for so many years. However, in the presence of decaying animal or vegetable matter, the calcium phosphate becomes much more readily soluble and therefore available. From this it would seem that the best method of applying rock phosphate is to mix it with manure and to apply it to the land in that form. In order that the manure may come into intimate contact with the phosphate rock, the latter should be ground very fine.

At this point various methods of procedure will suggest themselves to the intelligent farmer. Dr. Hopkins suggests that the ground phosphate rock be scattered from day to day over the manure as it collects in the stable or in the feed lot. This certainly would give an intimate mixture with decaying animal and vegetable matter. Or the ground phosphate rock might be mingled with the manure at the time of spreading the latter over the field. If it is remembered that every grain of ground phosphate rock in actual contact with decaying manure is worth more than the same grain of phosphate rock mixed up with the ground, away from decaying material, the various methods of applying the phosphate rock will suggest themselves readily enough.

When no stable or barnyard manure is available, a good substitute may be found in a plowed under green crop. For instance, clover, cow peas, soy beans, fall rye, etc. Of course, the clover, cow peas, and soy beans are best, since they furnish at the same time the nitrogen for which the farmer pays such enormous prices, considering the amount obtained, when he secures his nitrogen from a commercial fertilizer. Dr. Hopkins suggests the use of 1,000 to 2,000 pounds of finely ground rock phosphate per acre every three to six years, depending upon the system of rotation of crops employed.

Information upon the availability of phosphate rock may be obtained from the agricultural experiment station at Lexington, Kentucky. Those who like to keep up with what is going on in other States will find the subject taken up not only by most of the agricultural experiment stations of other States, but also by the United States Agricultural Department.

In a recent bulletin by the Ohio Agricultural Experiment Station, circular No. 120, the following statements are made:

"When preceded by manure, ground limestone is apparently producing a greater total and net gain than an equivalent quantity of caustic lime. When used in the absence of manure, however, caustic lime is followed by a larger total and net gain than ground limestone.

"While the yield on the land receiving 1,000 pounds of floats (ground phosphate rock), applied to the surface after the manure has been plowed under, is greater than that on the land similarly treated with gypsum, in neither case is the effect at all comparable with that observed in the barnyard manure test, previously reported, in which one-third this quantity of these materials is mixed with the manure before application. Nor is the effect on clover of either floats or gypsum equal to that of lime or ground limestone.

"When used in the absence of manure as a direct application to the land, 320 pounds of floats has produced a much smaller net gain than the same quantity of acid phosphate costing twice as much.

"So far, therefore, as the results of this experiment may be accepted, they support other experiments of this station in showing that ground limestone should be used only as a supplement to liberal manuring or fertilizing, and floats only as a reinforcement of manure, and that neither should be regarded as a substitute for manure or fertilizers."

The preceding observations suggest the importance of making definite tests of ground phosphate rock on definite Kentucky soils and on specified crops. Ground phosphate rock should cost much less in Kentucky than in Ohio, since shipping expenses should be less. With the farmer thoroughly conversant as to what ground phosphate rock will do and what it will not do, there should be a great increase of its intelligent use and, of course a ready sale for the ground rock. Obviously, the railroads have it within their power to facilitate the ready transportation of the ground rock.

CORRELATION OF TRENTON STRATA IN KENTUCKY WITH THOSE OF WESTERN TENNESSEE.

In Tennessee, the Bigby limestone includes at least four phosphatic zones. Of these, the lower two zones furnish the typical brown, or Mount Pleasant phosphate. The lower zone contains *Cyclora minuta*, *Cyclora parvula* and *Microceras inornatum*, all phosphatic shells of very small size. In addition to these minute gasteropoda, the second zone contains also *Hebertella frankfortensis* and *Rhynchotrema increbescens*. In the third zone, *Constellaria teres*, *C. emaciata*, *C. grandis*, *Eridotrypa briareus*, and *Escharopora ponderosa* occur. The fauna of the fourth zone is not listed separately. In the third and fourth zones the deposits of phosphatic rocks are much more local than in the underlying zones.

Judging merely from the published lists of fossils, there is no reason to believe that the Woodburn bed of Central Kentucky belongs to any part of the Catheys, as originally described from Tennessee. If the Woodburn bed finds any stratigraphical equivalent in Tennessee it appears to be the Bigby. Nothing equivalent to the Brannon bed is known in Tennessee, and this may be asserted notwithstanding the occurrence of *Brachiospongia digitata* and *Pattersonia aurita* in that state. The association and succession of fossils is quite different there. It is difficult to understand on what basis only those strata which are below the Brannon bed and which here are called the Benson layer are to be included in the Bigby. The most characteristic fossils of the upper part of the Benson bed, *Stromatocerium*, *Strophomena vicina*, and *Dinorthis ulrichi*, do not occur at all in the Bigby of Tennessee, and the associated fossils occur also in the Woodburn bed. As a matter of fact, it is the Woodburn fauna, rather than the Benson fauna which is characteristic of the Bigby of Tennessee.

As regards the Perryville bed, it is probable that the Faulconer and Salvisa horizons may find their equivalents in the Dove limestone forming part of the Capitol Hill section at Nashville. This is the horizon for *Leperditia linneyi*, it is one of the *Orthorhynchula linneyi* horizons, and this may also be the horizon at which Troost found *Brachiospongia digitata* somewhere in Davidson county in 1838, although unknown at this horizon in Kentucky. It is possible that equivalents of this Dove limestone have been included in the Catheys formation in Tennessee, but no equivalents of the Cornishville layer have been identified there. In fact, neither the upper nor lower *Strophomena vicina* and *Dinorthis ulrichi* horizons are known in Tennessee, although their distribution suggests introduction from some more western area. Apparently their source was northwest rather than southwest, and the Benson fauna may never have reached Tennessee. For this reason the term Benson is preferred to Bigby for the strata between the Wilmore and Brannon beds. It seems to the writer that the term Bigby either should include all the strata between the Wilmore and the Perryville, in a collective sense, or, if a more restricted use be preferred, should be confined to the Woodburn horizon.

The Wilmore is unknown in Tennessee, and the Logana is equivalent to the Hermitage of that State.

With these interpretations in mind, the phosphate horizons in Central Kentucky may be regarded as approximately equivalent to the Mount Pleasant phosphate horizons in Tennessee, at least in origin, even if weathering and segregation has resulted in the accumulation of this phosphatic material locally in the upper part of the Benson bed.

DESCRIPTION OF LOCALITIES FROM WHICH SAMPLES FOR CHEMICAL ANALYSIS HAVE BEEN COLLECTED.

3400. One mile northwest of Versailles, in Woodford county, Ky., northwest of the junction of the Frankfort pike with that to Midway, in the shallow ditch on the west side of the pike. Here a two foot section of phosphatic rock was exposed. The sample consisted of medium and small sized chips, and appeared like a good grade of phosphatic rock.—Woodburn bed.

3401. A mile and a half southwest of Wallace, on the Lister Witherspoon farm, along a lane leading from the pike westward toward a series of farm houses. The sample was taken about 300 yards from the Woodford county pike. Here a two foot section of phosphatic rock was exposed, 15 feet below the top of the limestone section exposed in the quarry east of the pike. The sample consisted of small fragments, exposed in the road side, and not making a favorable impression in the field.—Benson or Bigby bed.

3402. A mile and a half southwest of Wallace, on the Lister Witherspoon farm. On the south side of the stream which follows the lane, south of the locality at which sample 3401 was collected. Woodford county.

Loose scattered chips. Average thickness of the chips collected equals half an inch.—Benson or Bigby bed.

3403. A mile and a half southwest of Wallace in Woodford county, Ky. Quarry on the east side of the pike, east of the localities at which samples 3401 and 3402 were collected. Stark's quarry—

The phosphatic rock forms the top of the quarry section, where the rock exposed is most weathered. Phosphatic sections, fully 5 feet thick, are interrupted by large limestone horses. Average thickness of phosphatic chips equals one inch. Benson or Bigby bed.

3404. Same quarry as that from which the sample 3403 was collected. Stark's quarry, east of the pike from Versailles to Wallace, in Woodford county.

Unweathered rock, whose decay gives rise to the phosphatic rock. Dark, phosphatic rock, between limestone bands, alternating with the latter. The limestone with which this darker rock alternates is less phosphatic than the latter.—Benson or Bigby bed.

3405. An eighth of a mile east of Wallace station, in Woodford county, Ky, on the Davis farm. A pit had been dug 300 yards south of the pike, and from the material thrown out, the phosphatic rock was selected. None of the matrix was included. Six foot section of phosphatic rock.—Benson or Bigby bed.

3406. Davis farm, east of Wallace station, Woodford county. Same locality as that from which sample 3405 was secured, but 600 yards southeast of the farm house. A pit had been dug in the field east of the house, and from this the general run of the phosphatic section was sampled, including the matrix. Thin phosphatic strips of rock interbedded with a clayey matrix.—Woodburn bed.

3407. A mile east of Wallace station, on the south side of the pike, west of a small stream. On the farm of William Steele, Woodford county. A five foot section of phosphatic rock was sampled, at a pit which had been dug on the hillside. The general run of the phosphatic section was taken, but little of the matrix was included. Phosphatic chips in the sample average half an inch thick. Woodburn bed.

3408. Nearly two and a half miles a little north of west from Midway, in Woodford county, Kentucky. On the Slack farm, nearly a quarter of a mile south of the Leestown pike, southeast of the first large lime sink. A deep pit had been dug and the sample was taken from material selected from a seven foot section of phosphatic rock.—Woodburn bed.

3409. Slack farm, same region as that from which sample 3408 had been collected. A pit had been dug in the second tier of fields east of the farm house, close to the farm line, nearly half a mile south of the pike in Woodford county. The sample was selected from the phosphatic chips thrown out from a section 3 feet thick, no matrix being included.—Woodburn bed.

3410. Along the traction road from Lexington to Nicholasville, a quarter of a mile north of the line between Fayette and Jessamine counties (Stop 11), in a large exposure opened in order to furnish material for the fills along the traction road, southwards. Here clay overlies a phosphatic section. The sample includes only the clay section, 5 feet thick, between the soil and the phosphatic section. Yellowish red clay, containing concretionary iron ore pebbles.—Woodburn bed, residual clay.

3411. Same locality as that from which sample 3410 was secured. Upper half of the phosphatic section, four and a half feet thick. No good chips of rock phosphate found here.—Woodburn bed.

3412. Same locality as that from which samples 3410 and 3411 were secured. Lower part of phosphatic section, 6 feet thick. Decomposed phosphate rock residue.—Woodburn bed.

3413. Same locality as that from which samples 3410-3412 were collected. Argillaceous rock underlying the phosphatic section. Thin bluish, argillaceous limestone chips, weathering brownish.—Brannon bed.

3414. Crystalline limestone enclosed as a horse in the argillaceous limestone furnishing sample 3413. Beneath the phosphatic section. Brownish gray limestone.—Brannon bed.

3415. One hundred feet northeast of the road crossing at Pine Grove, in western edge of Clark county, Ky., north of the railroad track. Phosphatic section, several inches thick. Sample selected from loose chips, from half an inch to three quarters of an inch thick.—Woodburn bed.

3416. East of Pine Grove, in Clark county, Ky. At the east end of the railroad siding, at the mile post, 12 miles east of Lexington. The total phosphatic section here is 18 inches. Far better phosphatic material is found 200 yards southeast of this locality, on the south side of the railroad, but was not sampled. Very thin chips selected from among the best material.—Woodburn bed.

3417. Half a mile west of Pine Grove, on the north side of the railroad in Fayette county. Here the ground had been removed for a long distance north of the track, along the railroad, to furnish material for the fill westward. A short distance above the base of the long excavation, along the northern side of the cut, chips of rock are found in the lower part of the clay. Chips, forming the sample, about half an inch thick.—Brannon bed.

3418. A mile and a half east of Pine Grove, on the Colby pike, north of the railroad, 100 yards west of the gate leading to the home of S. T. Prewitt, in Clark county. Siliceous looking stuff, formed by shaly layers inter-bedded with the heavier argillaceous limestone. Not phosphatic in appearance. Selected by P. B. Winn.

3419. Two miles south of Glenn Creek station, on the railroad from Versailles to Frankfort, in Woodford county, Ky. The locality is on the farm of Mrs. Ben Williams, east of the pike, at a small quarry in a small valley.—Perryville limestone; sample from upper part of Faulconer division.

3420. Davis farm, an eighth of a mile east of Wallace, Woodford county, where samples 3405-3406, were collected. A ditch had been dug in an east and west direction across the hill slope, 150 yards south of the farm house. The overburden of soil and clay was 7 feet. Below this level was the phosphatic rock, which was sampled. Phosphatic rock fragments about an inch thick.—Benson or Bigby bed.

3421. A mile and a quarter east of Wallace station, about 400 yards south of the pike, and 300 yards northeast of the home of William Steele in Woodford county. A pit about 15 feet deep had been dug, and the sample was selected from the material thrown out. Chips about half an inch thick.—Woodburn bed.

3422. Road side exposure, two a half miles east of Wallace, half a mile west of the crossing of the Pisgah pike in Woodford county. Thin weathered layers of phosphatic rock between crystalline limestone layers. 860 feet above sea level. Chips very thin and mixed with clay.—Woodburn bed.

3423. Three quarters of a mile east of Wallace station. Roadside exposure found by Prof. Arthur M. Miller, 10 years ago, in Woodford county. Chips of phosphatic rock fragments, from a quarter of an inch to half an inch thick.—Benson or Bigby bed.

3424. Railroad cut at Versailles, Ky., on the railroad from Versailles to Frankfort. Here the railroad passes by means of a concrete bridge under the Frankfort pike. The sample includes the rock from the base of the arch of the bridge to a point nine and a half feet lower. Only the phosphatic rock resulting from the decay of the limestone was collected. The material was collected east of the bridge. Yellowish brown chips.—Woodburn bed.

3425.—Versailles, Ky., from the same railroad cut as sample 3424. The sample was taken from the section from sixteen and a half to nineteen feet below the base of the arch at the bridge. Here the rock, unweathered, consists of alternating bands of light and dark gray limestone. From rock of this character most of the more valuable deposits of phosphate rock result, on decay. Sample selected near the private overhead crossing a short distance west of the Frankfort pike, used for a railroad entrance to grounds south of the railroad, by another line. Dark gray limestone, furnishing the phosphate rock on weathering. Sample of the unweathered rock.—Woodburn bed.

3426. Versailles, Ky. from the same railroad cut as samples 3424 and 3425. Eight foot section, from 19 to 27 feet below the base of the arch at the cement bridge. Gray limestone.—Woodburn bed.

3427. Versailles, Ky., from the same railroad cut as samples 3424-3426. Thin layers of phosphatic rock picked out from between the horizontal layers of crystalline limestone which furnished sample 3426. This is an eight foot section, of which only a small percentage is phosphatic. Thin, brown phosphatic chips. —Woodburn bed.

3428. Versailles, Ky., from the same railroad cut as samples 3424-3427. Section includes the strata from sixteen and a half to nineteen feet below the base of the arch at the cement bridge. Sample includes the weathered phosphatic rock resulting from the unweathered rock represented by sample 3425. Brown phosphatic chips, in thin lumps.—Woodburn bed.

3429. Versailles, Ky., from the same railroad cut as samples 3424-3428. Sample of section from nine and a half feet below the base of the arch at the cement bridge, to seven feet lower. Sample collected on the west face of the bridge foundation. Unweathered rock. Dark blue limestone, crystalline or compact in different pieces. Fossiliferous; bryozoans.—Woodford bed.

3430. Versailles, Ky., from same railroad cut as samples 3424-3429. Phosphate rock resulting from tne decay of the rock furnishing sample 3429. Sample collected between the cement bridge and

the railroad depot, eastward. Brown, phosphatic chips.—Woodburn bed.

3431. Versailles, Ky., from the same railroad cut as samples 3424-3430. West face of the bridge foundation at the cement bridge. Sample, unweathered limestone from the same part of the section as that which furnished sample 3424.—Woodburn bed.

3432. South of the depot at Millville, Ky., in Woodford county, on the railroad from Versailles to Frankfort. Logana member of the Lexington limestone. The soft shaly clay forming about half of the Logana member.

3433. South of the depot at Millville, Woodford county, Ky. Same section as that from which sample 3432 was obtained.

Brownish gray limestone, rather soft and argillaceous. Logana member of the Lexington section. Limestone forming half of the Logana section.

3434. Along the pike from Frankfort to Bridgeport, along the road ascending the hill southwest of the city, in Franklin county.

Upper part of Woodburn bed, including the rock from the columnaria horizon at the top at this locality to a point 14 feet lower. Dark thin chips of phosphate rock and limestone.

3435. Two and a half miles east of Georgetown, Ky., in Scott county, on the Paris pike, on the Harrison Smith farm.

Material collected at a former pit opening, now closed. Said to have included two feet of phosphatic material, but this is doubtful. Actual exposures show very little phosphate rock.

3435-2. An eighth of a mile east of Wallace, Ky., on the Davis farm, from which samples 3405, 3406, 3420, were collected in Woodford county.

Sample consisting of the mixture of the phosphatic rock and matrix secured at about 30 localities between 300 and 600 feet south of the farm house, and between 60 and 70 feet east of the old line fence, east of the present railroad siding entering the farm. Twenty-two pounds of chips and matrix. The rock phosphate chips were thicker than in case of any of the preceding samples.—Benson or Bigby bed.

3436. Five miles east of Wallace, and nearly two miles east of Faywood, on the pike to Lexington, southwest of the home of H. P. Headley, along the pike in Fayette county.

Phosphatic rock is exposed for a vertical distance of 5 feet. Two pounds of thin phosphatic chips, with practically no matrix included.

3437. Davis farm, an eighth of a mile east of Wallace. Same locality as that furnishing samples 3405, 3406, 3420, 3435, Woodford county.

Four hundred and fifty feet south of the house and lot surrounding the farm house, 170 feet east of the line fence on the east side of the field entered by the siding from the railroad.

Overburden of soil and clay, 2.5 feet. Phosphatic rock sampled, 2.5 feet. Six pounds of phosphatic chips which seem to be of a cherty nature, general run of the section, including the matrix. —Benson or Bigby bed.

3438. Davis farm, an eighth of a mile east of Wallace. Same locality as that furnishing samples 3405, 3406, 3420, 3435, 3437, Woodford county. Seven hundred feet south of the house lot, and 170 feet east of the line fence on the east side of the field entered by the railroad siding.

Overburden of soil and clay, 3 to 4 feet. Phosphatic rock sampled, two and a half feet. Four pounds of small thin phosphate rock chips, with little matrix but representing general run of rock section.—Benson or Bigby bed.

3439. Nearly a mile northeast of Lexington, at a quarry on the J. P. Headley farm, on the eastern side of the Russell Cave pike, in Fayette county.

The top of the quarry rock is weathered and phosphatic. Selected chips, not including the matrix. A pound and a quarter of thin chips.—Benson or Bigby bed.

3440. Davis farm, an eighth of a mile east of Wallace, in Woodford county, Ky. Same locality as that which furnished samples 3405, 3406, 3420, 3435, 3437, 3438. Six hundred feet south of the house lot, and 170 feet east of the line fence on the eastern side of the field entered by the railroad siding.—Benson or Bigby bed.

Overburden of soil and clay, 1.5 feet. Phosphatic rock sampled, 2.5 feet. Four and a half pounds of thin chips, no clay included.

3441. Nearly a mile northeast of Lexington, on the Russell cave road in Fayette county. Quarry on J. P. Headley farm, which furnished also sample 3439.

One and three quarter pounds of dark brown phosphate chips with a small amount of adhering clay.—Benson or Bigby bed.

3442. Three miles south of Versailles, in Woodford county, Ky. half a mile south of the point where the road to Pinckard leaves the pike. The sample was secured in the field west of the pike to Nicholasville, where the hill slopes southwest toward a hollow. —Benson bed.

A pound and three quarters of rock phosphate chips, with no matrix included.

3443. High Bridge, Ky., Jessamine county. Full section of that part of the Camp Nelson bed which is exposed here. This equals the upper 150 feet of the Camp Nelson bed. Road leading west to the river level.

Four pounds of limestone, weathering so as to have yellowish spots.

3444. Three miles north of Lexington on the Newtown pike, at the former McMeekin quarry, a quarter of a mile south of the point where there is a strong bend in the pike, opposite the Crowell farm. This is one of the localities examined by Dr. Peters years ago in Fayette county.

One pound of thin brown chips, selected from the small quantity found near the surface of the quarry rock.

3445. Glenn Creek, Woodford county, a short distance west of the Old Crow distillery, a road starts off southwards up the hill. Lower part of the Benson or Bigby bed from 9 to 25.5 feet below the strophomena vicina horizon.

Three and a half pounds of light gray crystalline limestone, rather impure and siliceous looking. Medium sized lumps.

3446. West end of Georgetown, where a new street was opened in 1911, on the south side of the Frankfort pike, Scott county. Four and a half pounds of brown chips, with a small amount of clay. —Benson or Bigby bed.

3447. Four miles northwest of Versailles on the Frankfort pike, between stations 46 and 47 on the traction road, Woodford county.

Sample consists of selected specimens. Four pounds of brown chips of medium size and thickness.—Woodburn bed.

3448. North end of Cynthiana, in the quarry between the pike and the railroad, eastward in Harrison county.

Phosphate rock consisting of very thin layers picked out from between the seams of the Benson limestone, below the Strophomena vicini horizon. One pound of very thin chips, with about an equal weight of clayey material.

3449. Seven miles north of Lexington, on the Newtown pike, north of the entrance to the Walnut Hall stock farm, called also the Harkness farm. The same was taken on the east side of the pike, probably from the old Winton farm of Dr. Peters reports, many years ago. Fayette county.

A pound and a half of thin, small size chips. No clay matrix.—Woodburn bed.

3450. Full quarry section, an eighth of a mile north of High Bridge station. Top part of the Tyrone limestone, 51 feet of this member sampled, leaving only the lower 30 feet of the Tyrone not included in this sample. Jessamine county.

3451. Glenn Creek, along the road leading up hill southward, about an eighth of a mile west of the Old Crow distillery, in Woodford county.

Sample of the lower 23 feet of the Wilmore bed. More cherty, and full of Dalmanella, compared with the overlying part of the Wilmore. Same section as sample 3445. Two pounds of dark and light gray crystalline limestone with fossils.

3452. Old Crow distillery, same locality as that which furnished samples 3445, 3451, Woodford county.

Upper part of Wilmore bed, 33 1-2 feet thick, from 25.5 to 59 feet below the Strophomena vicina horizon. Three pounds of medium sized lumps, of gray crystalline limestone. Crystals of calcite in some.

3453 Glenn Creek, same locality as that furnishing samples 3445, 3451, 3452. Middle or argillaceous part of limestone section forming Wilmore bed, from 63 to 121 feet below the Strophomena vicina horizon. Woodford county. Three and a half pounds of medium sized lumps of gray crystalline limestone.

3454. Ten miles west of Georgetown, on the Frankfort pike, where the road to Spring Station starts off. Franklin county. Selected phosphatic chips very abundant on the quarry dump. Four pounds of brown, medium sized chips. No matrix.—Woodburn bed.

3455. Versailles section, on the railroad from Versailles to Frankfort, Woodford county. Same section as that from which samples 3424-3431 were collected.

Unaltered rock from which the phosphatic rock is obtained by weathering. Cross bedded layer. From the same part of the section as that which furnished samples 3425 and 3428.—Woodburn bed. Two pounds of medium sized lumps. Rather soft, gray argillaceous limestone.

3456. Curdsville bed, south of Frankfort, at the quarried bluff immediately north of the waterworks, Franklin county.

3457. Oregon bed.—Kentucky marble. High Bridge section, Jessamine county. Two pounds of dark gray and light gray limestone, with the darker predominating.

3458. Upper Perryville bed.—Cornishville bridge, Mercer county.—Salvisa bed. Very white, very fine grained limestone with small translucent specks.

3459. Cornishville bed, Cornishville, Mercer county, Ky. Crystalline limestone, brownish. Supposed to be phosphatic. Upper strophomena vicina horizon.

3460. Lower Perryville or Faulconer bed, Cornishville bridge, Mercer county. Fossiliferous. Isochilina horizon. 15.5 foot section.

3461. Big railroad cut southeast of Harrodsburg, Mercer county. Argillaceous basal Catheys, 7 feet thick, nearly unfossiliferous. Dark gray.

3462. Big cut, southeast of Harrodsburg, Mercer county. Upper Catheys, rubble limestone, 12 feet thick, omitting the clay at the top of the Winchester section, several feet thick.

3463. Big cut on railroad, southeast of Harrodsburg, Mercer county, Cornishville bed. Equivalent to upper Strophomena vicina horizon.

Following are analyses of the samples, made by Mr. J. S. McHargue, Survey Chemist:

Table of analyses of samples of Kentucky phosphate rock collected by Aug. F. Foerste, during July and August, 1911, and analyzed by J. S. McHargue.

1	2	3	4	5	6	7	8	9
Lab. Number	Phosphoric Acid (P_2O_5)	Bone Phosphate ($Ca_3(PO_4)_2$)	Double Phosphates of Iron and Alumina ($Al_2P_2O_8$ and $Fe_2P_2O_8$)	Double Phosphate of Iron. ($Fe_2P_2O_8$)	Double Phosphate of Alumina. ($Al_2P_2O_8$)	Iron Oxide, obtained from Phosphate of Iron. (Fe_2O_3)	Alumina obtained from Phos. of Alumina. (Al_2O_3)	Sum of Iron and Alumina Oxides. (Fe_2O_3 and Al_2O_3)
3400	31.70	69.26	15.00	5.13	9.87	2.71	4.12	6.83
3401	37.00	80.80	5.26	2.37	2.89	1.25	1.21	2.46
3402	30.02	65.99	6.80	2.73	3.93	1.25	1.64	2.89
3403	34.50	75.38	9.20	2.56	2.78	1.35	2.78	4.13
3404	29.55	64.57	14.46	6.32	8.14	3.34	3.40	6.74
3405	35.00	76.47	7.56	5.76	1.80	3.05	.75	3.80
3406	16.00	34.96	26.30	9.95	16.35	5.26	6.83	12.09
3407	32.00	69.92	13.20	2.60	9.60	1.90	4.01	5.91
3408	32.60	71.23	12.24	3.02	9.22	1.60	3.85	5.45
3409	37.70	82.37	5.12	2.11	3.01	1.12	1.26	2.38
3410	3.80	8.30	18.50	15.98	2.52	8.45	.94	9.39
3411	16.50	35.05	34.48	13.25	21.23	7.01	8.84	15.85
3412	12.50	26.65	25.12	11.44	13.68	6.05	5.72	11.77
3415	34.80	76.04	7.90	3.62	4.28	1.91	1.79	3.70
3416	32.00	69.92	19.38	9.34	10.04	4.94	4.20	9.14
3420	35.00	76.00	7.90	3.62	4.28	1.91	1.79	3.70
3421	35.00	76.00	5.84	3.06	2.78	1.62	1.16	2.78
3422	10.80	23.59	6.84	3.02	3.82	1.59	1.60	3.19
3423	35.80	78.22	8.40	4.08	4.32	2.16	1.80	3.96
3424	32.80	71.66	11.50	7.83	3.67	4.14	1.53	5.67
3425	12.50	27.31	2.94	2.27	0.67	1.20	0.28	1.48
3427	33.90	74.01	8.96	5.72	3.24	3.03	1.35	4.38
3428	31.50	68.83	11.00	7.83	3.17	4.14	1.33	5.47
3430	30.20	65.99	9.10	4.54	4.56	2.40	1.90	4.30
3434	17.70	38.67	4.08	2.40	1.68	1.27	.87	2.14
3435-2	31.50	68.83	15.18	5.72	9.46	3.02	3.95	6.97
3436	34.00	74.29	9.82	4.54	5.28	2.40	2.21	4.61
3437	33.90	73.74	9.78	3.32	6.46	1.76	2.70	4.46
3438	30.10	65.76	16.86	6.93	9.93	3.57	4.15	7.72
3439	32.70	71.45	13.84	6.64	7.20	3.51	3.00	6.51
3440	30.20	65.99	16.02	5.13	10.80	2.20	4.51	6.71
3441	25.00	54.62	22.90	8.15	14.75	4.31	6.16	10.47
3442	32.80	71.67	13.62	8.13	5.49	4.30	2.29	6.59
3444	27.40	59.87	13.96	6.33	7.63	3.35	3.19	6.54
3446	30.80	67.30	11.24	5.43	5.81	2.97	2.43	5.40
3447	31.30	68.39	13.30	2.11	11.19	1.12	4.68	5.80
3448	21.70	47.41	18.70	9.05	9.65	4.78	4.03	8.81
3449	29.00	63.37	27.64	15.93	11.71	8.43	4.89	13.32
3454	32.10	70.34	9.36	4.21	5.15	2.23	2.15	4.38
3455	25.40	55.50	3.50	2.11	1.39	1.12	.58	1.70
3463	9.16	....	....	....	....	....	....	....

BARYTES DEPOSITS OF KENTUCKY.

By F. Julius Fohs.

CHAPTER I.

GEOLOGY.

Introductory.

Barytes deposits occur in Kentucky as follows: 1. Central Kentucky district comprising Anderson, Bourbon, Boyle, Clark, Fayette, Franklin, Garrard, Harrison, Henry, Jessamine, Lincoln, Madison, Mercer, Owen, Scott and Woodford Counties; 2. Western Kentucky district comprising Russell, Cumberland, Caldwell, Christian, Crittenden, Livingston, Lyon and Trigg Counties; 3. Union County; 4. Casey County, and 5. Geode occurrences in Clinton, Grant, Estill and Lincoln Counties. Nos. 4 and 5 are not of commercial importance.

The vein deposits of the first three districts named occur respectively in the Ordovician, Mississippian and Carboniferous rocks, the barytes occurring most abundantly in the lowest of these strata divisions and decreasing in each succeeding higher one. The Casey County occurrence is in Devonian shale, while the geode occurrences range through the whole stratigraphic series.

Just as the barytes occurs in three of the more important stratigraphic divisions of the State, so also is it connected with the three greatest earth movements or disturbances in Kentucky rocks, the Cincinnati geanticline affecting the Ordovician rocks, the Crittenden fan-fold-monocline affecting the Mississippian rocks and the Rough Creek anticline affecting the Carboniferous and Mississippian rocks of West-Central Kentucky. In each instance, these disturbances present great domal or modified domal or uplift conditions.

The principal barytes deposits are those of the Central Kentucky district and it is to the description of these that this bulletin is chiefly devoted. The Western Kentucky and Union County deposits are fully described in Bulletin 15, shortly to be issued by this Survey.

STRATIGRAPHY.

The rocks exposed in Central Kentucky range from lower Mississippian to lower Ordovician inclusive. Lower Mississippian, Devonian and Silurian rocks cap small outliers, these rocks having been lowered by faulting to the level of the Ordovician rocks which cover the major portion of the district. The barytes deposits range through only the Ordovician, but are more prominently developed in lower or Mohawkian, than in the Cincinnatian or upper series of this division.

TABLE OF FORMATIONS FOR CENTRAL KENTUCKY.

SYSTEM	SERIES	
Mississippian	Keokuk-Waverly	
Devonian	Ohio Shale Boyle limestone	
Silurian	Niagaran	
Ordovician	Cincinnatian	Richmond 140-210 ft.
		Maysville 280 ft.
		Eden 185-265 ft.
		Cynthiana 40-150 ft.
	Mohawkian	Lexington (Trenton) 270-300 ft.
		Highbridge (Stone's River) 400 ft.

The workable deposits really begin at the top of the Cynthiana (or Winchester) limestone. Rather massive beds carrying abundant small crinoid stems, together with blue and gray knotty limestones, clay and clay-shale constitute the upper beds. These where faulted in Garrard County, show fissures two feet wide, the crinoidal beds showing two feet aditional replaced by barytes, zinc blende, etc. The lower member consists of argillaceous limestone alternating with shale, the former predominating. These beds rarely carry much mineral and then only in narrow fissures; geodes are commonly lined with calcite, fluorspar, and occasionally barytes.

The Lexington (Trenton) limestone embraces five members of which the Bigby and Wilmore beds aggregating about 150 feet offer the best barytes deposits. The uppermost bed of the Lexington is a coarse cross-bedded limestone. Then comes the Perryville (upper Birdseye) which is compact, dove-colored, has glassy calcite grains disseminated, and a conchoidal fracture. It is usually brecciated where fractured and does not carry workable deposits although it offers excellent specimens of lead and zinc ore. The Bigby is a coarse-grained, heavy bedded, calcitic limestone containing only two per cent magnesium carbonate, with very little shale interbedded. The upper 40 feet is highly phosphatic and the extreme top very cherty. The Bigby carries the widest fissures and the best barytes deposits. The Wilmore member is a coarsely crystalline, somewhat argillaceous limestone interbedded with shale. It carries deposits next in value to those of the Bigby, but the deposits are usually narrower and the lower beds are apt to carry breccias. The Logana member is fine-grained, well bedded, and inclined to be shaly, and gives rise chiefly to breccias. The Curdsville is a crystalline limestone cherty chiefly in the upper 20 feet; occasionally the upper 15 feet is coarse massive limestone. This member contains mixed breccia and narrow fissure deposits.

The Tyrone limestone while similar in composition to the Lexington limestone differs physically in its fine compact birdseye texture and brittleness, making it liable to be easily broken into small angular fragments thus accounting for the breccias common to this formation; the

compactness at the same time accounts for its being almost impermeable to water and its slight solubility, hence the absence of either marked fissure or replacement deposits. Its breccia deposits usually consist of barytes, zinc blende, fluorspar and calcite. The underlying Oregon member is a gray-to-cream colored magnesian marble which weathers yellow and has a thickness of 10 to 40, usually 25 feet. The Camp Nelson limestone, the lowest geological horizon exposed in Kentucky, has an exposed thickness of 285 feet. Both owing to its being slightly magnesian (containing 10 per cent magnesian carbonate) and its coarser, more open texture, it is more readily soluble than even the Lexington limestone so that the deposits are again fissure-filling and crustification is common with fluorspar, barytes, and calcite in alternating bands. The Camp Nelson member carries occasional thin beds of white shale which apparently do not affect the character of the deposits.

The character of deposits in lower-lying beds is problematical.

STRUCTURE.

The principal structural feature of the district is the Cincinnati geanticline, which trends a little East of North through Central Kentucky, crossng the Ohio River East of Moscow and extending thence to the latitude of middle Ohio. The Jessamine dome first described by Prof. A. M. Miller is one of its two larger domal culminations.

Following the axis of the Cincinnati geanticline, north and south from the apex of the Jessamine dome the strata dips are very gentle, while the greatest dips are those east and west of the apex, and along the eastern flank of the geanticline. The regularity of the dips is of course broken by faults and fault zones which were necessary corallaries to the folding of such rigid strata as heavy limestone beds.

Attendant upon the uplift and broad gentle folding was the formation of the following fault zones: Frankfort, Elkhorn West Hickman, Kentucky Anticlinal, and Barrett Knob. The Frankfort and Kentucky Anticlinal fault zones form a V starting immediately south of the apex of the Jessamine dome, the first named striking northwest and the other northeast. With minor exceptions, the barytes district lies almost wholly within this V. In eastern Jessamine county, the west Hickman fault zone branches from the Kentucky Anticlinal fault zone, striking first north and then northeast through Fayette and Bourbon counties. From the vicinity of Lexington, the Elkhorn fault zone extends northwest into Scott and Franklin counties, branching also from the Kentucky Anticlinal zone. In Garrard county, the Barrett Knob fault zone strikes south-southwest from the Kentucky Anticlinal into Lincoln county. For details of these zones reference may be made to Chapter III.

These fault zones represent minor folds modifying the regularity of the geanticline.

The topography and drainage of the Blue Grass region has been largely influenced by these structural conditions. The Kentucky River follows up the Frankfort zone to near the apex of the Jessamine dome where the Dix River intersects it and the latter continues along the course of the Frankfort zone while the Kentucky River thence follows eastward along the Kentucky anticline. Part of the distance across Jessamine county, Hickman Creek follows the latter anticline. The West Hickman zone and also the Elkhorn follow likewise the creeks whose names they bear. The folding and faulting of the strata along these zones has subjected to quicker erosion the edges of the beds rather than their flat surfaces and the streams naturally followed the lines of least resistance.

Each fault zone represents a broadly shattered strip varying locally from a few feet to one mile wide, and is from five to seventy miles long. Usually a number of faults and fractures make up each zone.

The faults are of two types: 1. The normal fault with vertical or nearly vertical displacement of one wall; this type is common to the major fault zones; 2. The shift fault in which one wall has shifted past the other in the direction of the strike of the fault; this is predominant along the Frankfort zone and in areas intermediate between the fault zones.

While the strike of many of the faults vary 5° to 10° east or west of north, there are many exceptions in which the strike more nearly approaches east or west.

In some instances, the faults parallel the course of the zone and in others constitute a set of complementary intersecting faults. Between major zones, especially in areas where two zones are in close proximity there has been a shearing of the strata so that numerous faults occur. Such faults are likely to have strikes intermediate of those of the bounding fault zones, as for examples between the Elkhorn fault zone with its northwest strike and the West Hickman zone with its northeast strike, the faults of the intermediate area striking nearly north. These strikes were perhaps more influenced by the fault zones than by the general trend of the geanticline, the latter having been the general supposition heretofore.

The strike of a single fault is often found to vary from east to west of north, in other words the fault may be extremely sinuous but at the same time generally maintains a fairly regular strike. The shift faults are usually vertical while the normal faults dip 80° to 85° but sometimes as much as 60°.

The faults vary in length from 1,000 feet to from three to five miles. The displacement in the case of normal faults is usually less than 100 feet, occasionally reaches 200 to 300 feet, and in rare instances exceeds this. The movement in the case of shift faults parallel to the strike is seldom more than a few feet. The faults may reach depths of from 1,000 to more than 2,000 feet from the present surface and in many instances 600 feet or more has been eroded from their tops so that the present veins represent the stumps of the originals.

The number of faults mapped exceeds 200 and a large number yet remain to be found.

The distance between parallel veins varies greatly but usually parallels are to be expected within one-fourth mile of the central fault.

The lack of joints except in proximity to the veins is quite marked and the lack of calcite or barytes seaming even more so. In the Russell county vein occurrence the jointing shows for a width of 100 feet, and at the Mrs. Rufus Lisle vein near Lexington for over 200 feet. At the latter they strike N. 10° E., N. 20° W., N. 50° W., and N. 50° to 65° E. In some instances jointing is helpful in suggesting the strike of nearby faults which it usually parallels.

Bedding faults are of minor importance and only rarely seen. Such faults are the result of the shifting of strata beds one upon the other for a few feet. Where the veins are broken and the upper portion shifted it becomes an easy matter to recognize them. Two occurrences may be mentioned, one on the Miller Lee and the other on the Prewitt land, the displacement being 2 feet in each instance.

CHAPTER II.

ORE AND SPAR DEPOSITS

BARYTES AND ASSOCIATED MINERALS.

Barytes is the commercial name commonly used for barite or barium sulphate. From the fact that it is heavier than the common spar minerals, it has been termed heavy spar.

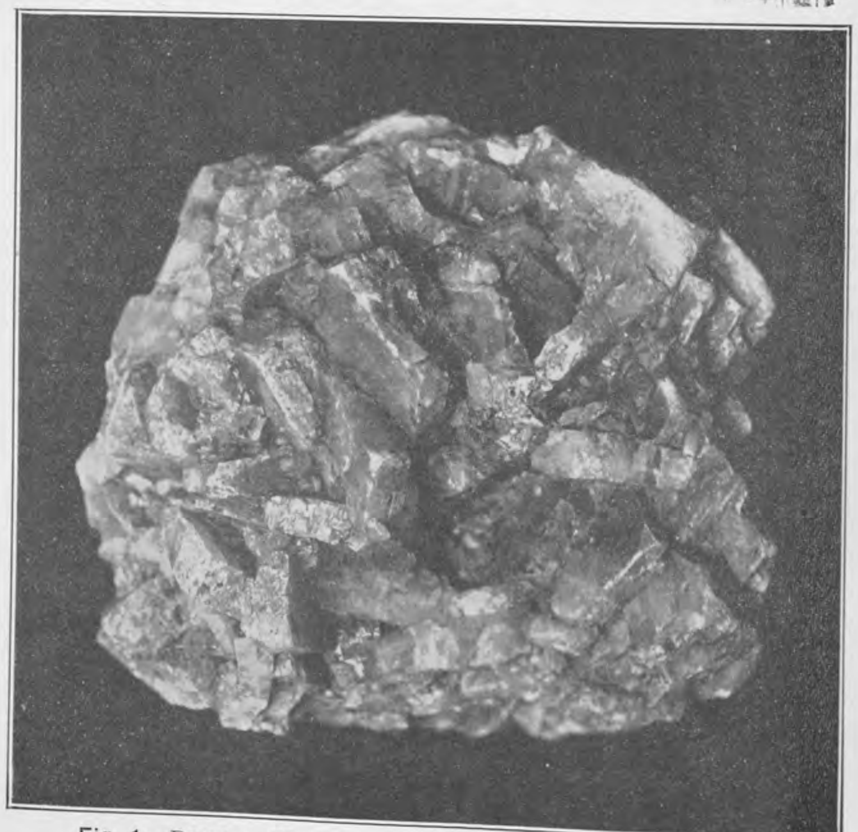


Fig. 1.—Barytes Crystals. Perkins Prospect, Mercer County.

Crystals of barytes occur rarely in Kentucky and then are small, always a combination of the unit prism and basal pinacoid. Its cleavage is orthohombic, cleaving into rhombohedrons similar to calcite except that the angles are nearer right angles. Barytes occurs in granular, closely reticulated or radiating fibrous, or earthy masses or as an aggregate of straight or curved cleavable plates. When encrusting other minerals it occurs in fibrous knob-shaped masses.

The fracture of barytes is conchoidal, sometimes splintery; its hardness varies from 2.5 to 3.5, the soft variety being of the earthy type, and the harder fresh crystalline. Its specifin gravity varies from 4.2 to 4.6. The luster is vitreous to pearly or dull earthy. Kentucky barytes is usually white, rarely bluish-gray to gray, and even black, and its streak is white. Intimate iron-staining gives barytes a pinkish, reddish or yellowish cast. It is usually translucent, rarely opaque.

Barytes, the chemical formula of which is $BaSO_4$, consists when pure of barium monoxide 65.7 per cent and sulphur trioxide 34.3 per cent. It contains strontium, calcium and rarely ammonium sulphate in isomorphous mixture or as mixed crystals. Hydrocarbons color the mineral gray to black. Other impurities occur as stains on the barytes and consist of silica and oxides of iron and alumina, etc., while intergrown with the barytes are associated minerals which often constitute impurities.

ANALYSES.

No. 3530. White and gray bands alternate: barytes containing considerable celestite probably in the dark bands; has a silky luster. Bands up to one half inch wide. Lexington limestone walls. John Baughman prospect one half mile N. of Danville, Boyle county, Ky.

No. 3531. Cream colored barytes with arborescent texture. Upper Lexington limestone walls. Lee River prospect, one half mile S. of Harrodsburg, Mercer county, Ky.

No. 3532. White fibrous barytes with silky lustre with black mottling or staining, probably due to hydrocarbons; sample partly weathered, partly fresh. Lexington limestone walls. Farris prospect, four miles N. E. of Danville, Boyle county, Ky.

No. 3533. Pure white barytes with thin orange-red iron-stains in seams; has satin lustre and is fine-fibrous. St. Louis limestone walls. Meyers prospect near Mexico, Crittenden county, Ky.

No. 3534. Soft white fibrous barytes representing weathered product. Ste. Genevieve limestone walls. Ray mine, two miles from Fredonia, Caldwell County, Ky.

No. 3435. Hard, fine, granular, crystalline barytes, dark cream colored and glassy; unaltered sample corresponding to No. 3534, and from same locality.

No. 3536. Barytes with some limestone, calcite and zinc blende, partly altered; from Hayden opencut. Upper Lexington limestone walls. One mile and a half S. of Danville, Boyle County, Ky.

No. 3537. Celestite. Grayish-white interlacing needles. Truesdale, Owen county, Ky.

No. 3538. Dark gray barytes crystals. Upper Lexington limestone walls, Perkins prospect, one mile and a half S. E. of Burgin, Mercer county, Ky.

No. 3539. Arborescent creamy barytes containing minute grains of chalcopyrite, partly altering to copper carbonate, these grains arranged more or less in bands, 1-4 to 1-2 inch apart; sample slightly altered. Lexington limestone walls. Mosby prospect, one mile and a half S. of Shryock ferry, Woodford county, Ky.

No. 3540. White lamellar crystalline barytes. Upper Lexington limestone walls, Shelton open cut, four miles east of Danville, Boyle county, Ky.

Analyses of Kentucky Barytes.

Number	3530	3531	3532	3533	3534	3535
Ignition	0.17	0.34	0.87	0.28	0.62	0.23
Silica	0.34	0.11	0.11	0.25	0.10	0.05
Iron oxide	0.06	0.02	0.04	0.06	0.06	0.03
Barium oxide	50.86	50.96	60.26	64.72	59.80	50.96
Strontium oxide	8.99	11.65	3.80	Trace	2.41	11.10
Calcium oxide	3.61	Trace	0.76	Trace	2.09	0.88
Sulphur trioxide	33.87	36.31	34.60	33.82	33.23	35.66
Fluorine	2.45	Trace	0.52	0.00	1.42	0.60
Zinc oxide	Trace	0.00	0.00	0.00	0.00	0.00
Total	100.35	99.39	100.96	99.13	99.73	99.51

Barium sulphate	77.44	77.60	91.76	98.54	91.06	77.59
Strontium sulphate	16.31	21.32	6.90	Trace	4.38	20.13
Calcium sulphate	2.47	0.00	0.53	0.00	0.00	0.60
Calcium fluoride	5.03	Trace	1.06	0.00	2.91	1.23
Calcium carbonate	0.00	0.00	0.00	0.00	1.07	0.00
Zinc carbonate	Trace	0.00	0.00	0.00	0.00	0.00
Specific gravity	4.228	4.381	4.456	4.444	4.291	4.333

Number	3536	3537	3538	3539	3540
Ignition	1.40	0.65	0.15	1.19	0.28
Silica	0.55	0.18	0.10	0.20	0.23
Iron oxide	0.06	Trace	0.04	0.08	Trace
Barium oxide	54.95	10.71	64.68	49.98	60.55
Strontium oxide	6.75	45.06	0.20	11.07	3.72
Calcium oxide	0.20	0.25	Trace	Trace	Trace
Sulphur trioxide	34.22	42.28	33.97	35.12	35.38
Fluorine	0.14	0.00	0.00	0.50	0.00
Zinc oxide	1.23	0.00	0.00	1.50	0.00
Total	99.50	99.13	99.14	99.68	100.16
Barium sulphate	83.67	16.88	98.48	76.09	92.90
Strontium sulphate	12.25	81.75	0.37	20.08	6.75
Calcium sulphate	0.00	0.60	0.00	0.00	0.00
Calcium fluoride	0.28	0.00	0.00	1.02	0.00
Calcium carbonate	0.10	0.00	0.00	0.00	0.00
Zinc carbonate	1.89	0.00	0.00	2.31	0.00
Specific gravity	4.428	3.918	4.523	4.417	4.524

The foregoing series of analyses were made on samples typical of the various kinds of barytes occurring in Kentucky. It will at once be noted that they show varying percentages of strontium sulphate ranging in the case of the barytes from 0.37 to 21.32 per cent, while a celestite (of rare occurrence) contains 16.88 per cent of barium sulphate. Unfortunately, the lack of laboratory facilities prevented the analysis of but a small part of the samples collected for this purpose, the number analyzed being insufficient to say that more than a part of Kentucky barytes carries marked percentages of strontium sulphate.

Fig. 2.

Barytes encrusted with Strontianite, Johnson Mine, Scott County.

The question arises as to the effect of strontium sulphate in the barytes for the purposes for which barytes is used. Analyses from other regions frequently contain greater or less percentages of strontium sulphate, however, no special determinatians have been made of the commercial barytes of the principal competing districts such as the Missouri, etc. By ordinary methods the strontium oxide would be determined with the barium oxide.

A comparison of the compounds of barium and strontium show that chemically they have much in common, both belonging to the group of alkaline earths, the stron-

tium compounds having slightly lower specific gravity, slightly less solubility of the hydroxide, but greater solubility of the sulphate. Both are inert to acids. For all ordinary purposes the uses of the mixed strontium-barium sulphate mineral or compounds prepared from it, will serve for all purposes for which the pure barium sulphate mineral or any of its compounds is adapted, with one exception, the preparation of barium peroxide.

The specific gravity of pure celestite is 3.91 to 3.97, that of pure barytes 4.5 to 4.6. Combinations of barium and strontium sulphates and other impurities lower the specific gravity to 4.23. Difference in physical character will also effect slight differences in the density. It appears quite probable, that many barytes heretofore considered nearly pure barium sulphate contain more or less strontium sulphate, hence the specific gravities of 4.3 and thereabouts frequently given for barytes.

Strontium sulphate is next to barium sulphate the most insoluble of alkaline sulphates, calcium sulphate being fourteen times as soluble, while strontium sulphate is about five times as soluble as barytes. This accounts for the lower percentage of strontium sulphate and softened physical appearance of the weathered barytes; the weathered samples analyzed contain less than seven per cent of strontium sulphate.

It appears entirely probable that the strontium and barium sulphate are not isomorphous chemical compounds but are in fact of the type of mixed crystals, that is to say physically intergrown. Investigations to determine this definitely have not yet been made. From a trace to about 2.5 per cent of calcium sulphate may be similarly present.

Ignition in the analyses represents doubtlessly some free moisture, combined carbon dioxide, and hydrocarbons, if any, present. The silica content in the barytes will be noted as abnormally low, it being highest in No. 3536, in which it was probably present in the associated limestone. The iron oxide content is very low in all the samples. No. 3539 which is typical of maximum copper content shows a negligible percentage, (.04 per cent copper oxide). The zinc oxide estimated by the chemist as carbonate was in each case largely in the form of the sulphide, zinc blende.

Barytes may be distinquished from its associated minerals first by its being white or almost so except for iron staining, when freshly broken. Its fibrous structure is distinctive. It does not dissolve or react with cold acids. It is decidedly heavier than any of the associated spar minerals; galena is somewhat heavier and zinc blende is lighter. Barytes may be distinguished from calcite by the fact that the calcite effervesces with acid and from gypsum by the solubility of the latter in hydrochloric acid.

The principal associated minerals are calcite, fluorspar, zinc blende and galena. Quartz, strontianite, pyrite, chalcopyrite, zinc carbonite, limonite, etc., are less frequently associated.

The calcite is usually gray to milk-white of the rhombohedral-cleavage type and rarely translucent. The fluorspar is usually colorless, rarely purple. The zinc blende varies from fine-grained to coarse-cleavable but is more frequently of the latter type as it is fine-grained only where disseminated in limestone. The color varies from reddish to black, and may constitute as high as ten per cent of a deposit. The galena occurs only in cubical

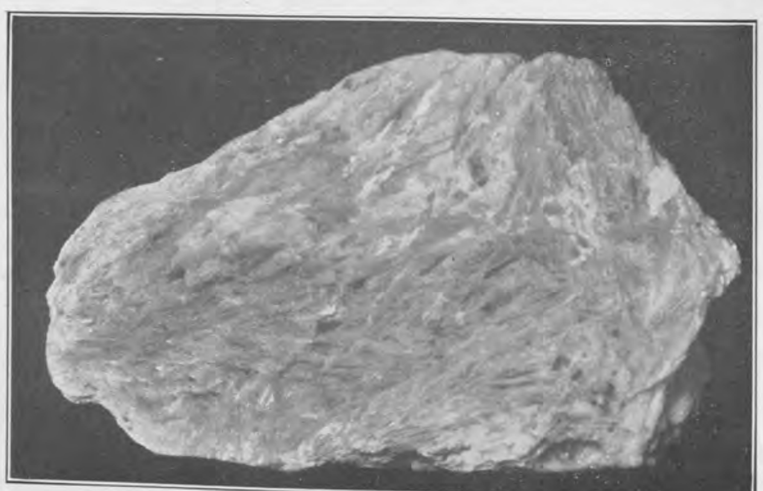


Fig. 3.

Celestite,
Truesville, Owen County.

cleavages intergrown with the other minerals. Strontianite is carbonate of strontia and occurs usually in fibrous gray to white crystalline coatings on the barytes and was seen notably at the Davis mine in Scott county. It froths in dilute acid and burns with a red flame. Celestite as a distinct mineral is rare; it is strontium sulphate, has a hardness of 3. to 3.5, and is similar to barytes but is more soluble and burns with a crimson flame.

Pyrite occurs rarely and then usually with zinc blende. Marcasite was noted on the Stafford land along the Kentucky anticline in Jessamine county. Chalcopyrite partly altered to copper carbonate occurs intergrown with zinc blende and in fine grains disseminated in barytes at the Mosby prospect in Woodford county. Zinc carbonate lines the minute cavities from which zinc blende has leached, but does not occur in commercial quantity. Limonite occurs both in such cavities and as a result of the alteration of pyrite.

The principal minerals occur intergrown, but it is seldom that they are all to be found in a single band or specimen. The zinc blende may be intergrown with any of the spars or may be disseminated in limestone. The galena occurs most frequently in the barytes.

CHARACTER OF DEPOSITS.

The barytes and associated minerals occur in three forms of deposits, veins, bed-veins, and geodes, only the first of which is economically important, though a bed-vein might occasionally prove so.

Geodes have been found notably in the Cynthiana limestone, in some of the upper Cincinnatian limestones, in the Keokuk limestone and in the Waverly sandstone.

Bed-veins result from the cementation of brecciated limestone. The brecciation results from the crushing of a limestone bed which has either been altered through leaching or else shrunk upon being changed to magnesian limestone, the crushing resulting from the weight of strata resting above. Bed-veins are represented by the zinc deposits in the limestone in Lewis county; by the Keokuk limestone brecciated and cemented with barytes in Estill, Madison, Menifee and Rockcastle counties, and by a bed of Richmond limestone in Lincoln county.

The Veins: These are vertical or slightly inclined deposits which pinch or swell on following the dip or strike. They may reach a depth of over 1,200 feet, a length of four or five miles and a width of 16 feet. The average present depth of the known deposits is 600 feet at least half of which carries a commercial product. The average width varies from two to four feet.

The deposits fill three types of fissures: simple fissures, shift faults, and normal faults, those of the first type being rare. Perhaps the most important deposits occur in the shift faults, and good deposits occur more frequently in normal faults of small displacement than in those of greatest displacement. This is explained by the presence of a larger amount of open space for the deposition of mineral where there has been small shift or vertical displacement, there being also a larger amount of rock fragments produced. Thus the circulation of mineralizing solutions was much more restricted in the large primary faults.

The narrowness of the veins usually two to four feet, (rarely as much as sixteen feet) is explained by the slight dissolution of rock-fragments prior to deposition and also to the lack of replacement deposits, barytes seldom producing deposits of the latter type. The lack of replacement deposits explains partly also the greater regularity in width of these veins as compared with those of Western Kentucky.

The veins although sinuous maintain a fairly regular general strike, and are sometimes short and arranged in step fashion or are linked.

The shoots are of irregular shape and size, but are seldom wide, the widest noted being 16 feet, this at the Sandidge mine in Boyle county.

Types of Deposits: The deposits are either of the fissure, breccia, or replacement types or a combination of two or all of them.

The fissure deposits consist of the several vein minerals and some enclosed country rock; they are characterized by the arrangement of the minerals in alternate bands. The bands consist of either one mineral or of two or more in all possible combinations. Much of the barytes and fluorspar-barytes belong to this type. The Cole and Coleman veins offer good examples of fissure-filling barytes. Interbanded fluorspar, calcite, and barytes may be seen on the Lee Riker land near Harrodsburg. The following section of the vein at the Thomas prospect (Scott county) illustrates its banded character; 1. limestone; 2. clay, 6 in.; 3. rotted limestone, 4 in.; 4. barytes with a little calcite, and with galena in bands and grains, 3 to 7 in.; 5. barytes coating and cementing calcite, 2 to 7 inches; 6. barytes and a little galena, 2 to 3 inches; 7. barytes, 1 to 2 in.; 8. calcite and barytes, 1 in.; and 9. limestone wall. The sections of the Twin Chimney vein given in Chapter III are excellent examples of a banded vein.

Barytes is the predominant mineral and the most concentrated, calcite is next abundant, and fluorspar stands third but is much scattered; zinc blende is associated with all of these minerals but chiefly with the barytes, while the galena occurs in smallest quantity and is chiefly associated with the barytes.

Fragments of country rock are occasionally enclosed in the veins, either angular or partly altered. These may locally completely take the place of mineral but driving through them usually results in the location of another shoot.

Breccia deposits occur both along shift and normal faults and are least common along the faults of great vertical displacement. They are especially prominent along secondary normal faults along the Kentucky and West Hickman zones.

Deposits of this kind will occur in all of the veins but most frequently where they cut compact brittle rocks such as the Tyrone limestone. Breccias appear to favor the deposition of fluorspar and calcite somewhat more than that of barytes. At the Dr. Stephenson prospect in Clark county, fluorspar cements chert breccia. The Cotton prospect offers excellent examples of limestone brec-

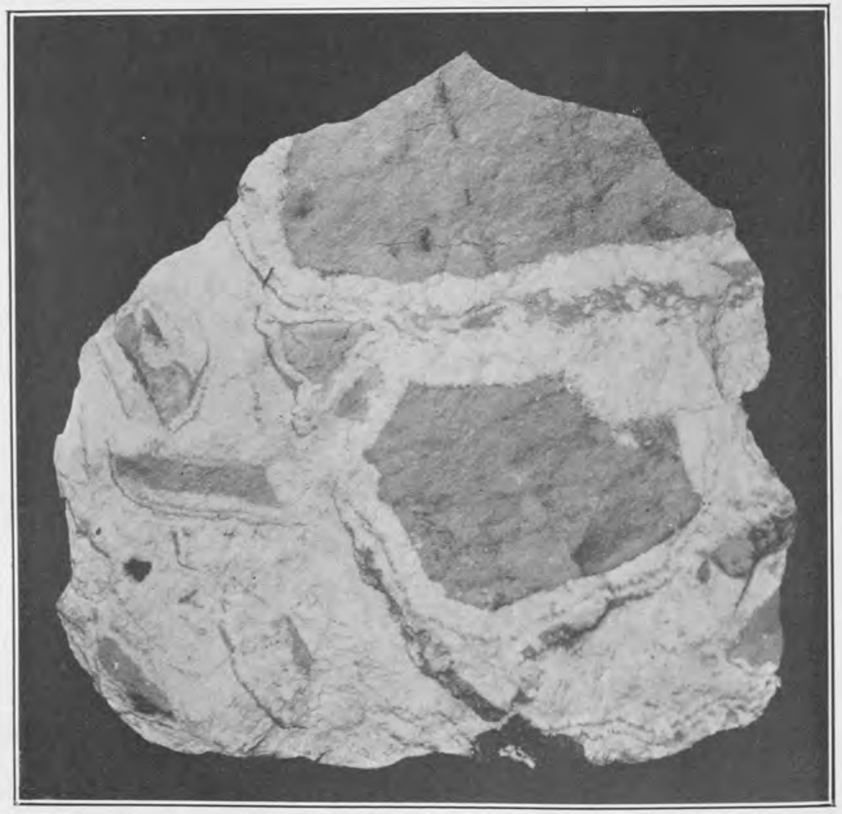


Fig. 4.

Limestone Breccia cemented by White Barytes, Horine vein, Jessamine County.

cia cemented by barytes, zinc blende, etc. The Kentucky fault zone at Cleveland shows breccias cemented with fluorspar and barytes. Many of the barytes breccia deposits become available by the natural leaching of the limestone and calcite; where unaltered, the barytes can be made available by jigging.

Where the limestone is coarsely crystalline and its grains loosely cemented, free access was given to mineralizing solutions so that in some instances the limestone was wholly or partly replaced by mineral. The shape and position of the deposit will depend on whether

vertical sheeted limestone, shaly beds, or massive limestone was replaced.

The order of facility and frequency of replacement appears to be: 1. Calcite; 2. Zinc blende; 3. Fluorspar; 4. Barytes; 5. Marcasite and 6. Galena.

Calcite deposits such as the Million are partly the result of replacement, the process being the complete dissolution and simultaneous re-deposition of the calcium carbonate in large crystalline cleavage aggregates.

No large replacement deposits of zinc blende were seen, the zinc being usually in barytes deposited in open spaces; however, where such deposition was for any reason prevented the zinc blende replaced the limestone in from fine-grained to coarse cleavages. Examples occur at the Cotton, Hoggin, and numerous other localities.

Fluorspar, commonly a replacement mineral elsewhere, appears seldom to replace limestone in Central Kentucky. Where a replacement mineral it is colored purple as at the John West vein.

Barytes as a replacement product is only of occasional occurrence perhaps owing to its being difficultly soluble. In its replacing limestone there is a complete substitution for calcium carbonate, the latter being simultaneously dissolved. In Central Kentucky, replacement barytes usually forms an arborescent mass with unreplaced limestone between the fibers. Such barytes is usually grayish to bluish colored. The most important examples are the deposit on the John West land, and part of the barytes obtained from the Gunn vein on the Farris land.

Marcasite replaces the limestone breccia fragments on the Stafford land. Galena as a replacement product has been rarely observed.

Few important deposits aside from calcite appear the result of replacement, the John West deposit in Jessamine county being an exception. Part of the zinc blende may usually be expected in this form but probably nowhere in large amount. Most of the deposits represent a combination of fissure and breccia and frequently also of replacement deposit. The Smitha deposit represents a combination of the first two and the Cotton prospect of Woodford county, a combination of breccia and replacement.

AREAL DISTRIBUTION OF MINERALS: It is important to consider this for certain general locality phases occur: Thus, fluorspar-barytes predominates in the Athens region, barytes alone or with some lead and zinc in the Georgetown-Lexington region, barytes-calcite with lead and zinc in the Gratz region, fluorspar-barytes and calcite in the Harrodsburg-Wilmore region, zinc blende-barytes in the Danville region, zinc-lead-barytes in the Paris-Millersburg region, etc. The presence of fluorspar and calcite in those localities in which they are prevalent appears best explained by later fracturng and later deposition.

Fig. 5.

Lead-zinc ore, Lockport mine, Henry County,
Dark bands and patches represent galena intergrown with zinc blende. White bands consist of barytes except one just to right of center which shows some calcite.

While in the regions named, the grouping of minerals is fairly constant, exceptions occur, an entire vein sometimes maintaining a different character, and in a few instances as for example, in the Overstreet vein in Jessamine county, barytes may predominate in local shoots in a fluor-barytes vein, an encouraging fact. The presence of chalcopyrite in barytes and pyrite in calcite appears also a regional effect, having been noted only in the Shryock's Ferry region.

It appears in general where the wider portions of the veins consist principally of barytes, the narrow portions (and those filled by a horse, breccia, etc.) consist chiefly of calcite or limestone replaced by lead or zinc; rarely, in local areas, the lead and zinc ore may fill the wider shoots instead.

VERTICAL DISTRIBUTION OF MINERALS: There is some conflicting data regarding this, especially in relation to certain wall rock, and yet certain facts appear prominent. The best barytes deposits occur in the Bigby-Flanagan beds of the Lexington limestone. Fluorspar is not confined to a specific geological horizon, but in those localities where it appears it ranges through the whole stratigraphic series. Calcite and fluorspar-calcite seem to occur most abundantly in the Highbridge limestones. The McChord vein (Fayette county) exposed for almost the full section of the Lexington limestone and partly also in the Tyrone limestone, shows barytes in excess in the former and fluorspar in excess where the vein cuts the Tyrone limestone; this is probably explained by the greater amount of open-fissure space in the Lexington limestone. In general, prospecting for these deposits in higher rocks, than the Greendale limestone is not advised. For fuller details as to specific effects on the type of deposit of the different limestone beds reference should be made to Chapter I, Stratigraphy. Next to the Lexington limestone, the Greendale and Highbridge limestones may be expected to yield the best deposits.

The veins are exposed to a depth of over 300 feet along the Kentucky river cliff, the gorge having penetrated the rocks to that depth. The chances for the veins continuing to a depth of 1,000 to 1,500 feet below the present surface, are good.

WEATHERING OF DEPOSITS: Water level occurs at varying depths, few of the vein openings having penetrated it, notable exceptions being the Horine and Shropshire prospects. The depth to wall rock is usually 10 to 16 feet and the deposits appear but slightly altered within a few feet below, the solid deposits being reached.

Owing to its sparing solubility, barytes is but slightly affected by surface waters; only one instance of water-worn barytes was noted. The effect of weathering on barytes is two-fold; First, to soften and accentuate the fibrous, reticulated structure and to break it into small masses or gravel, which is found scattered through the clay above the vein.

A circumstance attendant on this change is loss of luster, the mineral becoming a dull chalky white. Cavities seldom result from the leaching of barytes.

Due to its fibrous structure, barytes is not readily reduced to gravel. Where fractured or jointed, however, there is access for solutions laden with iron oxides, silica, alumina, etc., which are deposited in such fractures and swell the mass apart, the result being barytes gravel which becomes bedded in residual clay. The stains caused by the deposition of iron oxides, etc., in the cracks usually constitute so thin a film as to detract but little from the purity of the barytes. The thickness of these stains depends on the length of time and depth of erosion of the wall rock, a process constantly active. The staining is therefore less heavy on Kentucky barytes from the Lexington limestone than on Tennessee barytes from the Knox dolomite.

Gravel barytes deposits are larger than the vein from which they are derived for they represent an accumulation from a considerable depth of eroded vein. The thickness of the original vein is more nearly the depth through the layer, the width of the layer usually representing the fallen or overlapped vein. When the Lexington limestone has been eroded the gravel deposit will greatly exceed what may be expected below.

Much of the weathered mineral is honeycombed from the leaching of the more soluble constituents. It is important to note the character of the cavities formed because some barytes is thereby partly freed from objectionable impurities, and also because it is often possible

to predict from their appearance the character of the fresh ore to be expected when solid walls are reached. Cavities chiefly result from the leaching of limestone fragments which leave irregularly angular shaped cavities and calcite which leaves scalenohedral shaped cavities, some red clay filling the cavities in both instances. Zinc blende ranks next in solubility and when leached small rounded cavities remain, coated with a film of zinc carbonate or iron oxide.

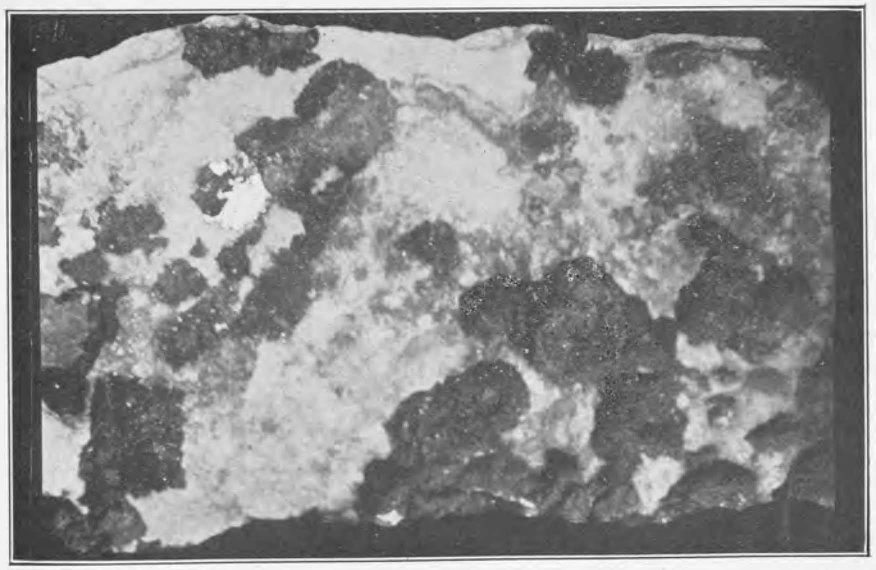


Fig. 6.

Barytes and zinc blende and cavities from which zinc blende has been leached.
Mosby Prospect, Woodford County.

The leaching of galena is less common, although good examples were noted at the Withrow and Woodland Academy veins; the cavities nearly always contain some remaining galena and lead carbonate. The ores from the Hayden and Stoll veins are good examples of the leaching of zinc blende, limestone and calcite.

EXTENT OF THE DEPOSITS.

Summarizing the results of the investigations the following are the number of veins located by counties in the Central Kentucky district:

Anderson 5, Bourbon 25, Boyle 23, *Clark 6, Fayette 43, *Franklin 4, Garrard 14, Harrison 5, *Henry 7, Jessamine 30, Lincoln 8, Madison 2, Mercer 10, Owen 3, Russell and Cumberland 1, *Scott 9, and Woodford 11, making a total of 199 veins. In the counties marked with a star (*) further investigation would unquestionably disclose a much larger number of veins, while other veins will doubtlessly be located in all the counties.

The following counties failed to show deposits worthy of further consideration: Barren, Boone, Breckinridge, Carroll, Casey, Clinton, Estill, Gallatin, Grayson, Grant, Marion, Meade, Menifee, Metcalfe, Monroe, Nelson, Oldham, Pendleton, Shelby and Trimble.

Owing to the great weight of barytes, comparatively narrow deposits may be profitably exploited. A solid cubic foot of the mineral would weigh 280 lbs. and allowing for voids, etc., the net cubic foot would weigh 200 lbs., requiring 10 cubic feet to the ton.

The calcite, where in sufficiently large veins, can be profitably exploited. The fluorspar-barytes deposits may be utilized for paints without separation. Lead and zinc sulphides, chiefly as by-products in barytes mining may be expected to add materially to the profits; the lack of proper milling facilities has prevented previous realization from this source. An occasional deposit of lead-zinc ore may prove a primary source of profit but such instances are likely to be few.

With such considerable barytes deposits, deposits greater in extent than those of any other State, Kentucky should have the greatest barytes industry in America, the chief requirement to accomplish this being capital for the development of the deposits and the erection of proper plants for the separation of the minerals and their manufacture into finished products.

CHAPTER III.

DESCRIPTION OF TYPICAL OCCURRENCES.

1. FRANKFORT FAULT ZONE. This zone consists of a series of shift faults and some normal faults and has a general course of N. 16° W.; the faults vary in strike but a few degrees east or west of north. Beginning at the Kentucky Anticlinal fault zone, the Frankfort zone follows the course of Dix River to its mouth at Highbridge, and thence down the Kentucky River as far as into Owen county.

The Drennon Springs, Gratz, Lockport, Shryock Ferry, Twin Chimney, and other veins form part of this zone. Between the veins mentioned are areas along which veins have not yet been located but prospecting would doubtless uncover them. The zone has a length exceeding 65 miles and its vein materials are as varied as there are kinds of deposits in the district. For particulars reference should be made to the descriptions of the veins mentioned, in this and the succeeding chapter.

Northwest of the Elkhorn fault zone the Frankfort zone has upper Lexington and higher rocks along its course, while further southeast the rocks are Lexington, Tyrone and Camp Nelson limestones.

II. SHRYOCK FERRY VEIN. From a short distance north of Shryock Ferry in Woodford county, this vein trends S. 7° E. into Anderson county. It forms part of the Frankfort zone and cuts limestone ranging from the Greendale beds to the Tyrone.

Immediately north of the ferry on the J. W. Newman land, the vein strikes north and contains calcite with minute pyrite inclusions and slight barytes encrustatons cementing Tyrone limestone breccia. One band 12 to 15 inches wide, is separated by 24 inches of limestone from another calcite band 6 inches wide. Further prospecting is suggested where this vein cuts Lexington limestone although the prospect is not encouraging.

On the Widow Shryock land, which is up the first rocky branch north of the Old Barbee distillery, the vein shows barytes-limestone breccia containing a little zinc and copper.

At the top of the cliff on the Mosby land, south of the last, the vein was prospected by shaft and cut, showing 10 to 24 inches of barytes-limestone breccia cutting Lexington limestone. The barytes contained a little zinc blende, galena, pyrite, and chalcopyrite, the last altering to malachite. An adit near the river level was driven 90 feet on the vein which consisted chiefly of calcite (with some zinc blende, fluorspar, pyrite and barytes) cementing limestone breccia. The zinc blende was red when fine-grained and black when in coarse cleavages. According to Prof. Miller the vein in the adit was 18 inches wide and strikes N. 5° E.

To the south across the river it has been opencut on the Routt land in Anderson county. This prospect is 300 yards west of the Kentucky river and six miles and one-half southeast of Lawrenceburg. The vein is in the Perryville bed and strikes N. 7° W. A sheet of compact limestone, three feet and a half wide almost fills the fissure. This block is shattered diagonally with the strike of the vein, the seams being cemented with barytes. Between the block and either wall, is a narrow space 2 to 12 inches wide filled with barytes containing galena and zinc blende, the galena filling the center of the seam, the zinc blende the outer edges, the whole being irregularly banded. The width of the deposit will probably increase upon sinking to the Bigby limestone.

III. KENTUCKY ANTICLINAL FAULT ZONE. This great fault zone is one of the largest in Kentucky, being 100 miles long and as much as three-fourths of a mile wide. It was recognized by W. M. Linney who named it the Kentucky anticlinal in his report on the "Geology of Lincoln County," 1882. This anticlinal is paralleled to the south by a basin-like trough or synclinal also described originally by Linney. This uplift and attendant depression cross the Cincinnati geanticline in a northeasterly direction. The fault zone is confined to the anticlinal.

Beginning in eastern Larue county, it extends northeast across Marion and Boyle counties, north-northeast through Garrard county to Camp Nelson, thence northeast through Jessamine county, east-northeast through southern Fayette, northern Madison and through Clark county within five miles south of Winchester; whether it extends east of Clark county has not been determined. It passes immediately southeast of the Jessamine dome.

On the Tates Creek pike between Spears and Valley View, an 800-yard cross-section was obtained and is shown herewith. This exhibits a number of interesting features which are characteristic of other sections obtained along the zone. The major fault has a throw of 100 feet and is between Tyrone and Wilmore limestones, with downthrow to the south. A number of secondary faults of less displacement but similar downthrow occur, having the general effect of raising the Tyrone beds northward in accordance with the domal uplift and of lowering the Wilmore beds to the south. The crests of two anticlines occur at a distance of 235 and 515 yards respectively north of the main fault which is itself at the crest of an anticline, while to the south three anticlines are exposed at distances of 85,245, and 405 yards respectively. A calcite vein occurs 140 yards north of the main fault while 280 yards south of the fault there is a fluorspar-barytes vein 2 to 3 inches wide, the filling in each case being in a secondary fault, and some distance removed from the crests of the smaller anticlines upon which they occur. This illustrates the lack of mineralization of major faults with deposition principally in the secondaries.

Generally the zone is bounded to the northwest and southeast by normal faults of maximum displacement with secondary parallel and intersecting faults on either side and between them at varying intervals, in some instances sufficiently mineralized to repay working. The greatest number of prospects follow the northwestern boundary, probably because of the lower wall rocks which appear at the surface. Much brecciation occurs with the faults so that breccia deposits are the common type.

Details of properties examined along this fault zone will be found along the respective county heads through which the zone passes; see also descriptions IV and V which immediately follow, descriptive of the Sandidge and Hayden veins.

IV. SANDIDGE VEINS. Three to five miles east of Danville in Boyle county, these xeins form part of the Kentucky Anticlinal fault zone, which here cuts Lexington limestone with a general strike of N. 40° E. and consists of a series of linked shift faults whose strikes vary from N. 5 to 30° E. Parallel fissures occur within one half mile east of the main faults and possibly others occur to the west. The walls are sheeted parallel to the vein and show slight offsets, especially prominent at the Shelton opencut. The vein consists of a breccia band constituting one half or more of the width, the remainder being a fissure deposit. The breccia is limestone cemented with barytes and some fluorspar and calcite while the fissure deposit may be almost wholly barytes as at the Shelton, barytes in narrow bands alternating with fluorspar as on the Wood, or barytes encrusted with fluorspar crystals which constitute a 12-inch band adjacent to the east wall on the Sandidge land. The barytes varies from the best grade of white to that which is weathered, iron-stained, and contains considerable impurities, and from finely fibrous to coarsely lamellar. The deposits vary from one to sixteen feet wide, and average three feet or more.

V. HAYDEN VEIN. This represents zonal fissuring along the Kentucky Anticlinal, and is to the southwest of the Sandidge veins, one mile and a half south of Danville. The vein has a general strike of N. 72½° E., and cuts Winchester limestone. The strata to the south dip 7° south.

The vein is sinuous and consists of two to three bands of ore separated originally by vertical limestone sheets, two to three feet wide. The ore bands consist of limestone breccia cemented with barytes and to a less extent with zinc blende, with the percentage of limestone small. The bands, beginning with the south one measure 6 to 12 in., 18 to 22 in., and 18 to 36 in., respectively. The two more northerly bands combine at a depth of 16 feet and another appears 2½ feet to the north. The bands have a total width of 4 to 6 feet.

The barytes is bluish-white, hard, coarse, fibrous when fresh, but milk and cream-colored as well as iron-stained when altered. Since the barytes is above water level, most of the limestone fragments and much of the zinc blende have been leached. Where clay remains in place of the limestone, the barytes may be bleached after

crushing and washing and thereby raised to the best grade. A little pyrite was noted in some of the barytes. The north side of the middle band has a coating of zinc blende; the latter also occurs scattered through the barytes generally. The limestone between the bands has been weathered so that red clay and float barytes remain. The entire width of the vein zone is from 8 to 14 feet.

This vein was opencut in the spring of 1909 by the Kentucky Barytes Co. and a considerable tonnage was mined. It can be traced for 1500 feet west-southwest of the field in which the cut was made, and crosses the railroad east-northeast where for a distance of 300 feet a large amount of float barytes appears on the land of Dr. George Cowan, the vein being covered to the eastward.

On the Stanford pike, two miles southeast of Danville, some prospecting was done on the Walker land. Here the ore is similar to the Hayden, and the vein strikes N. 85° E. The width where prospected by opencut was two feet. This lies between the Hayden and the Sandidge veins.

VI. CLARK VEIN. The irregularity of this vein as shown in surface cuts is evident from the accompanying plat. This vein is five miles northeast of Danville and one-fourth of a mile south of the Davistown bend of Dix River. The vein strikes N. 87° W. in Tyrone limestone. The barytes is only 12 inches wide and is honeycombed from the leaching of limestone and calcite, the vein having originally cemented a limestone breccia. The prospect is poor.

VII. WEST HICKMAN FAULT ZONE. This fault zone follows a synclinal fold on the east slope of the Cincinnati geanticline. It is forty miles long and has a width of one-half to three-fourths of a mile. It probably branches from the Kentucky Anticlinal fault zone shortly west of Logana, Jessamine county, strikes N. 3° W. to Fayette county passing the Lexington reservoir ponds, striking N. 40° E. into Bourbon county where it passes immediately south of Paris and through Millersburg, going thence into Nicholas county, where with the presence of higher strata trace of it is lost.

The zone is bounded on either side by a fault, the intervening fault block consisting of higher strata, chiefly

Cynthiana limestone, the block being dropped and wedged between Lexington limestone. The faults bounding the block may be expected to dip slightly toward its center, a fact that may prove helpful in suggesting whether the other bounding fault is to be expected to the north or south of one that may be known; this would be especially helpful where the strata of the block is distinguished with difficulty from the strata on either side, owing to small displacement. The displacement of the fault varies from 20 to 75 feet, being greatest for the west fault and least in eastern Fayette and in Bourbon county.

Prospecting should be confined to the border faults and intersecting veins in proximity to them.

The accompanying cross-section gives an idea of the tilting of the rocks and the position of the faults relative to the main block.

In the vicinity of Millersburg, the faults show barytes with some galena, fluorspar, etc., and at Paris, the Marsh fault shows chiefly lead and zinc ore. To the southwest with the approach of higher strata, there is little evidence of mineralization although sinking on the faults would doubtlessly encounter mineral upon reaching the Bigby-Wilmore limestones; here sinkholes and tilted strata are the best guide while the fossils for distinguishing the Lexington and Cynthiana limestones are also helpful. In the northern part of Jessamine county, to the east of Union Mills, lower Greendale and Lexington limestone form the walls of the faults which are mineralized with barytes, fluorspar, some zinc blende, etc., usually cementing breccias but also partly replacing limestone. The west fault strikes N. 3° E. and the east fault N. 2 to 3° W. Further south as lower beds are reached along the valley of West Hickman creek in the vicinity of Logana no surface float was found, although the zone probably continues south and intersects the Kentucky Anticlinal one mile south.

VIII. MARSH FAULT. This has been prospected one mile and a half northeast of Paris and strikes N. 34° E. in Bigby limestone. This is probably a north boundary fault of the West Hickman fault zone, has small displacement and dips 70° southeast. The strata to the west dip 10° west and immediately at the fault 45° west. This has

resulted in a brecciated zone mineralized with 8 to 10 per cent of zinc blende, 10 per cent barytes, a little galena, with calcite and limestone making up the remainder. The width of the zone is 18 inches usually in two bands, which locally become lean in lead and zinc. The ore is partly a replacement, and partly cements breccia. The zinc blende is coarse to fine-grained and the galena coarse grained.

On the line between the R. B. Marsh and Daniel Isgrigg land, the Blue Grass Development Co. sunk a shaft 114 feet. A drift at a depth of 34 feet showed 17 inches of brecciated limestone replaced by zinc blende and cemented by a little galena, barytes, and calcite. At 40 feet in depth, the southwest drift showed a northwest band of 8 to 12 inches of limestone, replaced by zinc blende and a southeast band 6 to 16 inches wide of similar character but containing a little galena, the two bands being separated by a 15-inch mud gouge. An average sample of the ore here showed 32.7 per cent zinc blende and 24.5 per cent barytes. In this drift the bedding planes on the northwest are cemented with barytes, etc. for several inches from the main ore band and there is a replacement by zinc blende, both along these planes and along cross-seams for several inches. At a depth of 50 feet, a brecciated zone, 20 to 30 inches wide occurs cemented with calcite and barytes, but having very little zinc or lead. At a depth of 100 to 110 feet, the vein was up to 16 inches wide and of similar character.

At the bottom of the shaft, the ore band is 24 inches wide and the material taken from it runs 6 per cent zinc blende and 6.8 per cent barytes.

The vein has been traced for more than one mile by means of bore holes and shallow prospect pits, passing from the Marsh through the Isgrigg, Marsh Sisters, and Steel Marsh farms. The pits on the last two gave indications of a vein similar in character to that developed in the Marsh shaft previously described.

This vein is chiefly encouragng for lead and zinc, the quantity of barytes and other minerals being too small to pay even as a by-product, but sufficient to complicate the separation of the minerals, and make unprofitable its mining. Sinking the present shaft 50 feet deeper (after reducing the size of the shaft) and further drifting are advised as this may show an ore body sufficient to warrant mining. The erection of a separating plant for this vein alone is inadvisable.

IX. CLAY VEINS. Four miles southeast of Paris, a large number of veins have been found and many of them prospected on the land of the Hon. Cassius M. Clay. Besides the veins of barytes, lead and zinc which carry also limestone breccia and calcite below water level, one well defined fault strikes N. 15° W. and perhaps others occur. The large number of sinkholes attest to the thoroughly fissured condition of the Clay land, while barytes outcrops are also common. Veins striking N. 15° E., N. 35° to 40° E., and N. 15° W. have been prospected by numerous opencuts and shafts as much as 50 feet deep.

Most of the barytes shipped comes from three veins which strike N. 35° to 40° E.; the opencuts on these veins range from 7 to 9 feet deep, and from 3 to 8 feet wide. The maximum width of the barytes was 5 feet, the usual width being 2 to 3 feet. One vein is said to measure 35 feet between walls, but none of its mineral bands exceed 2 feet; this is the vein striking N. 15° W.; it has barytes predominant in some bands and in others there is much zinc blende. Some of the veins show a heavy sprinkling of zinc blende, especially below water level; in others galena predominates over zinc blende in the barytes. The surface barytes is, aside from discoloration and its cavernous condition, (due to the leaching of calcite, limestone, and zinc blende), of good quality and usually contains several per cent of galena. Some portions of the veins carry heavier percentages of lead and zinc than do others. In a shaft 42 feet deep the vein consisted at the bottom of lead, zinc, barytes, calcite and limestone, 13 to 36 inches wide.

X. DR. STEVENSON VEIN. This vein has been opened three miles southeast of Pine Grove, and immediately west of Becknerville. The general strike of the vein which may be a continuation of the Smitha fault is N. 37° E., but on the Stevenson land it strikes N. 15° E. and cuts upper Bigby limestone. The filling is barytes with more or less calcite and 20 per cent of fluorspar, zinc blende and limestone, and it has a width of 12 to 36 inches. The vein was worked by opencut to a depth of 30 feet.

North of the Stevenson, the vein can be traced by outcrop in a lane; it passes through Becknerville and parallels a line of sinkholes that occur 200 yards east.

Some shipments were made from the Stevenson land, but the admixture of much fluorspar has proved detrimental to further development of the deposit.

XI. CRAIG VEIN. This vein illustrates the possibilities of a vein of the Lexington-Georgetown area, and also how the character of deposit may change in a short distance following the course of a vein. It has been open cut on either side of the Ironworks pike, one and two-fifths of a mile west of the Russell Cave pike, five miles northeast of Lexington.

The vein strikes N. 4° W. except south of the pike where the strike is north, and the wall-rock is Lexington limestone. The deposit was soft and weathered to a depth of 15 feet where the walls were encountered and the barytes became hard crystalline. At one end of the workings, the barytes chiefly has zinc blende associated; at the south end, it contains chiefly galena, while between them the deposit consists largely of barytes alone. Some limestone and calcite are associated with the barytes. The vein varies from 15 to 54 inches wide.

Development has been confined to the W. G. Craig land which lies north of the Ironworks pike and the Mrs. W. G. Craig land which lies immediately south of it. These lands were first prospected over 40 years ago, and are now operated by the Central Pigment Co.

The extension of the Craig vein both north and south can only be determined by prospecting as surface evidences are meager.

XII. COLE VEIN. This vein is an excellent example of simple fissure filling and great continuity, having been traced for a distance of more than five miles. Beginning at the West Hickman fault zone, three miles east of Lexington, it strikes N. 10° W. with a slight westerly dip, and cuts Lexington limestone. The vein filling is chiefly barytes wth which either zinc blende or galena is locally associated. The width is one to four feet, pinching and swelling irregularly both with depth and lengthwise of the vein.

Beginning almost at the West Hickman fault zone it can be followed northward by sinkholes on the Maas land (which is immediately north of the Bryant Station pike), then on the land of the Country Club, in a swag south of the club-house some barytes was found, while the pond and spring on the same land near the Paris pike and immediately south of the trolley stop are on this vein. Northward sinkholes mark its course until on the S. B. Logan land, east of a large tree in a cornfield, there is barytes float, and also further north on the same land. South of the Ironworks pike on the J. K. Newman land at the northeast turn in the race track there is a heavy barytes showing. Following sinkholes along its course still northward, a little barytes float is seen near a sink on the John Davis land after which it enters the J. B. Haggin land, crosses the Russell Cave pike and re-enters the Haggin land where it was prospected many years ago. It then enters the Sam Cole land where in recent years there has been extensive opencutting (for a length of over 300 yards and to a depth of 20 feet) and a considerable tonnage shipped; the vein here strikes N. 3° E. Still northward it has been worked on the Vance and Charles Haggin lands; crossing Huffman's Mill pike it enters the old Charles Moore land and can be traced across the Lemons Mill pike by means of sinkholes and float for a distance of 75 yards on the Mrs. Sarah Nutter land after which trace of the vein was lost.

XIII. SMITHA FAULT. On Boones Creek, two miles southeast of Athens, the Smitha fault has been prospected. It strikes N. 33° to 35° E. and dips 75° to 80° northwest. Wilmore limestone forms the northwest wall and upper Tyrone limestone the opposite. The beds of the latter wall dip 20° southeast but become horizontal a short distance southeast. The Wilmore limestones dip steeply northwest for several feet.

The filling is fluorspar and zinc blende with some barytes and calcite. This well illustrates a complex breccia and fissure deposit, the Tyrone wall being brecciated while the fissure deposit is adjacent to the Wilmore wall;

the vein is from 32 to 50 inches wide. A shaft was sunk 110 feet and an incline driven on the vein for 115 feet on the Lee Smitha land.

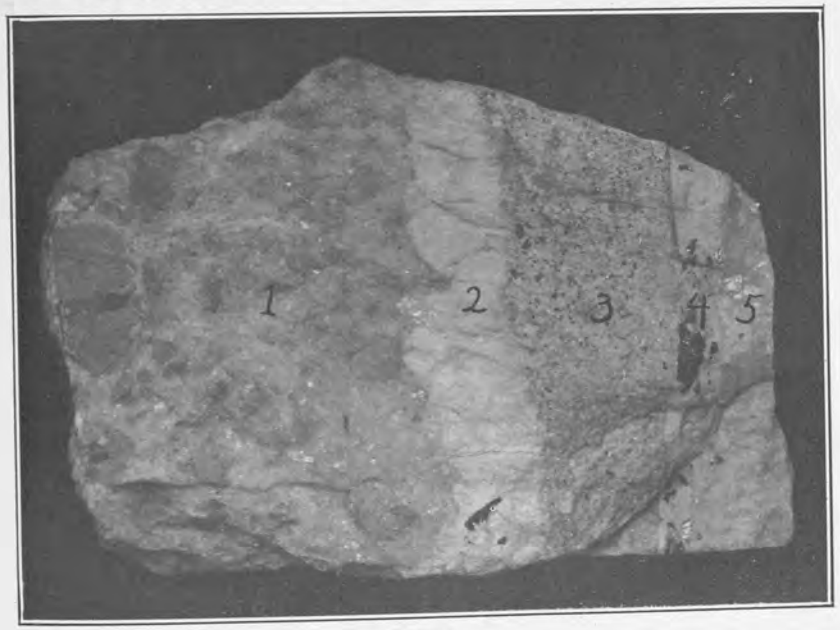


Fig. 7.

Alternate banding and brecciation,

1. Tyrone limestone breccia cemented by fluorspar.
2. Barytes with zinc blende.
3. Fluorspar, barytes and zinc blende.
4. Barytes and zinc blende.
5. Fluorspar.

Smitha Prospect, Fayette County.

Across Boones creek, in Clark county, the vein has been opened on the Pursely land where the walls are Bigby limestone on the northwest and Wilmore limestone opposite. Here the vein is 5 to 6 feet wide and consists about half and half of fluorspar and barytes with a little zinc blende.

Southwest of the Smitha, in Fayette county, on the John Morton and Jace Eads lands, fluorspar-barytes occurs, that on the Eads place striking N. 25° E. and being not over 12 inches wide. A small shipment of fluorspar was made from the Smitha.

XIV. ELKHORN FAULT ZONE. This fault zone branches northwest of the West Hickman fault zone in the vicinity of Lexington. Its course is marked in the northwest quarter of Fayette county by outliers of Cynthiana limestone, which in Scott county unite to form a solid strip one half to one mile wide striking west-northwest into Franklin county. The Elkhorn fault zone is the result of faulting along a synclinal fold, and the fault block constitutes a depressed strip between Lexington limestone.

Except in northwestern Fayette where some of the faults including the Crenshaw vein form a part of this zone, the border faults have not been prospected and the character of their deposits remains to be determined. The zone is at least 27 miles long and probably merges in northern Franklin county with the Frankfort zone.

Both north and south of the fault zone, mineralized shift faults formed incidental to it, occur with strikes at an angle of about 45° to that of the zone.

XV. BARRETT KNOB FAULT ZONE. Three miles south of Camp Nelson, this fault zone branches S. 5½° W. from the Kentucky Anticlinal zone. The individual faults of the Barrett Knob fault zone vary in strike from N. 40° E. to N. 21° W. in formations ranging from the Lexington limestone to the Richmond limestone and Ohio shale. The filling is usually a limestone, rarely a sandstone breccia cemented with barytes and containing lesser amounts of the usually associated minerals.

The most northerly of the prospects on this zone is on the Hogg vein which strikes N. 21° W. in Million limestone. This is a secondary to the fault of greatest displacement which occurs a short distance east between Million limestone and Ohio shale. Immediately northwest is Barrett Knob. The brecciated limestone contains barytes and a small amount of replacement zinc blende. The vein is too narrow to repay working, having been prospected by shallow pits.

To the southwest on the Hughes and Aldrich lands, a number of opencuts follow a strike of N. 20° W. These follow the faulted zone in Nicholas limestone and disclose pockets of limestone, 24 inches or more wide. One vein strikes N. 40° E. To the west of these prospects is a normal fault and probably Richmond limestone. The cuts are scattered for a distance of 200 yards and for a width of 50 yards. There is considerable barytes through clay on the dump which should be washed out. A very little zinc blende was noted. Further prospecting is advised.

The Boones creek fault striking N. 30° E. crosses the John Beazley, Harry Baughman, and the northern part of the John Burdette lands, while further south on the Burdette and the Jack Bourne it strikes N. 20° E. Upper Lexington limestone forms the west wall and Million limestone the opposite wall. The fault dips slightly northeast. The vein consists of a fissure deposit of barytes with a central band of 2 to 4 inches of colorless fluorspar, the total width of the deposit being 6 to 24 inches; in addition there is a vertical sheet of crinoidal limestone from the west wall which is brecciated and partly replaced, the cement being barytes and zinc blende, except locally where calcite predominates, while the limestone fragments are partly replaced by barytes, zinc blende, a little calcite and fluorspar. The total width of the vein varies from 6 to 48 inches, and averages 24 inches. In addition to the fluorspar a little pyrite occurs but neither of these minerals appear in sufficient quantity to injure the zinc ore. The barytes could be classed as second grade. The zinc ore would require concentration at a custom flotation process mill. A number of shallow cuts and one 42-foot shaft has been opened on this vein, and a small amount of barytes shipped. Further development is advised. On the Burdette land, 100 feet westward, is another fault with Million limestone forming the west wall. Between these faults are narrow veins striking N. 5° W. carrying barytes, calcite and zinc blende but are of insufficient width to work.

Southward in Lincoln county (all openings on this zone described previously are in Garrard county) openings have been made on the Bowen Givens and Mrs. Annie Englemen lands. The former is immediately south of Dix River. The vein on the Givens strikes N. 10° E. but changes locally to N. 5° W. in lower Lexington limestone. The filling is a breccia cemented with barytes and a little zinc blende, the deposit having a width of up to 7 feet or more. It has been prospected by opencut and by a shaft 50 feet deep. In the cut, the ore is partly leached. The bottom of the shaft, according to Mr. Burton Vance, who directed the work, showed a width of 60 inches of solid barytes and 72 inches additional of barytes-limestone breccia. With the Tyrone limestone shortly to be reached with depth, the prospect is not specially encouraging except that further development is warranted in drifting on the vein at the present depth. Other veins and faults occur in the vicinity with strikes of N. 40° E., N. 25 ° W., and N. 65° W., some of which may warrant prospecting.

The Engleman fault strikes N. 55° E., Greendale limestone forming the southwest and Lexington limestone the opposite wall; this fault is southwest of the Givens fault. Float barytes occurs on the Givens and Engleman lands and solid barytes 10 to 12 inches wide has been cut in two shallow pits on the James Robinson land.

XVI. HOGGIN VEINS. These veins were opened one mile south of Lair on the Hoggin land in Harrison county. The main vein strikes N. 21° E., and is one foot wide; a line of sinkholes and a pond were noted on its course. An intersecting vein strikes N. 30° W. while 200 yards west of the vein first described, a parallel is indicated by a line of sinks and is said to be mineralized. These veins all cut lower Greendale limestone.

The vein consists largely of breccia cemented with galena-barytes, the limestone being partly replaced by zinc blende and darker colored barytes. The wallrock shows seaming with barytes and replacement by zinc blende and less galena as was evident from a shaft 50 feet deep, sunk 15 feet west of the vein.

The barytes content of the veins is insignificant, the galena running 3 to 5 per cent and the zinc blende, largely leached, originally constituted a similar percentage which may be expected when water level is reached. The galena is confined chiefly to the cement and the zinc blende to the limestone fragments. Further sinking on these veins is advised. The prospecting was done by the Mutual Mining Co.

Northward, the vein crosses the river and should cut the J. R. Northcutt land.

XVII. LOCKPORT VEIN. This vein has been open-cut for a distance of 850 out of 1175 feet, and upon it two shafts have been sunk one 80 and the other 260 feet deep. It is located immediately west of Lockport, Henry county.

The vein has a general strike of N. 5° W. cutting what is probably Bigby limestone. The filling is largely a fissure deposit with a little breccia and consists chiefly of barytes containing a large percentage of galena, a little zinc blende and some calcite.

The deep shaft, at the bottom, has a cross-cut 80 feet west intersecting the vein and water; when this was completed work was interrupted owing to lack of capital. This property warrants development. The irregular trend of the vein is well shown in the accompanying sketch map.

XVIII. AMBROSE FAULT. This vein is of special interest in that it shows an intimate mixture of the minerals, walls of compact limestone favorable to shearage and brecciation, the deposition of fluorspar rather than barytes in breccia, the deposition of barytes prior to that of fluorspar and calcite, and secondary shearage after the deposition of the barytes.

This vein has been traced for one mile southeast of Ambrose (Sulphur well) which is four miles southeast of Nicholasville. This vein intersects the Kentucky Anticlinal fault zone. The more northerly section of the Ambrose frault strikes N. 30° to 40° E., while that further south strikes N. 16° W. and dips slightly east, cutting Tyrone limestone. The walls of the vein exhibit the horizontal slickensiding characteristic of shift faulting. It consists of a series of short veins arranged en echelon as was clearly seen on the Clark land.

The filling consists of 20 to 60 per cent of barytes, 20 to 60 per cent of fluorspar, zinc blende (locally as much as 15 per cent) and the remainder calcite and limestone. The width varies from 4 to 60 inches. It is a combination of fissure and breccia deposit and is widest where there has been the greatest shearage. A section of the vein obtained on the Horine land was as follows beginning at the west wall: Tyrone limestone; barytes and calcite, 2 in.; fissure deposit containing less than 10 per cent barytes, some fluorspar and calcite, 14 in.; Tyrone limestone sheared at 30° with the strike of the vein and seamed with calcite and zinc blende and less barytes and fluorspar, 36 in.

The vein can be traced by sinkholes and float from Ambrose south to the E. B. Hoover or Horine land where it was opencut for 425 feet and averaged only 12 inches wide to a depth of 15 feet, and a shaft showed similar conditions. On the Harriett Clark and Leroy B. Taylor lands to the south, the conditions are the same except that the fluorspar is predominant. On the Newt. D. Davis land the vein was open cut for 75 yards and here barytes was predominant with 20 to 40 per cent of fluorspar, calcite, limestone, and some zinc blende. The width of the vein was 24 to 72 inches here, but this was not all mineral. The calcite and limestone were largely leached. On the Davis alone, was the vein of such character as to permit mining, the mixture of minerals and narrow width preventing profitable working elsewhere. South of the Davis, the Ambrose fault intersects the fault zone.

XIX. CHINN VEIN.—Is one of the most thoroughly prospected veins of the district and the following description and the accompanying sections present certain interesting facts regarding the type of fissure deposits found in the Camp Nelson limestone.

The vein has been traced for a distance of several miles in Woodford and Mercer Counties, but has been chiefly developed within one mile north and a like distance south of Mundy's landing. This discription, however, is confined to that portion of the vein lying just north of the landing.

The Chinn vein has a general strike of N. 70° W., and cuts limestone ranging from the lower Lexington to that near the base of the Camp Nelson. It is a shift fault without evidence of normal faulting. The walls of the Twin Chimney open cut show en echelon arrangement, striking N. 40° W., N. 15° E. and N. 40° W.

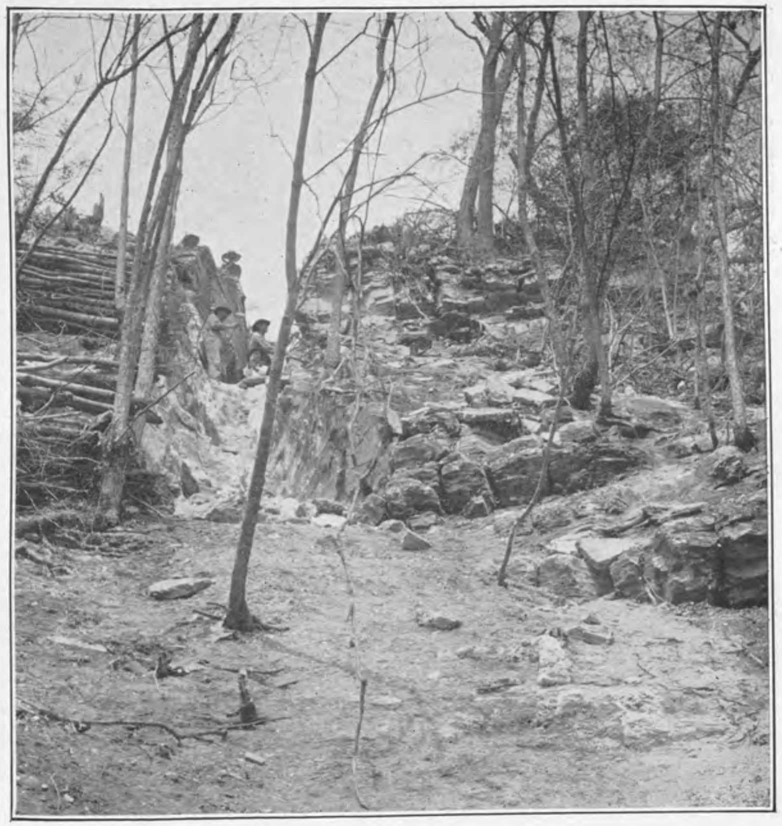


Fig. 8.

Open Cut on the Chinn Calcite Vein.

The filling is of the banded fissure type with at least fourteen distinct depositions as follows: 1, fluorspar; 2, calcite; 3, fluorspar; 4, calcite; 5, fluorspar; 6, barytes; 7, calcite; 8, fluorspar; 9, barytes; 10, calcite; 11, clear crystals of fluorspar; 12, fibrous barytes in the form of knob-like encrustations; 13, minute fluorspar crystals; 14, recent calcite; and central slip. As many as half of these may be absent from one or both sides of the central slip, since some of the bands were never deposited and still others were removed after deposition. The first two bands were possibly deposited simultaneously with two of the other bands, as the fissure may have reopened between the vein and the wall to permit this.

The barytes bands are usually less than 2 inches but may locally be as much as 8 in. wide; the fluorspar bands are from ½ to 8, and rarely as much as 18 inches wide; and the calcite bands are from ½ to 14 in., rarely as much as 18 in. wide. Nos. 4, 7, and 10 of calcite and 5, 8 and 11 of fluorspar are the bands constituting the bulk of the vein. The total width of the vein varies widely between 18 and 66 inches. The accompanying sections give details of the vein at fourteen different points, section No. 8 being from the Jim Dean prospect, Nos. 12 and 13 from prospects on the Faircloth land, and the remainder from the Twin Chimney property. Sections Nos. 1, 2, 3, 4, 10 and 11 and partly also No. 7 were prepared from notes obtained by Prof. Norwood. At all points where sections were taken, the Camp Nelson limestone formed the wall rock, the highest section obtained (No. 1) being 20 feet below its top, and the lowest section (No. 7) being 242 feet below its top. Sections 1 to 7 inclusive show variations of the vein with depth, and Nos. 8 to 13 show changes ocurring, following its course at an altitude of somewhat over 500 feet, for a distance of two miles north of Mundy's landing.

The following table shows the total width in inches of each of the following: calcite, fluorspar, and barytes together with total width of all these at altitudes varying between 420 and 642 feet on the Twin Chimney land:

Altitude Ft.	Calcite In.	Fluorspar In.	Barytes In.	Total Width In.
642	13.5	5.0	0.5	19.0
639	22.5	5.5	3.5	31.5
629	22.0	......	5.0	27.0
512	13.0	13.5	1.2	28.5
462	34.0	19.0	3.0	56.0
420	29.7	27.0	4.0	59.7

This shows a slight increase for each mineral with depth for 222 feet, the principal increase being in fluorspar. The total average width, for the depth given, of these minerals would be as follows: Calcite 29.8 in., fluorspar 12.9 in., and barytes 1.1 in. which expressed in percentages would be 60.9, 35.8 and 3.3 per cent respectively.

At an altitude of 500 feet at three points within two miles following the course of the vein we have the following total widths of the different minerals and of the whole vein:

Locality.	Calcite In.	Fluorspar In.	Barytes In.	Total Width In.
Dean ..	15.0	11.5	2.5	33.5
Twin Chimney	16.8	12.1	1.5	30.4
Faircloth	9.3	15.0	1.7	26.0

On the Twin Chimney, Widow Nave (now property of Chinn Mineral Co.) land, the vein has been opencut for some distance at the top of the cliff (altitude 642 ft.) An adit was run into the cliff at 37 feet above low water of the Kentucky river (altitude 512 ft.) and in the adit a shaft was sunk 130 feet. An attempt was made to separate the calcite and fluorspar by ordinary jigging but this necessarily proved unsuccessful. For discussion as to possible treatment and use of such material reference should be made to the chapter on Milling.

The vein crosses the James Britton and Jim Dean lands north of the Twin Chimney. On the Dean a prospect was opened in the cliff and a small parallel vein occurs 200 yards eastward.

Immediately north of Mundy's landing on the Faircloth land a number of shallow prospects were opened and an adit driven into the cliff. The accompanying photograph by Prof. A. M. Miller shows the vein at the

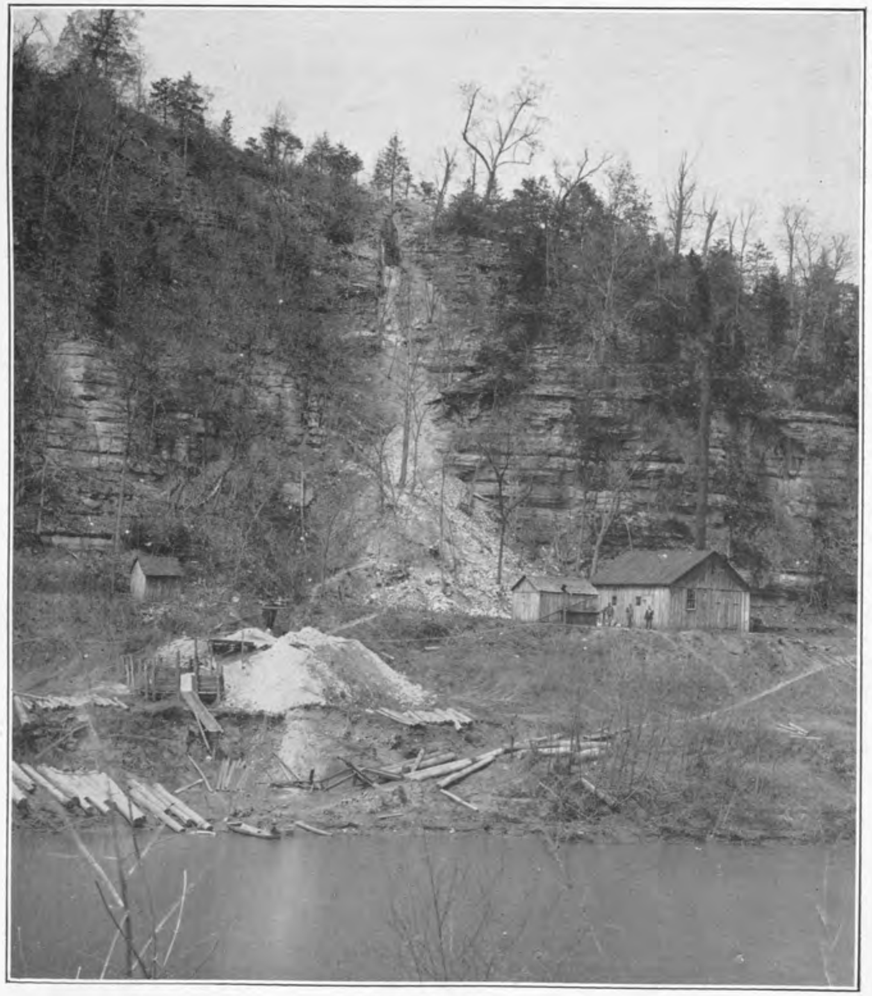


Fig. 10.

Twin Chimney Mine,
View in Kentucky River Cliffs.

entrance to the adit. The vein is similar to that at the Twin Chimney as the sections Nos. 13 and 14 show, except that there is more fluorspar, which reaches a maximum width of 28 inches, and there is also more breccia. The local strike varies from N. 10° to 15° E.

XX. GRATZ VEINS. These have been prospected one mile and a half northwest of Gratz and on the east side of the Kentucky River, 18 miles above Worthville (at the crossing of the L. & N. R. R. and Kentucky River). The development work was done by the Ohio Lead Mining Co., one shaft being sunk 380 feet and two others 70 and 83 feet respectively.

The ore consists of barytes-calcite with about 10 per cent galena and zinc blende, partly a fissure and partly a breccia deposit. Drifts were run 1040 feet on the 100-foot level, chiefly to the north and for 100 or more at the 200-foot level. Two parallel veins occur, each one-eighth mile on either side of the main fissure. To a depth of 250 feet, the vein is said to run 2 to 4 ft. wide, and below 150 feet to show principally galena, zinc blende, and calcite; at the bottom the vein has a reported width of 57 inches. At a depth of 300 feet, the dove-colored compact Tyrone limestone was encountered; that at the bottom of the shaft is dark compact. The average width of the vein is probably less than three feet. This property should receive fuller development.

XXI. WM. DAVIS VEIN. This is one mile and three fourths northeast of Duval, Scott county. The vein strikes N. 8° W. in upper Lexington limestone. It differs from most of the deposits in showing evidences of dissolution of the ore and redeposition in stalagmitic form—not only round but also in unique rectangular shapes. The barytes contains a small amount of pyrite altered somewhat by weathering, while at the shaft some of the barytes has a thin coating of strontianite. A small tonnage of barytes was mined by the Mutual Mining Co. in 1908. One shaft is 100 feet deep and has 100 feet of drift and an opencut was made 80 feet long.

XXII. JOHNSON VEIN. One mile and a half southeast of Stamping Ground, this vein has been opened by two shafts and an opencut. The vein strikes N. 20° E. and cuts upper Lexington limestone. The width varies from 18 to 48 inches, the average being 36 inches. The deposit is primarily of the fissure type with a small amount of breccia, and consists of alternating bands of barytes, galena coated with barytes, and zinc blende galena band in barytes, the last being attached to the wall. The vein is characterized by large mud pockets connected with surface sinks. The surface barytes is pitted from leaching of zinc blende. The property was developed by the Mutual Mining Co. who sunk a shaft 100 feet, and stoped much barytes and galena.

XXIII. Matthews Vein. In Russell county, on the north bank of the Cumberland River below the mouth of Dave's branch on the land belonging to the Matthew's heirs, a seamed limestone zone containing barytes-calcite and a little galena has been found.

The strike of this zone is N. 15° E. with cross-seams striking N. 47-55° W. The seams, each of which are under 15 inches wide, occur scattered through a zone 86 feet wide, but the mineral will not repay working.

Southward across the river in Cumberland county, a well bored for oil showed evidence of similar mineral. North from the Matthews in Russell County it is said to show three miles north in Sand Lick Creek and again near Mullers store, ten miles north of Creelsboro.

This occurrence is of interest chiefly in that it shows that the barytes veins extended originally well up into the Richmond formation, that deposits in the upper Cincinnatian limestones are unlikely to prove of economic value, and that the barytes veins follow the Cincinnati anticline into Tennessee, the fluorspar-barytes veins of Smith, Wilson and Truesdale counties, being a virtual continuation of the Central Kentucky deposits; the Tennessee deposits, just mentioned, have never been sufficiently investigated to determine their value.

CHAPTER IV.

Descriptive Table of Veins.

Anderson County.

1. Hammonds Creek Vein. Two and one-half miles southwest of Lawrenceburg. Strike N. 24° W. cutting Greendale limestone; barytes, calcite, and zinc

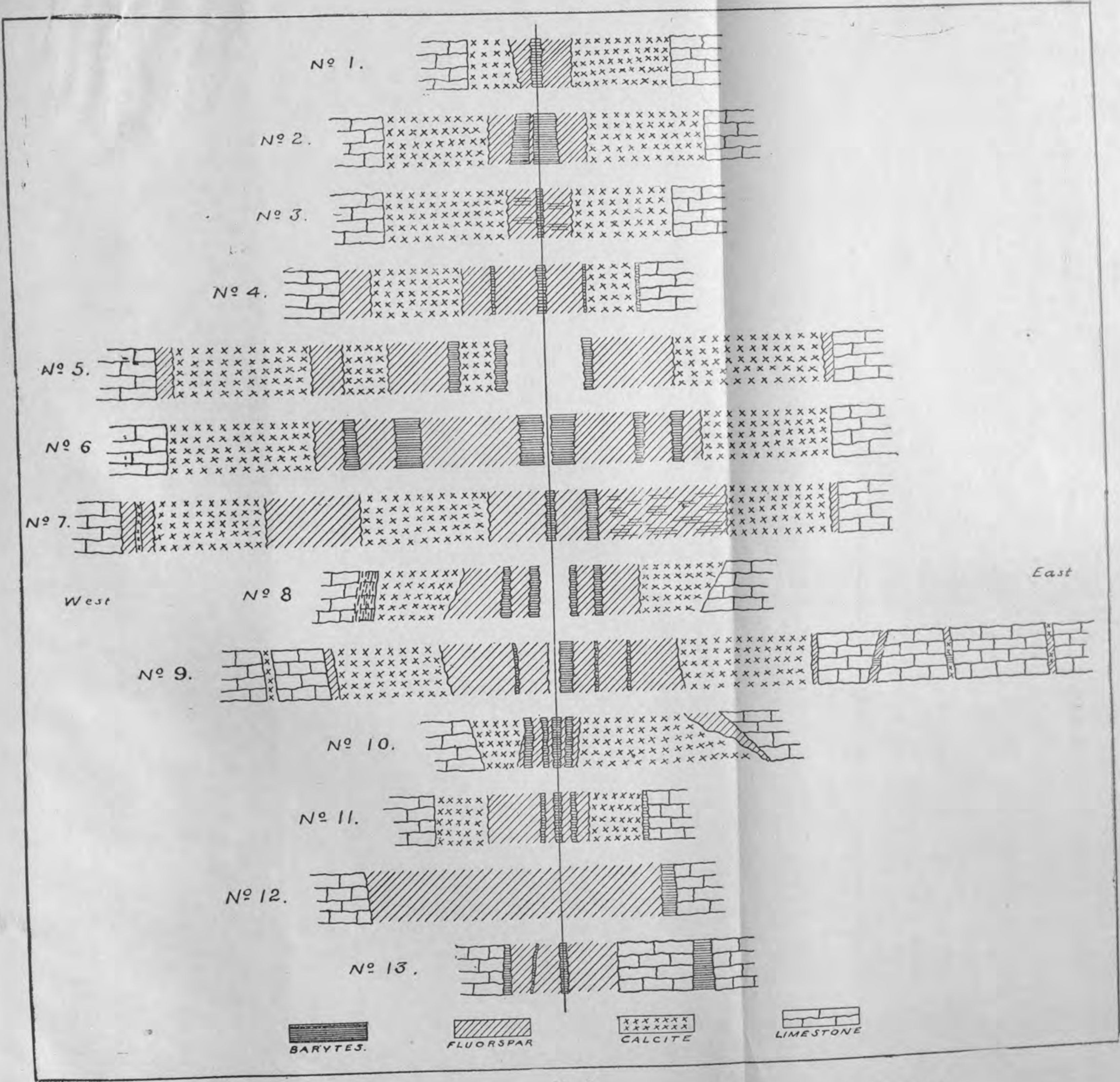


Fig. 9.
Cross Section of Chinn Vein at Twin Chimney Mine and two miles along vein. Scale—1 inch=2 feet.

blende cement limestone breccia, width 0 to 6 in. (linked vertically). Prospected on Hoskins land. Suggest testing by shaft 50 feet deep.

2. WATTS VEIN. Six and one-half miles northeast of Lawrenceburg and one and one-half miles west of Kentucky River. Vein strikes North in Greendale limestone, and consists of barytes, zinc blende and galena; width 1 ½ to 3 ft.; part of barytes is soft and part of the zinc blende, leached. The vein is continuous through a bed of shale. Shaft sunk 70 feet on the Freeman Watts land. Further development advised.

3. ZOPP VEIN. A short distance west of and parallel to the Watts vein. Consists of barytes, zinc blende, and galena, sometimes considerable of the last; maximum width 3½ ft. Shaft sunk 100 ft. and drift drifted 20 ft. Further development advised.

4. McBRAYER VEIN. Near Ninevah, a shaft was sunk on a vein on the McBrayer land; not examined.

5. ROUTT VEIN. See special description II, in the previous chapter.

BOURBON COUNTY.

1. PURDY VEIN. On Hinkston Creek, one mile N. N. W. of Millersburg. Vein strikes N. 11° E. and cuts Lexington limestone. It consists chiefly of galena and zinc blende in limestone with a little fluorspar and barytes associated. Prospected by opencut, and shaft was sunk 94 ft. on the John Purdy land. The width, 4 in. is insufficient to warrant further working.

2. CALDWELL VEINS. Immediately S. W. of Millersburg. They form probably the northwest faults of the Hickman fault zone. Two veins have been prospected having a general northeast strike and dipping southeast. The filling is chiefly barytes with up to 5 per cent galena, a little zinc blende, and about 25 per cent of limestone breccia; it has a maximum width of 40 in. and averages 25 in. for each vein.

Five shafts were opened on these veins on the J. F. Caldwell land, the main one being 80 feet deep and has a drift 62 feet long at the 42-foot level. A small mining plant was installed and some shipments made in 1906. Owing to lack of capital to install the necessary milling plant, nothing further was done. As soon as a custom mill is established in the district this property should be more fully developed.

3. MILLERSBURG VEINS. Barytes outcrops at several points in the town of Millersburg, especially on the south side and on adjacent farms to the northeast and southwest, there being three or more veins forming part of the West Hickman fault zone.

4. MARSH SHAFT. See description No. IV in the previous chapter.

5. PARIS VEIN. On the southeast edge of Paris. The vein strikes N. 30° E. and dips 80° northwest. The filling is barytes-limestone breccia containing lead and zinc. Shaft sunk 90 ft. on Daniel Isgrigg's land.

6. CLAY VEINS. See description No. V in the previous chapter.

7. PREWITT VEIN. 8 miles east of Paris; not examined.

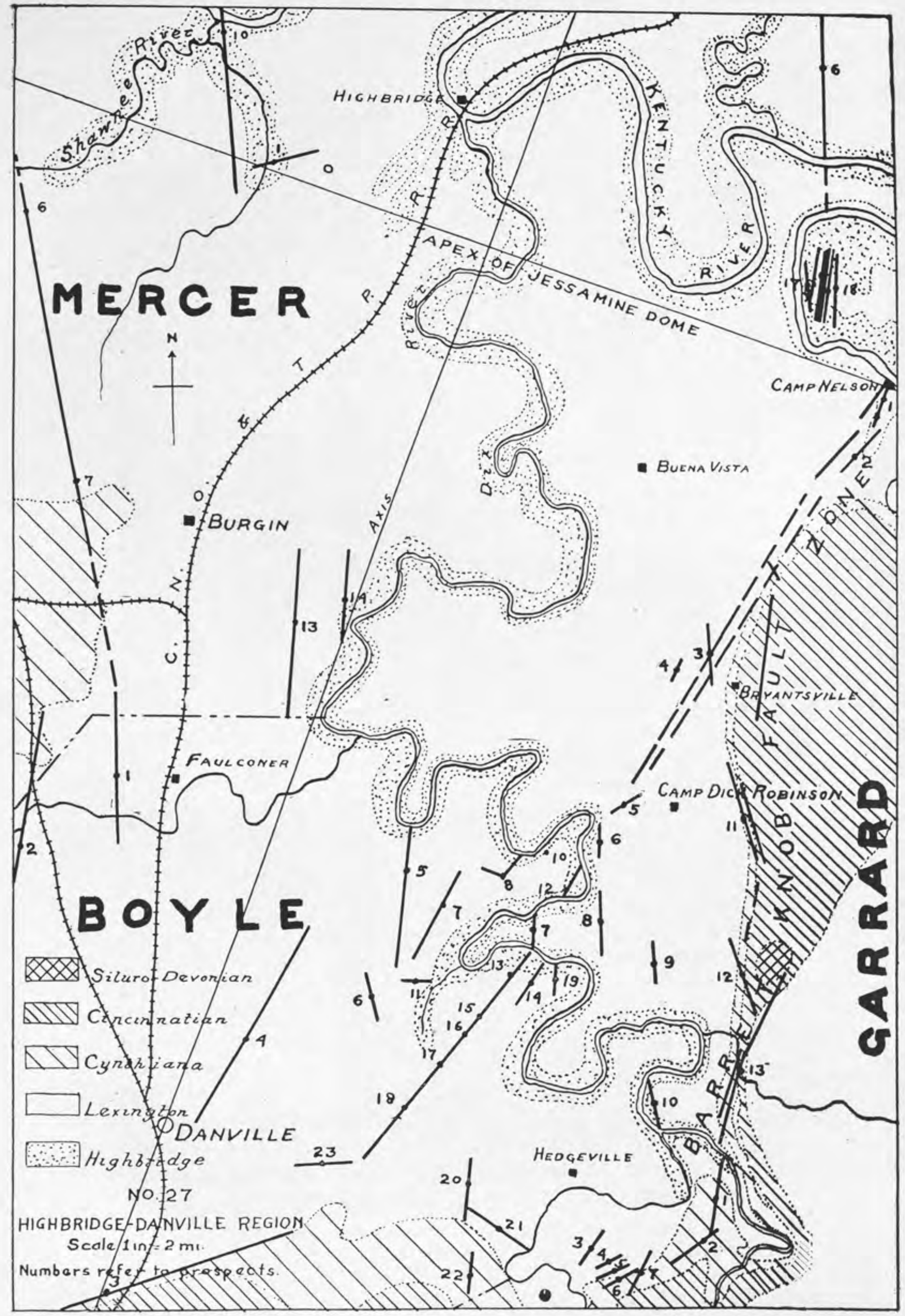
BOYLE COUNTY.

1. FAULCONER SHAFT. Three-fourths mile west of Faulconer station. The vein strikes north cutting Lexington limestone. Fluorspar with some barytes, 2 feet wide. The vein crosses the Louisville Southern railroad, the W. T. Robinson land, outcrops in a road, was prospected one-half mile north on the E. P. Faulconer land, and probably enters the Buster land in Mercer county. The prospect is poor.

2. HUNDELEY VEIN. Four miles N. W. of Danville and one-half mile S. W. of the Harrodsburg road. The vein strikes N. 10° E. and cuts Bigby limestone. It has not been prospected but barytes float appears on the surface near a copious spring on the A. E. Hundeley land, and probably extends south on the Summers land. Prospecting is advised.

3. HAYDEN VEIN. See special description No. II in the previous chapter.

4. BAUGHMAN VEIN. One-half to one mile north of Danville. The vein strikes N. 25° to 34° E., cuts Lexington limestone and averages 2 feet wide. Gray, glassy and white fibrous barytes bands alternate, and carry 12 to 16 per cent of strontium sulphate. The vein on the John Baughman strikes N. 25° E. and that on the Jerry



Danville Region. Scale—1 inch=2 miles.

Caldwell land N. 33° E. At the latter there is some fluorspar associated. On the Miller and Joe Lee lands, it shows the maximum northeasterly strike; a prospect on Wilson's run which separates these lands, shows fluorspar-barytes breccia, 8 in. wide. Further prospecting on the Baughman and Caldwell lands, is suggested.

5. GUNN VEIN. At Meuxtown, 2½ miles N. W. of Danville, and 1 1-4 miles N. W. of the Lexington pike. The vein strikes N. 8° E., cuts Lexington limestone, consists of soft white more or less iron-stained barytes with a little fluorspar, and is from 6 to 48 in. wide. It was opencut on the John Gunn (col.) land for 140 feet and to a depth of 18 ft., a considerable tonnage being mined and marketed. Four shallow prospects occur to the north on O. L. Harbel's (formerly Farris) land, but the vein was narrower and showed some replacement. Still further north it appears on the John Weisiger land. South of the Gunn, the vein passes through the lands of John C. Tibbs, W. W. Johnson (crosses Lexington pike) and John Weisiger. Float barytes occurs on the last. Further development is advised.

6. WEISIGER VEIN. Three-fourth mile S. S. E. of the Weisiger prospect just described, a vein striking N. 15° E. cuts lower Cynthiana limestone. Soft barytes with some fluorspar intergrown and interbanded appears here as surface float.

7. GEORGE DAVIS VEIN. Three miles north of Danville, and three-fourth mile N. E. of the Lexington pike. The vein strikes N. 28° E., and cuts Lexington limestone. The prospect consists of good quality float barytes with a little fluorspar. It passes south through the Johnsonia farm and should intersect the Gunn vein on the Weisiger land. Development is advised.

8-9. FAULTS. Three miles N. of Danville and 3-4 mile N. E. of the Lexington pike. One fault strikes N. 70° W.; the strata to the north dips 16° to 23° north, while on the opposite side of the fault they dip south, but after a few feet they dip 6° north again. The second fault strikes N. 35° E. and is east of the one previously described, which it probably cuts off. The strata dip 12° to 13° southeast. Some of the limestone is seamed with calcite. Probably unworthy of prospecting.

10. CLARK VEIN. This is described in description VI of the preceding chapter.

11. PRITCHETT FAULT ZONE. Three miles east of Danville on the land of Isaac Pritchett there has been folding and faulting on a small scale. The varying dips recorded for distances varying from 5 to 50 ft. beginning at the south and cutting across the faults, whose strikes are also given, were as follows: dip 30° north, dip 10° north, dip 50° south, fault 90° W., dip 20° to 70° south, fault N. 65° E., and dip 5° north. There are seams of barytes, fluorspar and calcite, and some slight replacement but nothing suggestive of a workable deposit.

12. CALCITE VEIN. On the Danville-Lexington pike, one-half mile west of Dix River bridge. The vein strikes N. 30° E. and consists of limestone-calcite breccia, 10 to 36 inches wide. A bedding fault has cut the vein and moved the upper portion over 24 inches. This vein is of no value. Nearby is limestone breccia striking N. 70° W. and a calcite seam striking N. 90° W.

SANDIDGE VEINS. (13 to 18 inclusive). See special description No. IV. of the previous chapter. For details of the several veins, see below:

13. YEAGER VEIN No. 1. Four miles N. E. of Danville. The vein strikes N. 16° E. and cuts Wilmore limestone. Chiefly barytes except at some of the smaller openings where breccia constitutes half of the vein and there is a little fluorspar. A considerable tonnage of barytes has been mined.

14. YEAGER VEIN No. 2. One-fourth mile east of Yeager No. 1. Its strike is approximately N. 30° E. in Lexington limestone. Opencuts show fresh and weathered barytes; much surface float.

15. SHELTON VEIN No. 2. Southwest of the Yeager. Barytes float found.

16. SHELTON VEIN No. 1. Southwest of Shelton No. 2. The No. 1 vein strikes N. 15° to 20° E. in Bigby limestone. The barytes is largely of the lamellar type; considerable has been shipped.

17. SANDIDGE VEIN. This strikes N. 22½° E. on the Pope land and N. 30° E. on the Sandidge land. These are southwest of the Shelton. The vein cuts Bigby limestone. The vein on the Pope was chiefly barytes, 1 to

4 feet wide, while on the Sandidge it was from 1 to 18 feet wide, the east band containing much fluorspar and the vein having an average width of over 4 feet. The mineral shipped is said to have averaged 92 per cent barytes.

18. WOOD VEIN. This strikes N. 23° E. in Bigby limestone. The vein consists of alternating narrow bands of fluorspar and barytes, at the opening nearest the Danville-Lancaster pike, with barytes predominant at other openings.

Further south this fault zone shows float barytes on the Allen and Browning lands.

19. ALEC HUGHES VEIN. This strikes N. 5° E. in Lexington limestone and is 500 yds. east of the Yeager vein No. 2. The filling consists of colorless, milky-white, and smoky, partly crystallized calcite, 30 inches wide. Some of the calcite is of the "Iceland spar" variety.

20. BRUCE VEIN. This strikes N. 5° E. in Bigby limestone. It outcrops in a lane on the Bruce (now Williams) land, but its extent is obscure. It is located 4½ miles S. E. of Danville and ½ mile S. of the Lancaster pike.

21. HUBBLE VEIN. One mile S. E. of the Bruce. The vein strikes N. 52° to 60° W. in lower Bigby limestone, which dips 6° north on either side of the vein. Weathered limestone breccia containing fluorspar, calcite and barytes, is 2 ft. wide; barytes predominates near a spring on the J. N. Chrisman land, while to the north on the land of Tuk Hubble, fluorspar predominates.

22. DUNNIGAN VEIN. Three-fourths mile S. W. of the Hubble vein. The Dunnigan vein strikes N. 5° E. in what may be Eden limestone. Much float consisting of fairly fresh, good quality barytes. This vein probably forms part of the same zone as the Bruce, and should be prospected.

23. WALKER VEIN. See special description V in the previous chapter.

CLARK COUNTY.

1. STEVENSON VEIN. See special description No. X in the previous chapter.

2. DUGAN VEIN. This parallels the Smitha fault (see special description XIII), striking N. 35° E,. and is 100 yds. east of the Smitha prospects. The vein can be traced by float fluorspar-barytes, and sinkholes, but has not been prospected.

3. THOMAS-STEVENSON VEIN. Two miles S. of Flanigan. It strikes N. 40° E. in Bigby limestone, and contains barytes with a little fluorspar, calcite and galena, 6 to 26 inches wide. It intersects the Hampton vein.

4. HAMPTON VEIN. This is just south of that last described. The Hampton vein strikes West and dips 75° south in lower Cynthiana limestone. The filling consists of hard, highly iron-stained barytes. This forms part of the Kentucky anticlinal fault zone. Eastward it crosses the Owens lands; 1½ miles east is an excellent cropping 30 to 36 in. wide.

5. DR. COLE PROSPECT. Five miles S. of Winchester; not examined.

KENTUCKY ANTICLINAL FAULT ZONE. The zone in this county shows a characteristic higher succession of strata going southward, at Elkin, with faults striking N. 45° E. and N. 70° E.

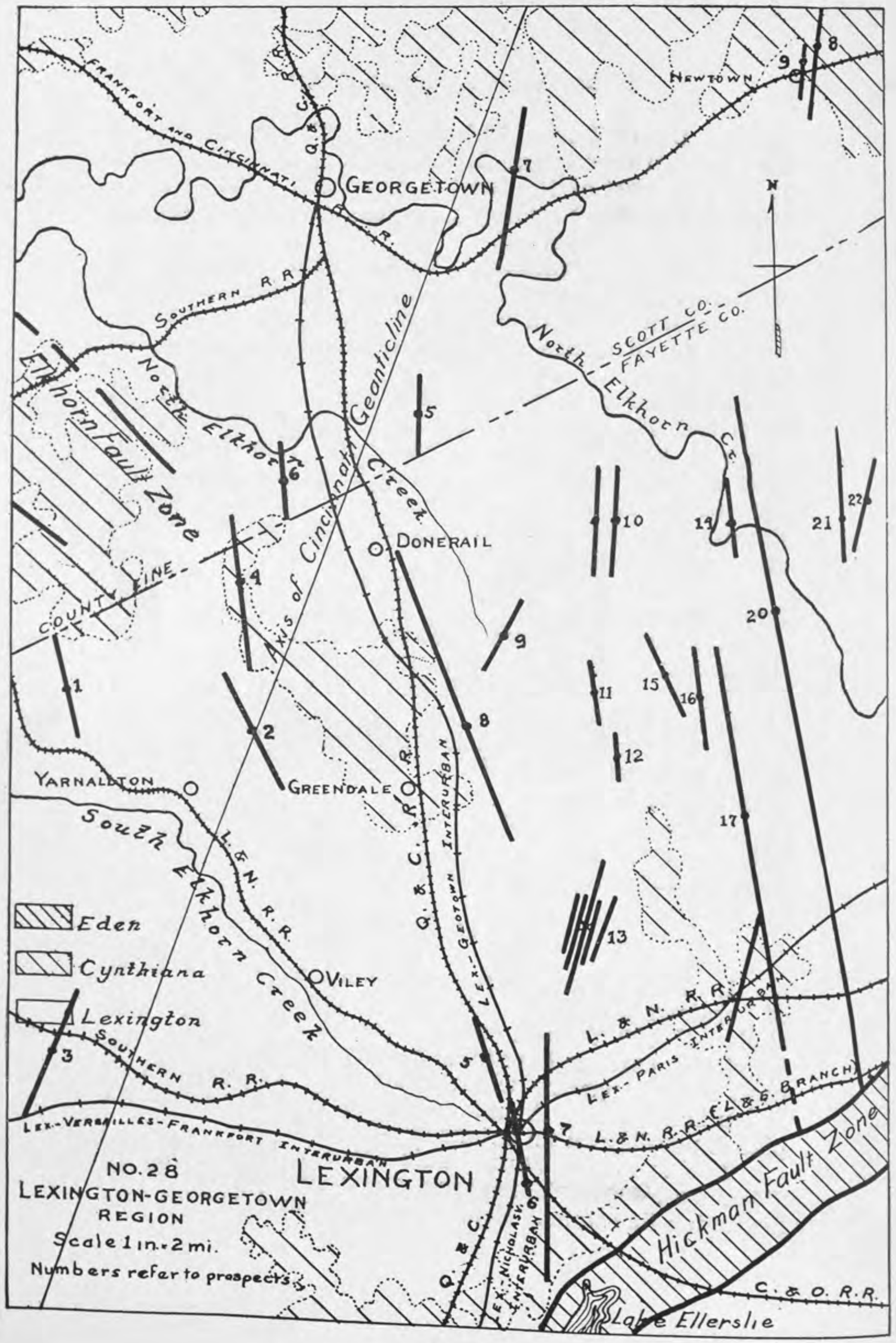
5. On the Thomas Lisle land, the fault strikes N. 70° W. A parallel striking N. 62° W. is filled with barytes less than 12 in. wide.

6. On the land of J. B. Carroll, adjoining Lisle, barytes occurs in proximity to the fault. Beyond the pond on this land, a fault strikes N. 76° E.

FAYETTE COUNTY.

1. DOLAN VEIN. Crosses Dolan lane, ½ mile N. E. of Leestown pike and 8 miles N. W. from Lexington. It strikes N. 10° W. and cuts Lexington Limestone. The barytes is hard and contains a little galena, but the deposit is very narrow where examined. Prospect on P. Dolan heirs' land. A sink on the north of the Leestown pike is possibly on an extension of this vein.

2. CRENSHAW VEIN. This crosses the Spurr pike 2½ miles N. E. of Yarnallton, and strikes N. 15° W. in Lexington limestone. Somewhat weathered barytes con-



taining galena and less zinc blende, 20 inches wide in a shallow prospect on the land of B. C. Crenshaw, south of the pike; further prospecting is advised. Northward on the Carr land, the vein probably passes west of the pond, and southward it crosses Payne's Mill lane near a spring. Another vein is said to have been noted by means of float found in plowing, 300 yards eastward on the Crenshaw land.

3. BOSWORTH VEIN. This outcrops one mile N. E. of Fort Spring, N. of the Versailles pike, and W. of the Richmond pike. The vein strikes N. 20° E. The barytes float is weathered and contains a little galena. This shows near Cedar spring on the Mrs. B. Bosworth land for 150 feet south; it should be prospected.

4. S. HAGGIN VEIN. Prospected 1½ miles W. of Donerail and one mile W. of the Georgetown pike. The vein strikes N. 5° W.; weathered barytes; shallow prospect in field W. N. W. or S. Haggin's house; extent of deposit obscure.

5. RUFUS LISLE VEIN. Exposed in quarry, one mile N. W. of Lexington, and south of the Leestown pike. The vein strikes about N. 10° W. or still more westerly, and cuts Lexington limestone; consists of barytes-calcite-limestone; width 9-14 in.; prospect poor.

6. WINSLOW STREET VEIN. Exposed in course of sewer construction opposite house No. 191 on Winslow street and near the northwest corner of the Stoll athletic field. The vein strikes N. 10° W. in Lexington limestone; width 1 ft.; barytes insufficient to mine.

On Maxwell street, there was a vein cut from which several tons were obtained in digging the sewer trench but the exact location was not learned.

7. STOLL VEIN. This crosses the belt line of Lexington in proximity to old potter's field. Fault of 10 feet displacement with Lexington limestone on west and Cynthiana limestone on the east; the fault strikes north. The filling consists of barytes, calcite, zinc blende, and limestone; partly a fissure and partly a breccia deposit, 2 to 5 feet wide. Shaft sinking advised. Some barytes shipped from open cut on the land of Mrs. J. G. Stoll.

8. PETTIT VEIN. From 3 to 6 miles N. N. W. of Lexington and within 3-4 to 2-5 mile east of the Georgetown pike, this vein has been prospected. It strikes N.

20° W. with local strikes varying from N. 23 to 32° W., in Bigby limestone. The filling consists of soft barytes, some limestone and calcite; toward the north there is some galena, while southwest zinc blende is associated; width 1 to 3 feet, averaging 2 feet or more. This warrants fuller development. Shallow opencuts opened on the G. N. Pettit land and barytes shipped. Northward, float barytes occurs on the Charlie Gorham and Mrs. Tanner lands; on the latter near an old prospect, and near the Stagg (Woolfolk) land. On the Pettit east of this vein is a parallel line of sinkholes which should be investigated.

9. DOWNING VEIN. Immediately east of Cave run, 4 miles N. N. W. of Lexington, and one mile east of the Georgetown pike the vein is evidenced by float barytes and sinkholes. It strikes N. 30° E., and has not been prospected. Another line of sinkholes striking N. 25° W. occurs N. E. and perhaps represents a small fault parallel to Cane run. These veins are on the land of Mrs. G. T. Downing.

10. PETER VEINS. Between the Newtown and Mt. Horeb pikes, 8 miles N. E. of Lexington, on the Peter land, two parallel veins striking N. 5° E. occur 450 yards apart in the Lexington limestone. The filling consists in each instance of weathered barytes with galena and some zinc blende, the width being 1 to 3 feet. Sink holes occur parallel to and along the veins, especially following the more westerly one. Each vein can be traced by float for 1-4 mile. Northward, 1-2 mile is a calcite vein striking N. 10° E.; this is 6 ft. wide.

11. GORHAM VEIN. This outcrops on the Newtown pike, 4½ miles N. of Lexington, strikes N. 5° W., and contains weathered barytes with a little galena. It is in front of the house of Mrs. L. D. Gorham and has been prospected slightly on the Andy Gorham land, 200 yards northward; further prospecting is advised.

12. ANDERSON PROSPECT. Float barytes of good quality was seen on the ridge between the pike and the house, and also at points further east.

13. ERDMAN VEINS. Five veins occur within one mile east of the Newtown pike and 2 miles N. of Lexington. They all probably strike N. 17° E., except the No. 5 which strikes N. 20° E., and all cut Lexington limestone. The No. 1 vein contains fresh barytes with a little zinc blende; on this there is an old shaft 200 feet deep on the C. W. Moore land. On the P. P. Erdman estate, 200 yards east, fairly fresh barytes float containing a little galena marks vein No. 2. Still eastward, 52 yards is the No. 3 vein, consisting of weathered barytes containing zinc blende and limestone; this was opencut and shipments were made. The No. 4 vein is 110 yards east of No. 3, and consists of barytes with some zinc blende cementing limestone breccia. The No. 5 vein is 244 yards further east, shows a slight westerly dip, and consists of barytes-zinc blende. A shallow prospect was opened on the No. 5 on the J. W. Coleman land and can be traced by float on to the Erdman land.

14. MOORE VEIN. This was prospected 1 mile west of the Huffman Mill pike, on North Elkhorn creek, 9 miles N. E. of Lexington. It strikes N. 5° W. and cuts Lexington limestone. The filling is hard barytes containing a little galena, and is as much as 3 feet wide. A shaft was sunk north of the creek opposite the C. C. Moore house, and float occurs eastward. Northward on the Campbell Cantrill land, some barytes was seen in an old quarry. The Moore vein appears worthy of further exploration.

15. WARE VEIN. Immediately north of the Ironworks pike, 1 3-5 miles west of the Russell Cave pike, and 5 miles N. E. of Lexington, this vein is evidenced by surface float, the latter showing from the road to a small branch near the first cross-fence. The vein strikes N. 12½° W. in Lexington limestone; the barytes is weathered and the extent obscure. Prospecting advised.

16. CRAIG VEIN. This is 2-5 mile east of the Ware vein. See special description No. XI., in the preceding chapter.

17. YARINGTON VEIN. This extends from a short distance east of the Craig vein on the Ironworks pike, four miles south until the vein intersects the West Hickman fault. The vein strikes N. 10° W. in Lexington limestone, and its filling is weathered barytes containing locally some lead and zinc. It is readily traced by means of outcrops, float barytes, sinkholes and ponds. Good

showings occur on this vein on lands of S. B. Logan, J. D. Yarington, Phister heirs, at its crossing of the L. & N. R. R. near the Maysville pike, and 300 yards west of the Van Meter residence near the Bryan Station pike.

18. CARROLL VEINS. One-quarter mile S. of the L. & N. R. R. where it crosses the Maysville pike, the Mike Carroll quarry exposes a number of narrow veins, two being 6 to 10 inches wide. The sheeted zone strikes N. 8° W. and can be followed by sinkholes beyond the Bryan Station pike. The filling is barytes or barytes-zinc blende and a little calcite. It is possible that locally these veins may widen.

19. LOGAN VEIN. This parallels the Yarington vein on the east. It was located in digging a cistern near the house of S. B. Logan's son.

20. COLE VEIN. See special description XII., in the previous chapter.

21. PRITCHETT VEIN. This crosses the Lemons Mill pike, 1650 feet east of where it is intersected by the Huffman Mill pike and 8 miles N. E. of Lexington. It strikes N. 1½° E., but varies from N. 5° to 10° E., cuts Lexington limestone and dips slightly east. The filling is fresh barytes with a little galena and zinc blende and more or less calcite, and locally contains a vertical sheet of limestone; its width is 1 to 3 feet. North of the pike it is on the Inness land and south of it on the Pritchett land, on both of which open cuts were dug years ago and a shaft 35 feet deep sunk on the Pritchett. The value of the vein is doubtful, further development being necessary to determine.

22. INNESS VEIN. This is 3-5 mile east of No. 21, and strikes N. 20° E. in Lexington limestone. The filling as seen on the surface consists of much weathered barytes. A shallow prospect cuts it on the Mrs. Columbia Inness' land and south of the Lemons Mill pike it can be traced by float for 75 yards.

23. WHITNEY VEIN. This vein was open cut 250 yards east of the Russell Cave pike, 1-2 to 1 1-2 miles east of its junction with the Lemon Mill pike, and 10 miles N. E. of Lexington. The vein strikes N. 5° E. (locally N. 7° E.) in Lexington limestone. At the surface the barytes is soft, but shortly below it appears fresh and contains more galena.

It was open cut in a branch, northeast of the Frazier residence, and for 500 yards south, float barytes appears, for another 500 yards there are old open cuts and a shaft, following which for 500 yards, are sinks or depressions on the course of the vein, while sinks also occur 100 feet west; float barytes occurs directly in front of the Whitney house and for 200 yards south, after which until the Russell Cave and Greenwich pikes are intersected, the vein is represented by sinkholes or larger depressions.

24. WOODLAND ACADEMY VEIN. In the rear of the brick school house, 9 miles N. E. of Lexington, on the Paris pike, this vein has been prospected on the J. B. Haggin land. The vein strikes N. 10° W. in Lexington limestone. The filling is weathered barytes containing 5 per cent or more galena. Sinkholes follow the vein N. W. across the Harp and Innis pike, and on the Harp and T. S. Johnson lands. This vein should be more fully prospected.

25. KNIGHT VEIN. Opened 2 1-2 miles N. N. W. of Brannon, 5 miles S. W. of Lexington. The general strike is N. 1 1-2 ° W. but locally it is as much as N. 17° W. The filling is barytes-limestone breccia with some zinc blende. It has been prospected on the J. McLeod land and can be traced southward, chiefly by float, on the lands of Leslie Knight and Rankin Clemens. Further development is necessary to determine the value of this vein.

26-27. WEST HICKMAN FAULT ZONE. See special description No. VII. of the previous chapter.

VEINS OF THE ATHENS REGION. These veins vary in strike from N. 10° to 35° E., and are incidental to the Kentucky Anticlinal fault zone, which is immediately to the south and which they intersect. These veins are characterized by the presence of fluorspar either in amounts equal to the barytes or in excess and have calcite and some zinc blende associated. To this group belong the Stevenson and other veins of northwestern Clark County, as well as those of southeastern Fayette.

28. NIHIZERVILLE VEIN. Immediately east of Nihizerville, fluorspar barytes float appears with strike probably N. 25° E. Recently this has been prospected to some extent.

29. GOFF VEIN. Exposed near and on Ravens Creek 3 1-2 miles S. W. of Athens. It strikes N. 10° E. and con-

sists of calcite, fluorspar and barytes, with fluorspar predominant at the highest and calcite predominant at the lowest outcrop, with a width up to 20 inches. It outcrops on the Bowen and Land place, and is said to continue north to where it crosses Raven's creek. The value of this vein mixture must depend on its sale for use in cheap paints.

30. McCHORD VEIN. This outcrops 2 miles S. E. of Athens and strikes N. 25° E. in Lexington limestone. The filling here is fluorspar, barytes and calcite. It was found near a large sink near a small tenant house south of the Richmond pike and again at a filled sink back of the barn. The width is not known.

31. McCHORD SCHOOL HOUSE VEIN. This outcrops 150 feet N. of the school house, 1-4 mile E. of the McChord vein and strikes N. 20° E. in Lexington limestone. It consists of fluorspar, barytes, and calcite, the first in greatest amount, the calcite least. The calcite is principally leached from the surface outcrops which show the vein 10 to 15 inches wide. The barytes content increases with rise in strata, being most in the upper beds of the Lexington limestone. The vein outcrops on the Carroll land north of the house, and on the McChord land south of the road for some distance where a large spring issues south of the vein. On the W. B. Oldham land near a partially filled sink, 100 yards north of the Jacks Creek pike, barytes float is found probably on this vein, with a strike of N. 18° E.

32. CARROLL VEIN. Outcrops 1-4 mile east of the McChord school house, in an old orchard S. E. of the Carroll house. It strikes N. 30° E. in Lexington limestone. The northwest half of the vein consists of fluorspar and barytes in alternate bands, while the other half consists of the same minerals intimately intergrown. The extent of this vein was not determined.

33. HALSEY VEIN. Opened 3 miles S. of Athens and S. of the Richmond pike. The general strike is N. 5° E., the vein consisting of short *en enchelons* striking N. 20° E. in lower Lexington and Tyrone limestone. The filling consists of intergrown fluorspar, barytes and calcite, 12 inches wide. It can be traced for several hundred yards back of the house occupied by L. Devore on the Halsey land.

34. SMITHA FAULT. See special description No. XIII of the previous chapter.

35. KENTUCKY ANTICLINAL FAULT ZONE. For a general description of this zone, see special description No. III of the previous chapter. This crosses the extreme southeast corner of the county. A cross-section of the zone obtained on the Tates Creek pike, one mile south of Spears may be seen by referring to Structure in Chapter I.

On the Eugene Land place, 1-2 mile east, a calcite vein of unknown width occurs, striking N. 80° E. in the bed of the river, but no evidence was seen in the cliff. On the Jacks Creek pike the fault zone is plainly marked by upturned strata and calcite seams. At Cleveland on the Richmond pike, the Tyrone limestone is upturned at the fault for a width of 40 feet and is badly fractured and more or less cemented with calcite barytes and some fluorspar, the mineralization being most marked at a secondary fault where it is 36 to 48 in. wide, but not workable.

FRANKLIN COUNTY.

1. WAIT VEIN. This is on Flat creek, one mile west of Kentucky river, and 8 miles north of Frankfort. The vein strikes north in Lexington-Cynthiana limestone. It consists of zinc blende, galena and some barytes, 6 to 36 in. wide. It was prospected by a shaft by W. S. Pryor and others. Further development is urged.

2. CAMP PLEASANT VEIN. This is 4 miles N. W. of Kissinger, and strikes northeast in Lexington limestone. The filling is said to be chiefly galena and zinc blende up to 48 in. wide. A shaft was sunk 200 ft. by the Camp Pleasant Mining Co., and salt water said to be encountered at 140 ft. in depth. This vein should receive further development.

3. CLARK VEINS. These are 3-4 mile north of Kissinger. One vein runs N. 14° W. in Greendale-Lexington limestone, the filling being barytes containing much galena and encrusted with some strontianite, the whole being 0 to 36 inches wide. Another vein of similar width, strikes east in the same rocks. These veins warrant further development.

4. JONES VEIN. One and one-fourth miles S. of Switzer, according to Prof. A. M. Miller (Bull. 2, Ky. Geol. Survey, p. 32), this vein strikes N. 7° W. in Million-Cynthiana limestone. The filling is barytes with some galena; extent obscure. This was prospected slightly on the Mrs. T. W .Jones' land.

Many other veins probably occur in this county, insufficient time being at the writer's disposal to investigate them. The character of the veins known to occur is encouraging so that further prospecting and development, especially in proximity to the Elkhorn fault zone where it has Lexington limestone as the country rock, is strongly urged.

GARRARD COUNTY.

KENTUCKY ANTICLINAL FAULT ZONE. This zone enters the county at Camp Nelson. Prospects Nos. 1 to 7 below belong to this zone.

1. HIRAM CAMPBELL PROSPECTS. These are on a much broken zone in Tyrone limestone, ½ mile wide. The main or most easterly vein strikes N. 20° E. and outcrops immediately west of the road. This shows a barytes-limestone breccia containing a little zinc blende. Within 250 ft. west are two other veins, the first striking N. 5° W. and the second N. 32° E. The last is a fault carrying barytes. Cross-fractures trend N. 57° to 70° W. and contain calcite. The strata dips chiefly west 3° to 55°. Float barytes appears in a vein striking N. 20° E., ½ mile S. W., of the Scott house.

2. On the Bruner Bros. land still S. W., 200 yards west of the road, the east vein strikes N. 42½° E. and contains 24 in. of barytes-limestone breccia with a little zinc blende. Some of the barytes is of the coarsely lamellar type. A parallel vein occurs 100 yds. to the west marked by float barytes and sinkholes. The east vein continues south on the Charles Diedrich place. In front of the Bruner house is a fault in Tyrone limestone, which strikes N. 45° E.

3. The zone then crosses the lands of Mrs. Levi Dunn and Mrs. Burkely. On the latter a vein strikes N. 5° W. and cuts Lexington limestone. An opencut yielded

pinkish-white honeycombed barytes, some of which was shipped. Further south it crosses the Florence Ballard, Swope, Burkes and Swope lands.

4. Westward on the Thomas Ballard land, it is reported that float barytes was found.

5. Prospect cuts on the Dean land exposed barytes-limestone breccia veins, which were very narrow. These strike N. 55° E., and N. 70° W. and cut lower Lexington limestone. This place is ½ mile S. W. of Marcellus.

6. On the Ingram land, immediately east of Dix river, the zone cuts lower Lexington-Tyrone limestone and is marked by a number of narrow veins usually containing calcite-limestone breccia, while one vein having a strike of N. 10° E. was 24 in. wide and was filled with barytes containing a little fluorspar. Shipments were made from two cuts.

7. South of the bend in Dix River, a vein N. 7° E. cuts lower Lexington limestone on the land of Mrs. Sallie Pence. The filling is barytes containing 25 per cent fluorspar. Much float occurs. Further development necessary to determine the width of the vein. Float found 200 yds. westward indicates a similar vein on the Johnson land.

8. FOX VEIN. This was opencut 2½ miles S. W. of Camp Dick Robinson. The strike is N. 2° W. in middle Lexington limestone. The filling consisted of hard barytes with a little zinc blende and fluorspar, having a width of 1 to 4 feet. The strike at the N. W. end is N. 3° E. and shearage fluorspar-barytes seams in the limestone strike N. 40° E. These opencuts are on the lands of Mrs. Monte Fox from which a considerable tonnage was mined. Southward a prospect showing good barytes occurs on the Pence vein previously described.

9. TUGGLE VEIN. This is one mile east of the Fox and strikes N. 2° W. in Lexington limestone. The filling is barytes of good quality, 24 in. wide with a very little limestone. It is best exposed in the rear of the W. P. Tuggle's house, but probably cuts the Chestnut land going northward while south of Dix River it would enter the Robert Rankin land.

10. HERRING VEINS. These are immediately north of Dix River and strike N. 55° E. and N. 5° W. cutting Winchester limestone. The barytes contains a little

fluorspar, some zinc blende, much limestone, and is off-color It is a breccia and both the veins and country rock are sheeted. Considerable shipments were made, and mining is advised. Northward the vein crosses the Adams land and southward that of Doc Bourne, W. T. Bourne, and E. B. Miller, the last three having been slightly prospected and a small shipment made from the Miller.

11-12-13. BARRETT KNOB FAULT ZONE. See description No. XV of the previous chapter which describes in detail the (11) Hogg, (12) Hughes-Aldrich, and (13) Boones Creek veins.

14. RAY VEIN. On the eastern border of the county, 4 miles above the mouth of Paint Lick, opposite the Potts mill, is an old prospect on the Ray vein. This strikes N. 12° W. in lower Cynthiana limestone. The filling consists of barytes-fluorspar with a little calcite. The vein appears to be narrow but sinking into Lexington limestone might develop a better prospect. It is on the land owned by Mr. Oscar Ray (formerly the Potts land). Southward the vein would cross the land of Mrs. America Potts and thence into Madison county.

HARRISON COUNTY.

1. LAIR VEIN. This is 1 mile E. of Lair. The vein strikes N. 5° E. cutting Winchester limestone. The filling consists of barytes-limestone breccia with a little galena and zinc blende. An opening was made at a sinkhole south of the road on the John Lair land. Lack of pumping facilities prevented development.

2. HOGGIN VEIN. See special description No. XVI of the preceding chapter.

3. HINKSTON VEIN. This is 250 yds. S. W. of the Hoggin prospects. A limestone zone seamed with barytes, zinc blende and galena occurs here but is not of value. The seams strike east, N. 10° E., etc., and cut either upper Lexington or lower Cynthiana beds. There was a seam of galena 3 in. wide and 1 1-4 tons shipped. A shaft was sunk 50 ft. on the Stirling Hinkston land.

4. LAIL VEINS. On Silas Creek, 2 miles S. W. of the bridge on the Townsend pike. The veins strike N. 3° E. and N. 5° W., cut Cynthiana limestone and are 100 ft. apart. They consist of breccia cemented with galena-barytes. The wall seams make angles of 35° with the strike. Sinking might show a larger deposit.

CYNTHIANA LIMESTONE. This shows many geodes of calcite containing barytes occasionally in the center; calcite seams are also common. These have no value or significance.

HENRY COUNTY.

1. Campbellsburg Fault. This is exposed in the railroad cut 2 miles southwest of Turners and 1½ mile from Campbellsburg. A synclinal is here evident in Maysville strata. Near the west end of the cut is a fault and in small joints pink calcite is found lining them cemented in the middle with gypsum. This probably represents the upper continuation into Maysville strata of veins similar to those found to the south in Henry and Owen counties.

2. DRENNON SPRINGS VEIN. This is located immediately at the Springs. The vein strikes N. 15° W. and cuts upper Lexington limestone. It consists of barytes and some galena and zinc blende, said to be 2 ft. wide. Springs containing white sulphur water mark its course. A parallel vein occurs a short distance eastward. This was opened on the L. P. Crabbe land and should be prospected further.

The first prospecting in Central Kentucky was done on what may be the southern continuation of this vein; this on the land of Mrs. Eliza Ann Greene, 2½ miles east of Franklinton and reported by Prof. Norwood in his early report on the veins of Henry and other counties. There is no present surface evidence at this point which is now on the Shelton land.

3. MEEK VEIN. This was opened on the bank of the Kentucky river 2 miles south of Drennon Springs. It probably strikes N. 5° E. and cuts upper Lexington limestone. The filling consists of barytes, galena, and a little zinc blende, having a width of 3 to 10 in.

4. WHITE SULPHUR SPRING VEIN. This is on Drennon Creek about 4 miles S. of Drennon Springs. It consists of a seamed zone, 4 ft. wide with seams of barytes with some calcite, 2 to 6 in. wide. It strikes N. 17° W. with cross-seams N. 85° E. in Greendale limestone.

5. GRATZ VEIN. Union mine. This is across the river and 1½ miles south of the Gratz mine. The vein was here tested to a depth of 100 ft. and strikes N. 5° E. cutting upper Lexington limestone. The vein consists chiefly of barytes or again chiefly of calcite and a very little fluorspar, but carries 4 per cent galena and a very little zinc blende. The wall is seamed and the vein is locally reduced to seamed limestone. A 20-ton mill and lead smelter was in operation here when visited by Prof. C. J. Norwood in 1875. The first prospecting was done here according to Prof. Norwood in 1823 or 1824, and a furnace erected in 1836. Two shafts were sunk and an adit driven.

6. MCALESTER VEIN. This is ½ mile east of the Union mine, and parallels the Gratz vein. Barytes containing a little galena occurs 4 to 7 in. wide. A shaft was sunk 21 ft.

7. LOCKPORT VEIN. See description XVII of the previous chapter.

8. MONTGOMERY VEIN. This is in sight of Lockport on the S. E. bank of Six Mile and strikes N. 15° E.; filling galena-barytes 4 in. wide. On the land of Dr. W. L. Montgomery.

9. JAMES VEIN. This is on the south side of Six Mile Creek, 1 mile S. of Lockport. The vein strikes N. 0° to 5° E. and probably cuts Cynthiana limestone. Barytes-calcite seamed limestone was found on the James and Jones land. According to Prof. Norwood's report the vein was 3 to 20 in. wide, and a shaft was sunk 40 ft. Barytes 3 to 5 in. wide occurs in the same vein on the land of Aris James.

The Anna Bianna farm owned by Mrs. Judith Langham Marshall, of Louisville showing a vein of lead, zinc and barytes with some limestone occurs on the Kentucky river but its exact location was not learned.

JESSAMINE COUNTY.

1. MAHIN VEIN. This is 1½ mile southeast of Troy and strikes N. 5° W. in Wilmore limestone. The barytes is honeycombed and has fluorspar associated and a little zinc, being more than 12 in. wide. Abundant float shows on the surface on the line between the J. W. Mahin and A. C. Shields lands, south of the road. Prospecting is advised to determine value of deposit.

2. LOWERY VEIN. This is ¾ mile east of the Mahin which it parallels in similar country rock. The filling is barytes-limestone breccia containing a little fluorspar, 12 in. wide. Further development is necessary to determine value. It outcrops in the lane in front of J. C. Lowery's house and extends northward on the Mrs. Rankin Gynn's land, while south of the Lowery it enters the Asa Jewel (White) land.

3. NOEL VEIN. This has a general strike of N. 10° W. in Lexington and Tyrone limestone. The vein passes a short distance west of Brooklyn bridge, northward into Woodford county, and south into Mercer county. The local variations in strike run from N. 1° E. to N. 15° W. The filling varies from barytes to calcite-barytes and fluorspar and barytes interbanded, and is from 0 to 24 in. wide. Locally calcite may be the predominant mineral.

Considerable open cutting was done on the Mrs. Agnes Noel land and some mineral shipped. Northward it crosses the Haggin and Hawkins lands, and southward to the river it crosses the lands of Wilson (col.), Price, Reynolds and Haup. On the last the vein consists of two to three calcite seams constituting a zone 36 in. wide. See further No. 12 of Mercer county. It is doubtful whether this vein will pay to work in Jessamine county, this depending on the width of mineral obtained and the use to which the mixed minerals may be put.

4. VAUGHN ZONE. A sheeted zone striking N. 30° E. and a fault striking N. 85° E. cut lower Lexington limestone, one mile S. E. of Brooklyn bridge. This zone shows seams of calcite 1 to 6 in. thick but is not likely to have it sufficiently concentrated to repay working.

5. PRENTISS VEIN. This is ½ mile S. E. of Wilmore on the land of Will Prentiss (col.). The vein probably strikes N. 62° W. in Wilmore limestone. The barytes is of good quality except for honeycombing. The extent is obscure and should be prospected.

6. OVERSTREET VEIN. This has a general strike of N. 2° E. in lower Lexington limestone. The vein is sinuous with strikes of N. 0° to 5° E. on the McGee and

Overstreet lands and N. 8° W. on Corman. The vein was opencut more or less continuously. The filling is usually barytes which on the Overstreet was largely of the best grade, but locally as on the McGee, the filling consisted of two bands separated by an open space, and consists chiefly of fluorspar with some barytes and limestone. On the Corman land, barytes is again predominant. The width of the filling is usually less than 24 in. but occasionally reaches 48 in.

This vein beginning at the north on the Dan Rhoer, extends southward on the Moody, Hollin Corman, G. H. Overstreet, Harry McGee, and G. W. Prather lands, while south of the Kentucky river it crosses the McKenzie Moss land where in its course are a number of parallel veins. The Overstreet vein while locally containing fluorspar is primarily a barytes vein and is worthy of further development.

17-18. McKENZIE MOSS VEINS. 1½ miles north west of Camp Nelson are four parallel veins 35 to 225 ft. apart, three of which strike N. 10° E. and the fourth, N. 3° to 5° E. Except the most easterly which was only 12 in. wide, these veins were each 25 in. wide, the filling usually being barytes with a very little limestone, except the most westerly which locally carries calcite. The Dick Moss vein which is 800 ft. east of the McKenzie Moss veins, strikes N. N. E. also, and has similar mineral but has not been prospected. The two more easterly of the McKenzie Moss veins extend southward on the Brooks land. These veins should all be thoroughly prospected. Westward, calcite boulders were reported on the land of Terry Crutchfield.

7-8-9. CECIL VEIN. Starting 2 miles S. W. of Nicholasville, and ½ miles W. of the Danville pike, this vein has a general strike of S. 5° E. for a distance of 5 miles. The local strikes and wall rocks were as follows: (7) On the Wallace land, N. 2°½ E. in Wilmore limestone, (8) Cecil land N. 15° W. in Paris limestone, and (9) Sageser land, N. N. E. in Tyrone limestone. The filling varies from barytes-limestone breccia to fluorspar and barytes interbanded, and the barytes occurs coarse crystalline or fibrous, and both fresh and weathered. Here is a definite instance of where a vein carries fluorspar in Lexington limestone and lower rock fail to show fluorspar. Except locally where fluorspar predominates this vein should prove workable; at least, it is worthy a thorough investigation.

The sequence of properties on this vein beginning with the Wallace and going southeast is as follows: Joseph Wallace, Welch heirs, Ed. Bridges, Granville Cecil, G. C. Scott, T. P. Sageser, and Lewis Carter, where the Kentucky anticlinal is probably intersected. Whether it extends N. W. of the Wallace remains to be determined.

10-11-12. WEST HICKMAN FAULT ZONE. See special description No. VII of the preceding chapter for a general description, and for details the paragraph below:

Northeast of Union Mills, the west fault strikes N. 3° E. from the Lindsey Stoll to the Wm. Mackey lands, a distance of 1 mile. Two secondary faults within 18 feet east of the main fault shows breccias 6 to 20 in. wide cemented chiefly with barytes but containing also fluorspar, calcite and some zinc blende, as well as some replacement mineral.

The west fault starting at the Fayette county line passes through the following lands (those marked with a * show barytes float): Milton Young, Tom Sellers, *John Vince, (10) *Lindsey Stoll, *R. A. Cook, James R. Smith, Widow Scott, William Hargett, *William Mackey, *Hardin Hunter and Luke B. Greggs, south of which the vein was not traced. On the R. A. Cook land, 100 yds. west of the west fault is a secondary fault somewhat mineralized.

The east fault which is ¾ mile east of the west fault strikes locally N. 12°W., but probably has a general strike of N. 2° to 3° W. Float mineral occurs on the Young and (11) Sellers lands, while the fault is marked by sheared and titled strata on the Ben G. Smith place and ½ mile further south; south of the Union Mills-Spears pike on the (12) Luke P. Gregg land, it shows float barytes, originally forming part of a breccia deposit.

Development is necessary to determine the value of deposits along these faults; sinking to where Lexington limestone in the wall rock will show the best deposits.

14. HEMPHILL VEINS. These have been prospected on the land of Lewis T. Hemphill, 1½ mile N. E. of Am-

brose. They strike N. 5° E. in upper Lexington limestone and were 200 ft. apart. The filling is barytes, 12 in. wide and solid where between walls, with 2 to 3 ft. of float over the east vein. The barytes partly replaces limestone, partly cement breccia. The float is honeycombed from the leaching of limestone. Further prospecting is advised.

15. John West Fault. This is one mile east of Ambrose. It strikes N. 20° W. with upper Lexington limestone forming the east and Greendale limestone, the west wall; the strata of the latter dip 7° S. W. The fault can be traced south for 5-8 mile when it intersects the Kentucky fault zone. On this fault, for a width of 27 ft. there is barytes float including two solid bands, one 50 in. wide and another 12 feet to the east, 12 in. wide. The barytes partly cements breccia and partly replaces limestone; it contains a little zinc blende and a very little fluorspar. The float is weathered, honeycombed, and ironstained.

North of the West land, the vein crosses the William Woods and Price Berryman lands, and is fully 30 in. wide on the last. The John West fault is among the best of the prospects of undeveloped veins.

16. Fault. ½ mile west of the John West fault is another with walls of Greendale and Tyrone limestone.

17. Ambrose Fault. See special description No. XVIII of the preceding chapter.

18. Kentucky Anticlinal Fault Zone. See special description No. III of the preceding chapter, and for details the following paragraphs:

18 to 25. North Boundary Fault: Beginning at the Fayette county line, these faults cross the following lands: Carroll; Ben Thomas; Davis; W. T. Richardson; James B. Demaree (shows fault between Tyrone and lower Tyrone, striking N. 37° E. containing calcite seam only while another calcite vein strikes N. 25° E. and is 24 in. wide); (18) George Stafford (here the main fault strikes N. 40° E. with barytes-limestone breccia but is not workable, and a vein 50 yds. south shows barytes-calcite-zinc blende cementing limestone breccia, the latter partly replaced by marcasite, but is not workable); Benton; Mose Thomas; J. T. Cobb (fault strikes N. 60° W., zone much faulted, flexed and cemented with calcite); Hugh Miller (fault strikes N. 52½° E.); Jno. West; Jim Turner (fault strikes N. 40° E.); Leroy B. Taylor; Newt. B. Davis (see special description N.XVIII of the preceeding chapter); Nelson Davis; Newt. B. Davis; (19) Mrs. B. F. Foster (vein strikes N. 65° E., shows barytes float in shallow prospects, also a cross-fault striking N. 20° E. with the strata on the west dipping 30° west); (20) F. M. Hudson (main fault strikes N. 65° E. and 30 yds. S. E. another fault N. 42° E. which carries barytes, while a third further south carries 12 in. of calcite-barytes and strikes N. 46° E.); Mrs. Mary B. Walters (fault strikes N. 55° E.); Elbert Taylor (calcite seams N. 17° W. and N. 47° E., and an open fissure N. 15° W.); J. C. Lutes (main fault strikes N. 50° E. and a clay cemented breccia zone 35 ft. wide, strikes N. 5° E.); (21) H. G. Harris (vein strikes N. 30° E. with barytes cementing and replacing limestone while 150 yds. S. W. is calcite-limestone breccia, 48 to 66 in. wide, striking N. 50° E.); John Brumfield; Warren Taylor; (22) Mrs. Fannie D. Jasper (main fault strikes N. 53° E., barytes float); Joe Wallace; Clay Watts (main fault strikes N. 45° E., sinks and ponds follow fault); Mrs. Lulu Carter; Grover Carter; Herman Watts; Green B. Sageser (calcite-limestone breccia, 6 to 24 in. wide, striking N. 25° E.); (23) George F. Fain (fault about N. 50° E., strong showing of barytes float with N. W. wall sheeted N. 33° E., 20 yds. S. E. is barytes-limestone breccia striking N. 35° E., 50 yds. E. another showing of float barytes, while 150 yds. further east a vein strikes N. 12½° E. showing gray barytes float); Will Waters and Ed. Carter lands (vein chiefly on former with barytes showing); Mrs. John Perry; Hugh Scott (large boulders of barytes cementing and replacing limestone probably striking N. 10° E. in Camp Nelson limestone); (24) Charles Glass (vein strike N. 35° E. in Tyrone limestone, 7 in. solid barytes and much float; 200 yds. E. a vein strikes N. 60° E in Camp Nelson limestone, barytes-limestone breccia with beds on either side dipping 80° W.); Elmer Bruner; (25) Will Hall (col.) (vein strikes N. 60° E. in Camp Nelson limestone, width 36 to 84 in. consisting of barytes bands

alternating with calcite-barytes limestone breccia, locally much weathered; further prospecting advised); and Joe Smith; after which the Kentucky river is again reached. See description under Garrard and Boyle counties for the north fault of this zone further south.

26-27-28. SOUTH BOUNDRY FAULTS. These were not followed in the same detail, there being fewer mineralized localities evident. Beginning with the Preel land and going southward, the following were noted: (26) B. F. Peel (main fault strikes N. 41° E. in Tyrone limestone); Underwood; Ed. L. Carter (27) George H. Fain (vein in Greendale limestone strikes N. 28° E. with barytes-limestone breccia; 100 yds. west are two faults striking each N. 30° E. sheeted and calcite seamed); Ed. L. Carter; Mitchell Fain; (28) Mrs. Mary J. Bruner (vein strikes N. 34 to 40° E. consisting of honeycombed gray barytes float said to contain some pyrite, and to have a width of 36 in.; 90 yds. S. E. another vein striking N. 50 to 60° E., the fllling being partly weathered barytes, partly calcite-limestone breccia; between the two veins, the strata form a synclinal fold); and Hardin Underwood when the river is reached.

30. REYNOLDS VEINS. These occur ½ mile west of the lower Hunter ferry, 6 miles S. E. of Ambrose. One vein strikes N. 7° W. with a local strike of N. 12° W. in upper Lexington limestone. The filling is barytes with a little fluorspar and calcite, and the width probably 24 inches. It crosses the Lindsey Reynolds land ½ mile, going north on the Jerry Conley, and south across the Kentucky river into Madison county on the Wm. Murphey and Boss Warren lands.

A second vein, 300 yds. west of the above is supposed to strike N. 77° E. and a prospect showed a little barytes, galena, and zinc blende.

Further prospecting is necessary to determine the value of these veins.

29. CUSHENBERRY ZONE. A narrow zone striking N. 80° E. on the John Cushenberry land shows flexing and attendent fracturing in Greendale limestone, cemented with black calcite and calcite crystals. This is not worthy of further investigation. It is locally known as the "silver mine."

LINCOLN COUNTY.

1. GIVENS VEIN. See special description No. XV of the preceding chapter. A little prospect opposite the Givens house shows barytes-limestone breccia striking N. 25° W.

2. ENGLEMEN VEIN. See special description No. XV of the preceding chapter. p 477-478

3. SWINEBROAD VEIN. This is ½ mile W. of the old Lancaster pike and 5 miles S. E. of Danville. Float barytes is of irregular occurrences but the strike is probably N. 37° E. in Paris limestone. The float consists of rotted limestone cemented with barytes and a little fluorspar. Further prospecting is advised.

4. WHITE VEIN No. 1. This is a short distance E. of the Swinebroad. The vein strikes N. 72½° E. in Lexington limestone and shows honeycombed barytes at a prospect hole and 125 yds. N. E. near a sink on the J. H. White land. Further prospecting is advised.

5. KEETON VEIN. This is 200 yds. S. S. E. of that last described. It strikes N. 65 to 70° E. in Lexington Limestone. The filling is honeycombed barytes of good quality. It shows on the W. E. Keeton and also N. E. on the J. H. White land on Hanging Fork.

6. WHITE VEIN No. 2. This is 100 yds S. S. E. of the Keeton. The vein strikes N. 65° E. in Lexington Limestone. Excellent barytes float occurs at one point while at another the filling is calcite-barytes-limestone breccia. This is exposed on the J. H. White land and should be prosecuted.

7. GEORGE BRIGHT VEINS. These were located near the mouth of Hanging Fork and strike N. 90° E. and N. 27½° E. in lower Lexington limestone. The latter vein is nearest the creek and shows good barytes with a little limestone, and is worthy of development. The other vein and an extension of the Engleman vein on this land show barytes-limestone breccia.

8. VANDEVEER PROSPECT. This is 3 miles E. of Stanford on the M. O. Vandeveer land. No vein occurs but in clay shale beds probably of Richmond, appear lime carbonate concretions containing zinc blende, cal-

cite, and barytes, which after weathering expose these minerals which are not in marketable quantity.

9. LUNSFORD VEIN. This is 2 miles S. of Preachersville. Here, in upper Maysville rocks, calcite veins occur up to 4 inches wide, which strike N. 5° to 25° E. and consist of complimentary fractures, in one instance striking N. 35° E. and N. 18° W. These veins while not of value, show the upward extension of barytes veins in Cincinnatian rocks. The calcite veins ended abruptly upon reaching the shaly-clayey limestone above.

In upper Richmond limestone, 150 feet higher, less than 1/4 miles distant is a bed of brecciated limestone, 12 ft. thick cemented with calcite and less barytes, zinc blende, and possibly galena. These minerals occur only in small amount and hence are not of value; they were deposited from solutions rising along fissures similar to those described in the preceding paragraph.

In a similar bed on the Stanford-Preachersville pike, calcite-gypsum geodes were noted; this is within 3 miles of Preachersville.

MCKINNEY PROSPECT. In Devonian limestone, calcite geodes containing a little zinc occur, 2½ mlies S. W. of McKinney on the J. B. Williams land. These are of no value.

RICE PROSPECT. On the A. J. Rice (formerly Squire Murphey's) land, 3 miles N. of Stanford and north of the Houstonville pike is a prospect which was not visited.

MADISON COUNTY.

Owing to the prevalence of Cincinnatian and higher rocks in this county, there are few exposures of barytes deposits, although the occurrence of a number of faults makes it likely that at the depth necessary to reach proper wall rocks such deposits may occur, but under present conditions their development would not be warranted except along the Kentucky Anticlinal fault zone in northern Madison county.

1. KENTUCKY ANTICLINAL FAULT ZONE. On the north side of this zone, Lexington and lower rocks are exposed and close search may reveal barytes deposits.

REYNOLDS VEIN. See description No. 30 of Jessamine county.

2. On the Thomson land on Calloway creek, ½ mile east of Cleveland, calcite seaming appears along the fault with Wilmore and Tyrone walls.

3. MILLION VEIN. A vein of barytes is said to have been found in the railroad cut ½ miles west of Million station.

4. CLEAR CREEK FAULT. Barytes boulders are reported on the Tandy Eads land, 1 mile S. of Doylesville on Clear Creek, along a possible fault having a northeast strike.

5. SILVER CREEK PROSPECT. A barytes vein was reported 3 miles from the Kentucky river on Silver creek.

6. BEREA PROSPECT. Barytes flakes reported as occurring in the hill 3 miles east of Berea. These probably occur in Keokuk limestone breccia and are not of value.

MERCER COUNTY.

1. KENNEDY VEIN. This is exposed one mile N. W. of Van Arsdall, and strikes N. 12° to 15° W. The filling judging from weathered float is good barytes containing a trace of galena. On the W. H. Kennedy land; prospecting necessary to determine extent.

2-3. RIKER VEIN. 3 miles N. of Harrodsburg. Vein strikes N. 8° W. containing barytes, extent obscure on the (2) Henry Magee and Sam Forsythe lands which are west of the Frankfort pike. On the (3) Lee Riker land, ½ miles south of Harrodsburg what is possibly the same vein was opened. The strike here is N. 2° to 5° W. in lower Cynthiana limestone, the vein being 18 to 20 in. wide. The filling consists of narrow alternate bands of fluorspar and barytes and locally calcite bands also. Fluorspar predominates at some points. Was prospected by shallow pits.

4. THOMPSON VEIN. 4 miles N. of Harrodsburg, S. of Jackson pike, ½ mile W. of Mundy's pike. The vein strikes N. 15° W. The filling is barytes with a little fluorspar and less lead and zinc, somewhat weathered. Exposed at two points on the Mrs. Sam Thompson land where slight prospecting was done, and probably extends into Pearson Bros. land northwest.

5-6-7. FAULCONER VEIN. While forming a curved line, the Robinson, Bonta and Farley lands probably are on the northward extension of the Faulconer vein described previously under Boyle county. As there, in each instance fluorspar and barytes occur intergrown, and on the Robinson and Farley lands these minerals occur in narrow alternate bands. The general strike of the vein is N. 10° W. in upper Lexington limestone. On the Charles W. Robinson, Sr., land, the vein strikes N. 17½° W. and carries a little zinc blende, partly leached; this is 6 miles N. E. of Harrodsburg. Opposite the Chinn lane on the pike running north from Harrodsburg, the vein strikes N. 10° W. on the (6) Bonta Bros. land extending southward on the Glave Goddard land. Still southward on the (7) Joe Farley land, 3 miles N. E. of Harrodsburg, it continues with similar strike and with a width of 16 to 36 in. It crosses the Van Arsdall and Coovert lands, south of the Farley, and in northern Boyle county, it enters the Faulconer land. North of (5) two feet of barytes, possibly on this vein, has been opened on Lapsley's land.

8. KETRON VEIN. 9 miles N. E. of Harrodsburg and one mile W. of the Twin Chimney mine. This vein strikes N. 5° to 12½° W. with a local strike of N. 21° W. in upper Lexington limestone. The filling is chiefly fluorspar with a little barytes but locally calcite predominates. The vein is from 18 to 20 in. wide. It outcrops on the Lizzie Dangier, Helen Dean, Hugh Ketron, Helen Dean, Hugh Ketron and Sam Dean lands, the last being the most southerly. The vein has been slightly prospected.

9-10. CHINN VEIN. See special description No. XIX of the preceding chapter.

11. SHAKER FAULT. Immediately W. of Pleasant Hill is a small fault whose strike is N. 75° E. between Tyrone and lower Lexington limestones.

12. NOEL VEIN. What probably represents a continuation of this vein (see description No. 3 of Jessamine county) strikes N. 10° W. in Oregon-Camp Nelson limestone and is exposed in the cliff near the Long house, 1 mile S. of Brooklyn bridge. Here the vein consists of narrow seams and veins of calcite 4 to 12 inches wide but is not of value.

13. HUGELY VEIN. This strikes N. 5° E. in upper Lexington limestone. It outcrops on the J. T. Hugely land, 2 miles S. E. of Burgin, S. of the Bushtown road. The filling, judging from the float, is of good quality barytes with a little fluorspar sometimes intergrown or interbanded. May locally show sufficient barytes to work.

14. PERKINS VEIN. This is ½ mile east of the Hugely vein, just north of the Bushtown road, and 100 yds. east of the Kelly Perkins house. Float consisting of grayish colored crystal groups of barytes with a little fluorspar associated, covers a space 100 feet square. The course of the vein is doubtful, probably N. 5° E.

15. CURRY VAN ARSDALL PROSPECT. This is 3½ miles N. W. of Harrodsburg and immediately W of Salt river. A hole dug many years ago exposed a cave, and the small amount of crystal barytes present on the dump suggests a cavity containing this mineral, and further prospecting is not advised.

OWEN COUNTY.

1. HOOSIER VEIN. This is 1¾ miles E. of Cleveland. The vein strikes N. 10° W. cutting Wilmore limestone. It consists of calcite-galena with a little barytes and zinc blende at the Hoosier mine but on the land of Butler See it is chiefly barytes; width up to 14 in. The Hoosier shaft on the John Doan land is 130 ft. deep. The vein is probably too narrow to work. It was developed by the Lead Mining Corporation of America who had erected a concentrating plant which is now in ruins. A sample of this ore showed as much as 17 per cent strontium sulphate.

2. BARNETT VEIN. This is ¾ mile E of the Hoosier mine. The vein strikes N. 5° E. cutting Wilmore limestone; consists of barytes-calcite with some galena and is narrow. Shaft on John Barnett land is 20 ft. deep.

3. CANTOR VEIN. This is 1 mile S. E. of the Barnett, and strikes N. 10° E. in Lexington limestone. It consists of calcite, barytes, zinc blende and galena, having a width of up to 36 in. and averaging 22 in. Zinc is reported as principally in the upper part of the vein.

The vein is *en echelon,* and has been opencut for 50 ft. A mill was formerly operated here by the Twin Creek Mining and Smelting Co. Shafts are 80 and 90 feet deep with a drift near the bottom.

4. Gratz Vein. See special description No. XX of the preceding chapter.

Prospects not examined in Owen county were the following:

Stiggers and Matthews prospects ½ mile S. W. of the Hoosier. Dr. Mudd prospect (galena and barytes) on Seven Creek. Dripping Spring prospect (opposite Mint Spring schoolhouse) barytes, etc.; Mrs. Eliza E. Bailey prospect opposite Lockport, galena and barytes. Fault 1 mile N. of Lockport on the Douglass Spurr land. Marshalls Bottom prospect said to be seen in the cliff 500 yds. below the mouth of the branch.

Scott County.

1. Hooke Vein. This is 1 mile E. of Stamping Ground, and the strike is doubtfully N. 12° E. in Cynthiana limestone. The barytes contains galena and a little zinc blende. Opencut but extent of deposit not determined.

2. Johnson Vein. See special description No. XXII. of the preceding chapter.

3. Wm. Davis Vein. See special description No. XXI of the preceding chapter.

4. Wilson Vein. This is ½ mile N. of South Elkhorn Creek and 4 miles N. E. of Paynes Station. The vein strikes N. 20° E. and is marked by float barytes, a spring, and sinkholes. Prospecting is advised. The vein crosses lands of Mrs. Hulda Wilson and Dr. S. J. Anderson.

5. J. L. Lisle Vein. This is ¾ mile E. of the Lisle pike and 3 miles S. E. of Georgetown. A zone of veined Lexington limestone striking N. 5° E. contains barytes with a little galena the latter partly altered to cerussite. The silicious character of the limestone probably explains the lack of concentrated deposit. Several cuts and a shaft were opened, but the prospect is poor.

6. Coleman Vein. This is ½ mile W. of the Georgetown pike and 1½ miles N. W. of Donerail. The strike varies to N. 19° W. but averages N. 2° W. in Lexington

limestone. The filling is partly weathered barytes with a little galena; a considerable tonnage was mined from open-cuts.

7. Thomas Vein. This is south of the Newtown pike, 1½ miles east of Georgetown. The vein strikes N. 10° E. and varies from 12 to 18 in. wide, but only a fraction of this width is mineral. The banded character of the vein is marked, galena and barytes constituting most of the filling although a little zinc occurs in some of the barytes. The vein has been opened on the Thomas land but is evident also to the north on the S. C. Wilhoit and Tisdall lands by means of float barytes, and to the south on the George Ware and John B. Graves lands, where it is reported as 12 in. wide.

8. Offutt Vein. This is 2-3 mile east of Newtown and has been opened on the north side of the pike. The strike is N. 10° E. in upper Lexington limestone and the width runs from 10 to 15 in. consisting of barytes with a little galena. It has been opencut and several cars were shipped. At a depth of 20 ft. the vein pinched on the Offutt land, but would suggest sinking shaft 60 ft. Southward it is marked by float barytes on the Coyle heirs' land and by 15 in. breccia on the Frank Brock land.

9. Arnspiger Vein. This was seen in the branch S. of the pike, 400 yards E. of Newtown. The strike is N. 5° E. the vein consisting of barytes-limestone breccia containing galena, and is 3 inches wide. This is on the J. D. Arnspiger land.

Woodford County.

1. Withrow Vein. This vein crosses the L. & N. R. R., 1 mile west of Spring Station, and strikes N. 14° W. in upper Lexington limestone. The filling is barytes containing fully 25 per cent galena, the latter being partly altered and leached. The width of the ore is 12 to 14 in. Prospect is good and further sinking is advised to determine value of the vein.

2-3. Shryock Ferry Vein. See special description No. II of the preceding chapter which treats of the (2) J. W. Newman, Widow Shryock and (3) Mosby prospects.

4. COTTON VEIN. This is on Griers Creek, $1\frac{1}{2}$ miles S. E. of the Newman (2). The vein strikes north in lower Lexington and Tyrone limestone. The limestone is sheeted and small veins are linked vertically. Barytes-limestone breccia containing 30 per cent zinc blende (coarse cleavage variety) with a little chalcopyrite, occurs 12 in. wide in one band. This has been prospected on the John Cotton land and is of doubtful value owing to the narrowness of the ore.

5. COLLINS VEIN. This is $\frac{3}{4}$ mile E. of the Mosby prospect (3) and $\frac{1}{4}$ mile S. of the Griers Creek pike. The vein strikes N. 10° W. in upper Lexington limestone, and the filling consists of barytes-limestone breccia with a little galena and zinc blende, the latter replacing limestone. Only a shallow prospect so that further development is necessary to determine value.

6. WILEY VEIN. 40 yds. above McCowan's Ferry, a vein is exposed in a cliff. The vein strikes N. 30° W. and shows 8 in. of calcite; is unimportant.

7. WILSON ZONE. This is a synclinal zone striking N. 50° W. in Lexington limestone, with calcite seams, vertical and horizontal. It was seen on the J. D. Wilson and J. I. Chapman lands, and while of no apparent value extends across the bend of the river for one mile.

8. CHINN VEIN. Two miles W. S. W. of Mortonsville, a vein strikes N. 5 to $7\frac{1}{2}$° W. in Wilmore limestone and probably constitutes the northern continuation of the Chinn vein. The vein here consists of limestone breccia, 4 to 12 in. wide cemented with barytes or calcite, and locally a little zinc blende. Shafts have been sunk on both the Dean Nave and James I. Orr lands, but the width of the deposit as well as its character makes further development unprofitable. If the vein were traced along its course to higher rocks, a better yield might be found. Further south near the river, the Chinn vein has not been prospected.

9-10. Openings have been made on this vein, 2 miles S. E. of Nonesuch. The general strikes is N. 10° W. in Lexington and lower limestone, with local strikes on the Rollie Prather land of N. 20° W. and on the Prewitt, of north. The filling consists of alternating bands of barytes, fluorspar, and locally also, of calcite. There is a little galena with the barytes and zinc blende with the fluorspar. The vein can be seen on the Rollie, Mary J., and Allie B. Prather lands, and float is said to occur to the south on the Mary Frohman, Will Bohanon, and George Frohman lands, while in the river cliff it is exposed on the Prewitt land.

11. CLEAR CREEK FAULT. This fault is evidenced by steeply dipping Tyrone limestone, 1 mile N. W. of Troy on the Versailles pike, where the latter crosses the creek. The general strike is N. 55° W. The rocks on the west dip 22° S. W. while those on the east dip 4° N. E. A spring of large volume issues from the fault in the creek. A short distance west of the fault, the rocks show reversed dip. Immediately west of the bridge is a narrow vein of calcite-limestone breccia. The fault is exposed on the J. D. Young and Johnson lands.

12. SHROPSHIRE VEIN. This was prospected $2\frac{1}{2}$ miles N. W. of Brooklyn bridge, 50 yds. E. of the Mundys-Troy pike on the J. D. Shropshire land. The strike is N. $2\frac{1}{2}$° in Wilmore limestone, and the filling is 24 in. of barytes with some fluorspar and a little partly altered galena and zinc blende. A stream of water was encountered in the shaft. The vein warrants further prospecting.

13. NOEL VEIN. This vein is fully described under Jessamine county. It occurs on the J. S. Hawkins and Edward G. Haggins lands in Woodford county, the strike here being N. $2\frac{1}{2}$° W. Barytes float containing a little zinc blende occurs on these lands.

CHAPTER V.

PRODUCTION.

In 1911, the barytes industry of Kentucky was confined to the Central District, and only a small number of counties were producing. Barytes was first marketed from this State in 1903, when shipments were made from the Ray and Lowery mines in Western Kentucky and by the Mutual Mining Co. from Scott county mines in Central Kentucky. No shipments were made from Western Kentucky thereafter except a small tonnage in 1907, whereas Central Kentucky has been a regular producer, with shipments prior to 1906 quite small. The total shipments from Kentucky prior to 1906 probably did not exceed 2,500 tons although no statistics are available. The following table gives the production from 1906 to 1910:

Barytes Production of Central Kentucky.
(In short tons.)

Year	Mined Tons	MARKETED				Stock close of year	Average value per ton	
		Crude		Ground				
		Tons	Value	Tons	Value		Crude	Ground
1,905	....	....	....	....	....	535	....	....
1,906	3,375	*2,000	$9,000	....	....	1,910	$4.50	
!1,907	9,435	*6,331	29,595	....	....	5,015	4.67	....
1,908	11,051	5,233	21,504	3,300	$39,600	5,904	4.11	$12.00
1,909	2,746	464	2,088	1,562	18,644	1,277	4.50	12.00
1,910	2,754	....	....	2,744	30,187	1,171	4.00	11.00

*Includes tonnage ground but value is for all as crude.
!Includes a small tonnage from Western Kentucky.

In 1906, Kentucky was the fourth largest producing State, and in 1908 ranked third. The ground product was produced at the Nicholasville plant successively operated by the Jessamine Barytes Co., Kentucky Barytes Co., and now the Central Pigment Works. A small part of the crude was ground at plants outside the state. Part of the barytes was manufactured into blanc fixe, depilatory, sodium sulphide, etc. at the works of the Mutual Mining Co. at Kissinger, Scott county, Ky.

The production and shipments increased annually, prior to 1909 when they decreased both owing to lower price, slack demand, and lack of capital to push manufacture and sale, the last being the chief cause. By-product galena and zinc blende were produced in small quantity each year.

The properties mined in 1910 were the following: Campbell, Glass and Leavell in Garrard county; Hayden, Pope and Sanders in Boyle county; and Stoll, Craig, Cole, Haggin, and Vance, in Fayette county.

In 1911, the Central Pigment Co. leased the properties and plant of the Kentucky Barytes Co. The same year Harrison Bros. and Co. also entered the field. These

companies will mine barytes and manufacture lithopone and possibly other barium compounds.

The world's production of barytes (including a small amount of witherite) may be conservatively estimated at 235,000 short tons. Of this amount, Germany produces about half. The average annual production of the United States for the past ten years has been 55,800 tons. England ranks as third largest producer, having a production slightly less than the United States.

About 75 per cent of the American production is ground, the remainder being used in crude form for conversion into barium salts and pigments, etc. The low percentage utilized for the latter purpose is explained by the fact that of imports 65 per cent are in crude form and imported for manufacture into lithopone and other barium pigments and salts. The average annual consumption of barytes in the United States for all purposes is slightly in excess of 80,000 tons. The production in the United States in 1910 was 42,975 tons valued at $121,746, which was considerably below average.

PRICES.

The price of crude barytes in Kentucky varies according to grades f. o. b. cars from $3.50 to $5.00. The average is slightly more than $4.00 per ton. The average for the United States for 1910 as reported by "Mineral Resources" was $2.83. This low figure includes the Tennessee product which averaged only $1.54 per ton, the low price in this instance probably being due to its inferior quality. Kentucky barytes sold locally to other operators brings a price just sufficiently less to warrant its handling and marketing. Crude barytes is frequently purchased by the ton of 2,240 lb. The tariff on crude imported barytes is $1.50 per ton.

American off-color ground brings $12 to $13 per short ton inclusive of package f. o. b. New York. Bleached ground or floated barytes brings $16 to $19 per short ton inclusive of package at New York, the price depending on grade and a difference of $1 to $2 per ton for freight to destination. Foreign floated barytes is quoted at $18 to $22.50 per ton at New York; this includes a tariff of $5.25 per ton.

IMPORTS.

So far as learned, ground barytes is imported by only one firm. The demand for this product is said to be due to its even quality as obtained from fissure veins in Rhenish Prussia, and hence not varying in quality as does the surface float product largely produced in Missouri and Tennessee. Central Kentucky barytes may be had equal in quality to the best foreign. The foreign ground barytes comes in two grades, selling at $18 and $22.50 per ton in New York. The American product has an advantage over the foreign in being finer ground (see further in this regard the discussion of the bleached ground barytes in Chapter VII). The imports for the fiscal year 1910-1911 amounted to 3,263 tons valued at $8.11 or $13.36 per ton inclusive of duty.

The imports of crude barytes (usually dark colored and of low grade and used principally by the lithopone manufacturers) for the fiscal year ending June, 1911, amounted to 18,395 tons valued at $2.46 per ton or $3.96 per ton inclusive of duty. The following regarding costs of imported crude barytes was obtained from the report of the U. S. Consul General at Hamburg made a few years ago:

"The principal European exporting points are Rotterdam, Antwerp and Hamburg. The prices at European seaboard for crude varied from $5.47 to $5.71 per short ton. The ocean freight from seaboard to New York runs from $1.70 to $2.19. The German rate from mine to seaboard, shipments being made in large barges is from $1.19 to $1.42 per ton. This made the price at the time $4.05 to $4.52 per ton. The German firms have formed a pooling agreement and have advanced these prices from 50 to 75 cents per ton, making the cost f. o. b. New York City, $7.67 to $8.65 per ton. According to the figures given by the "Mineral Industry" for 1908, the prices paid for imported barytes in New York vary only from $4.74 to $6.50 per ton, the average being $5.83, inclusive of $1 for ocean freight. It is difficult to correlate these figures but it is probable that the last are the nearest correct."

Imports of barium compounds for the fiscal year ending June, 1911, were as follows: Binoxide 245 tons

valued at $141.80 per ton or $177.25 inclusive of duty; chloride 1371 tons valued at $21.71 per ton or $27.14 inclusive of duty; sulphate (blanc fixe) 3,166 tons valued at $23.14 per ton or $33.14 inclusive of duty; and lithopone (no statistics available) estimated at 8,000 to 10,000 tons. Imports of strontia amounted to only $44 in value. The import statistics were obtained from the Federal Bureau of Statistics.

CHAPTER VI.

PROSPECTING AND MINING METHODS.

LOCATING VEINS AND FAULTS.

The selection of localities in which to prospect will depend upon three prime considerations: 1. Areal distribution of groups of minerals, selecting that portion of the district that contains the desired associated minerals. For a discussion of this subject reference should be made to Chapter II. For example, if barytes alone, is chiefly sought, prospecting would be pursued either in the Georgetown-Lexington or Danville area. 2. In local areas preference should be given (a) points along or closely paralleling important fault zones, (b) areas lying within a ten mile radius of the intersection of important fault zones, especially that confined and lying between such zones, and (c) secondary normal and shift faults since these are more likely to contain good deposits than the major faults. 3. Suitable wall rock at a reasonable depth (See Chapter I under Stratigraphy).

Float lumps of barytes, remnants of the eroded portions of the veins, occur usually immediately above the veins (rarely any distance from them, owing to the weight of the barytes) and aside from the exposure of a vein itself, are the surest guide to vein location.

The important criteria for the location of veins and faults in Central Kentucky, are the following:

1. The presence of unlike rocks such as a sandstone and a limestone or of a coarsely crystalline and a compact limestone, or of heavy bedded and shaly limestone in juxtaposition.

2. Presence of rocks of like texture but of unlike age as of Lexington and Greendale limestone in juxtaposition, both crystalline limestone but distinguishable by different sets of characteristic fossils.

3. The presence of shearage evidences such as sheeting (fracture of the rock into narrow vertical sheets), brecciation (the fracture of the rocks into angular fragments), and jointing (fracture of the rocks into fair sized blocks). These are all common to both types of faults and the openings formed are commonly mineralized with calcite, etc. These evidences are to be seen in the gorges of streams, in quarries, etc. Slickensiding (smooth grooving of the wallrock caused by friction or one part moving past another) is common to both types of faults, but when occurring lengthwise of the course of the vein is characteristic of the shift faults, and when inclined or vertical it indicates the normal faults.

4. Differential strata dips are especially common along the fault zones and in the case of normal faulting. The strata on one side of the fault may be horizontal or slightly inclined while that on the opposite side is more steeply inclined. The presence of such inclined beds nearly always indicates that a fault exists between them, though it may not always prove mineralized. Care must be taken not to mistake boulders or small inclined erosion masses in inclined positions for the dislocation of unweathered strata.

5. The presence of sinkholes, depressions, ponds, springs, etc., due to the dissolution and disintegration of fractured strata, where following some regular strike, are especially indicative of veins. Most of the ponds represent sinkholes fed with springs from the fissures, and the spring water while at times is fresh, at other times it is sulphur water as at Drennon Springs.

6. Upon the disintegration of the limestones, clay and chert remain, and as sometimes, the chert deposits of one limestone are more abundant than those of another, as for example those of Flanagan, it may be possible to locate a fault by the presence of abundant chert in clay on one side and its virtual absence on the opposite side.

7. The growing of blue grass on the soils of the more richly phosphatic limestones such as the Bigby and Greendale beds as against its more stinted growth on soils of most of the other beds, may suggest a change of formation, and hence in some instances may lead to the location of a fault.

Where no surface indications occur but there is good reason for prospecting as along the line of extension of a vein, resort may be had to the churn drill for the penetration of the thin surface clay and soil, rarely 10 to 15 feet thick, common on the hillsides, in search of float. Once the latter is located its extent can best be determined by means of a crosscut, 3 feet wide by 6 feet long. It will rarely prove wise to do initiative prospecting of this sort in vallies as the surface mantle may there reach a thickness of 40 feet. After a vein has been located, sinking and drifting may be necessary to prove its value.

Core drilling was done in prospecting the Marsh vein, but with vertical or slightly inclined veins of narrow width this is rarely successful and then only with intelligent direction, so that it is not advised. The core drill is of advantage in the location of parallel veins in crosscutting a deep shaft.

Post-development work is too often neglected. After mineral shoots are found they are commonly worked to exhaustion without any attempt to drive through pinches. The search for swells should be diligently prosecuted and drifting and sinking are the best means.

MINING METHODS.

The practice thus far has been largely to opencut the veins for the surface barytes, very few shafts being sunk or adits driven.

The opencuts are started wherever float barytes appears at the surface and when the deposit is encountered, it is followed in either direction, the cut being made to conform with its width as far as practical. These cuts may be started with a single man. Most cuts are shallow, usually less than 15 feet and rarely exceeding 40 feet.

A method successfully employed to break the barytes without pulverizing it as would be the case if shot on the solid was as follows:

Vertical holes 4 to 5 feet deep were drilled in the clay seam between the barytes and limestone wall, 5 or 6 feet back from the breast either in one or both sides of the vein and each hole is loaded with from 1 to 2 sticks of dynamite. This method has the further advantage of freeing the wall of clay bands which otherwise might endanger the workman.

Only in one or two instances have the cuts been timbered, and then inadequately, the timbers being too small and improperly placed. The surface earth is removed either by pick and shovel or by means of wheel scrapers. A portable wooden shelter is sometimes used to permit work in adverse weather. Blasting is usually unnecessary where the barytes is scattered as lumps through clay, and is chiefly used where it has become solid as between walls.

The latter are often treacherous due to sheeting of the wall rock parallel or at an acute angle to the course of the vein. The frequent testing of such walls by the foreman and miners will avert costly accidents and loss of life. It will be cheaper to remove all loose portions of rock, batter the sides of the cut, and where necessary timber the same, rather than risk accidents. Iron and wooden tracks with cars are used in some cuts, while in others a wheelbarrow is used, or the mineral where the cut is shallow, is shoveled directly on the bank.

Opencutting, while in many respects an unsatisfactory method is advised as a means of obtaining a large amount of the barytes at a small cost, which is to some extent relieved of its impurities. Both owing to the high value of the surface in Central Kentucky, and also since deeper mining is facilitated where surface waters are not permitted to enter the mine, it will prove the best practice to refill surface cuts immediately after the barytes has been removed from them. A saving in this connection can be made where it is intended to stope immediately beneath the opencut if heavy timbers and lagging are laid on the bottom of the cut, resting on the limestone walls if possible, prior to filling the cut, and preventing thereby the caving of such filling when the stoping is done.

Only a few shafts have been sunk and these chiefly for prospecting, and to depths varying from 50 to 400 feet. The shafts have usually been much larger than necessary, 8 by 8 and even 7 by 20 feet. For prospecting, a shaft with excavations measuring 5 by 7 feet (4 by 6 feet inside of timbering) will answer all purposes, and will also answer where an air shaft is desired. For a working shaft, either vertical or inclined, for tonnages up to 60 tons per ten hours, a shaft measuring maximum 6 by 9 feet (5 by 8 inside timbering) will answer every requirement to a depth of several hundred feet. With increase in operations shafting must be practiced and finally will entirely replace opencut methods.

Aditing (commonly called tunneling) has been practiced to some extent along the high Kentucky river cliffs which expose the veins for a vertical height of 300 to 500 feet. The adits are usually driven the width of the vein or only sufficiently wider to permit practical working, and 5 to 6 feet high. Where practical, this is an economical means of exploiting the veins.

With the sinking of shafts for the exploitation of veins in depth, drifting and stoping are necessary. The placing of drifts at vertical intervals of less than 60 feet is ill-advised. For stoping, the overhand method will prove preferable and least expensive. In this method, winzes (small shafts) are sunk or raised between drifts or levels, at intervals of 50 or 100 feet following the course of the vein. Since most of the veins are practically vertical, the horizontal "flat-back" stoping method is preferable; in this, the ore is broken in slices parallel with the floor of the drift, and the holes for breaking the mineral are driven partly horizontal, partly inclined upward. The use of the hammer air drill is an especially economical method of stoping for veins of this width.

Practically no attention has yet been given to ventilation since few of the underground workings are sufficiently extensive to have shown need therefor. The use of air shafts in connection with the adits, drifts, and main shafts will prove the simplest means of ventilating. As workings become more extensive compressed air will prove an aid, and the use of a small furnace or fan may prove advisable.

Either oil lamps, candles or even kerosene lanterns have been used for lighting. Acetyline miner's lamps have not been tried, but would doubtless be better and more economical.

Hoisting from opencuts may be accomplished by hoisting derricks such as are commonly employed at quarries for removal of refuse, and are here usually horse driven. For shallow cuts and shafts a windlass is sometimes employed. Horse whims could be used to advantage to a depth of 125 feet. For deeper shafts, a geared steam or gasoline hoist of 8 to 12 horse-power will prove preferable.

For sinking shafts, driving levels, and stoping, a of shovels, picks, hand drills, striking hammers, wheel barrows, hand windlass, and wheel scrapers, with possibly a hoisting derrick will answer; such an equipment will cost about $550.

For sinking shafts, driving levels, and stopping, a mine plant consisting of small air compressor, hammer air drills, steam hoist, boiler, etc., is required; this will cover requirements for an output of 50 tons per 10-hour day, and will cost $5,000. The use of a small compressor and air hammer drills is strongly advised for drifting, stoping, underground cross-cutting, and adit driving.

ROYALTIES AND LEASES. The royalties vary greatly, the royalty on barytes per long ton (2240 lbs.) running from 50c to $1.25 per ton. In some instances it is one-tenth to one-twelfth of the gross value, crude mineral, f. o. b. cars, and in still others it is this plus 50c. In still other instances, haul and royalty are combined, the charge being $1.50 per ton or a net royalty of 90 cents to $1.10 per ton. The royalty invariably increases with decrease in length of wagon haul. It will average $1.00 which is high compared with the royalty of other districts.

The reason for the high royalty is of course to be found in the high value of land for farming purposes

in the blue grass region, where the land is worth from $100 to $200 per acre, and unlike in many regions, the chances for the best mineral appears to be on the best farming lands (those having the Lexington limestone, especially the upper beds, as the surface rock.) Operators can hardly afford to pay in excess of 75 cents per ton royalty, and this would be reasonable to the land owner providing proper restrictions are placed in the leases, such as requiring the immediate refillment of opencuts; furthermore with increase in shaft sinking, less surface area will be required and the lower royalty will be justified on the land owner's part.

No extra charge should be made for zinc blende where it does not exceed 5 per cent nor for galena under 3 per cent. Where either of these minerals exceed the percentages given and concentration is practical there should be charged per each 2,000 lbs. of concentrate a royalty of not exceeding $3.75 per ton for blende and $4.50 for galena. Calcite where in veins of sufficient size to mine and over 95 per cent pure is worth a royalty of 50 cents per ton, and fluorspar the same amount. For the mixture of fluorspar, barytes, and calcite where neither the fluorspar occurs to the extent of 80 per cent nor barytes to the extent of 60 per cent, a royalty of 25 cents per ton for that sold will be ample.

The leases specify as high as 2,000 tons per year as minimum tonnage to be mined, but usually not less than 1,000 tons, if any specification is made. In other instances they require a money rental of 10 to 20 cents per acre per year. Timber rights are seldom given because practically no timber is to be had. Usually one to three months is allowed for prospecting, but this should be extended to six months or even a year, as that time is necessary to properly develop a property for mining, or determine its value.

HAULING AND TRANSPORTATION. Since most of the roads are macadamized, they are good for hauling. Teams with driver may be had for $3.00 to $3.50 per day, and two mules are able to haul 2 to 2½ tons per load. The cost of hauling per ton mile varies from 15 to 20 cents and averages 18 cents; thus a five mile haul costs 75 cents to $1.00 depending upon the locality. Wide tired wagons should be used for this hauling.

The district has both good rail and river transportation. It has the Kentucky river which is well locked and dammed and navigable throughout the year Among its railroads are the Chesapeake and Ohio, Frankfort and Cincinnati, Lexington and Eastern, Louisville and Nashville (Lexington-Paris branch, Paris-Maysville branch, Richmond and Rowland branch, Lexington branch and Knoxville division) and Southern Railway (main line, Burgin branch, Georgetown branch, and Lexington branch). The Blue Grass Traction Company's trolley lines from Lexington to Paris, Georgetown, Versailles, Frankfort, and Nicholasville should prove especially helpful in the development of the deposits and electric lines may be extended from these where necessary to connect local barytes areas with them.

COST DATA. The cost of labor runs from $1.25 to $2.50 per 10 hours, the highest wages $1.75 to $2.50 being paid drillers, engineers and foremen.

The cost of core drilling, 14 holes running 30 to 235 feet deep in Lexington limestone was from 29 cents to $1.00, the average cost being 65 cents per foot.

No figures on sinking costs in Central Kentucky are available, but judging from Western Kentucky practice under similar conditions, the cost exclusive of timbering for a shaft 4 by 6 feet in the clear should not exceed $6 to $8 per foot, and for a 5 by 8 shaft, $7 to $10 per foot for the first 200 feet and increasing somewhat with greater depth.

Drifting or aditing, using air hammer drills, should not cost exceeding $3 to $4 per foot in spar or rock, and by hand $4 to $8 per foot. The cost in soft ground would be about half.

The cost of mining as reported runs from $0.75 to $1.85 per ton, but with proper methods, the costs given below should not be exceeded. The cost of opencutting barytes, 25 tons per ten hours, per ton would be as follows: Drilling, blasting, picking, .30, shoveling and tramming .15, explosives .05, timbering .10, hoisting and foreman, .15, making a total cost of $0.75. Where mining is done, additional costs would be the following: timbering .11, lighting .05, explosives and smithing .09, thus making the total cost $1.00. With a 50 ton basis the cost for foreman, hoisting, and smithing would be reduced .08 making the cost $0.92 per ton. The tonnage produced should average not less than 1½ tons per 10 hours per man employed.

The general cost of crude barytes f. o. b. mine shipping point should average not to exceed the following: Mining $0.90, royalty and hauling $2.00, loading cars $0.15 and capital charges $0.30, making a total of $3.35 per ton. With opencutting the mining cost is less, with proximity to shipping point the haul cost becomes less, and a large output at a number of mines by one company would tend to reduce management and capital charges.

CHAPTER VII.

MILLING METHODS.

The steps in the preliminary treatment vary according to the character of the ore, their usual sequence being as follows: Preliminary picking before placing on dump, screening, hand cobbing, grading, washing, crushing, and concentration. Much of the crude mineral undergoes only the first three processes, and sometimes also the next two. For ground barytes, the additional steps necessary are drying, bleaching, grinding, and sizing.

The minerals associated with barytes in the Kentucky ore are calcite, limestone, fluorspar, galena, zinc blende. celestite, limonite (iron oxide) either massive, in scales, as thin stains or mixed with clay, hydrocarbon stains and some manganese dioxide. Quartz and strontianite as encrustations are associated to a lesser extent. The calcite, fluorspar, galena and zinc blende occur intergrown in all combinations. The celestite appears intimately blended with the barytes. The limestone is usually in the form of angular fragments which are cemented together by the minerals. The limestone, calcite, and zinc blende frequently are partly decomposed or else entirely leached.

During mining, it is often possible to separate much of the undesirable associated mineral, especially where it occurs in separate bands as is here frequently the case. Limestone, limestone-calcite, or calcite-fluorspar, may thus be separated with a little care in picking down, and filling cars.

After reaching the surface, the barytes is usually screened through an inch mesh screen. The lump thus separated is ready for hand cobbing, the screenings for washing. The cobbing may be done by use of a small hatchet, hack hammer, or pneumatic pick. By this means the larger masses impregnated with zinc blende and galena can be put on a separate dump and most of the heavy red clay and iron stain may be removed, and much otherwise impure, raised to the best grade.

Barytes may be classed into three grades:

1. The pure, white variety constitutes the best grade. This should be practically free from calcium carbonate, silica, free iron oxide, or free manganese oxide; its purity in these particulars being determined by chemical analysis. Further, this grade, when finely pulverized and thoroughly incorporated with refined linseed oil or turpentine, remains perfectly white. This grade is only to be had by careful hand picking and thorough bleaching. The whiteness is sometimes heightened by the addition of a small percentage of indigo or ultra-marine, but this is objectionable. This grade runs 98 to 99 per cent pure.

2. The second grade may contain as much as 20 per cent of such impurities as calcite, limestone, fluorspar, etc. This grade is also bleached and will show different tints when rubbed with oil depending on the character and color of the impurities, for example, a yellowish cast if the product contains much of lime compounds or zinc, a grayish cast where lead is present, a reddish cast if still containing iron oxides, etc. With such distinctions as a basis, sub-grades are sometimes produced. More oil is required to form a paste with this grade than with the first, owing to the more porous character of some of the impurities after the chemical treatment necessary for bleaching.

3. The third grade is off-color, usually deeply reddish from iron oxides, the percentage of these and other impurities being too considerable to permit of bleaching. This grade contains as high as 40 per cent or more of fluorspar, calcite, limestone, etc.

If the product contains more than 20 per cent fluorspar it cannot be classed as barytes, while fluorspar containing 15 per cent barytes is valueless for fluorspar. In the concluding section of this chapter under the heading of proposed treatment for Central Kentucky ore, the use of intimate mixtures of fluorspar, calcite and barytes where not admissible to the third grade, is discussed.

At the mills, the barytes after weighing on platform scales is stored on an open or covered receiving platform or more rarely there is a regular ore-house. On this platform the hand-picking is frequently done. The unloading of the mineral directly to an elevator boot, the breaking by sledge hammer of large lumps, its elevation by belt elevator to a self-feed (bottom inclined 45°) storage bin, and its release as required onto a picking belt would greatly improve the present method and avoid much unnecessary labor. The conveyor belt would transfer it directly to the first washer from which it could be delivered directly to the crusher. Some mills use an automatic ore feeder, but where connected with the washer this is unnecessary.

The gravel or screenings should be given a preliminary washing. Much of this material has heretofore accumulated as waste dumps which contain upwards of 60 per cent barytes and a considerable quantity of such material could be recovered. Preliminary washers for gravel or lump are usually in the form of logs with blades attached for stirring and moving the product toward the upper or finish end. Sometimes ordinary screw conveyors have been used. The washers are from 16 to 30 feet long and have 8 or 10 inch blades. For washing at the mines, where steam is not already at hand, a gasolene engine of 1½ or 2 horse-power will prove economical for the running of a single, double or tandem washer. The best practice would be the use of a 16-foot washer set tandem with a 12-foot washer. In the mills the position of the washer varies from preceding the crusher to between the crusher and the rolls, the latter being the usual practice since the crushed product permits of better separation from the clay and iron stains. The objection to this method is that the clay often clogs the crusher. Therefore, it would be better practice to first wash with the 16-foot washer, crush and rewash with the 12-foot washer. A saving of 25 per cent or more in cost is possible where the washing is done at the mine as both hauling and freight costs are greatly reduced. Therefore, if water is to be had at or near the mine, the installation of a small washing plant will prove a profitable investment.

The preliminary crushing is usually done wet by means of a Blake type jaw crusher, the sizes varying from 6 by 14 to 12 by 20 inches. In one instance a roll jaw crusher and in another a gyratory crusher are used. Owing to the small capacity demanded and the softness of the product jaw breakers will usually answer all requirements. These crush the product to 3-4-inch in all the mills but one, where it is crushed to one inch. A set of rolls usually 15 by 18 inches reduces the product to 3-8-inch. Such rolls are necessary and a second set would prove helpful in order to still further reduce the product for the pulverizer, for use with most of the fine grinders. The two sets of rolls may be replaced by a hammer pulverizer.

Jigging is often advantageous. Jigs have been employed in five of the mills and are of the Harz or New Century patterns, having either four or five cells. They are used to separate flint, calcite, gypsum, galena, fluorspar and iron-crusts from barytes. The screens used on the cells are from 6 to 20 mesh, and the cells are allowed to bed themselves. Both because of the softness and high density of the barytes much is found in the hutch. No advantage is gained in using a jig of more than four cells. This allows the first cell for galena, the second for middlings (zinc blende, barytes, fluorspar), the third for barytes, and the last for tailings (chiefly calcite, limestone, silica, etc.) In the absence of galena and zinc blende, and where much iron-crust is present instead, the first cell will carry barytes, the second barytes and iron, the third barytes, iron and fluorspar, and the last fluorspar, calcite and flint. In Central Kentucky barytes, the important use for the jig is in the removal of galena, calcite and limestone. Since much of the ore between the walls will carry angular limestone fragments, an efficient jigging system will become a necessity in the successful exploitation of such deposits. Special processes discussed below must usually be employed for the separa-

tion of other minerals. Mr. Schuyler Frazer states that in a plant constructed by him, the jigs washed the barytes and removed three-fourths of the iron and silica. The size of product fed the jigs will vary according to the character and extent of the intergrowth of grains and the tenacity with which they cling to each other, commonly called chatting. For a product containing galena, etc., crushing to at least 1-8-inch is necessary; in other instances coarser crushing may prove practical.

Concentrating tables have been used only in Central Kentucky for the separation of galena and zinc blende from barytes. Woodbury and Wilfley tables have been employed but proved unsatisfactory since it is impossible to separate zinc blende from the other minerals successfully by this process. The use of tables will prove an advantage where it is necessary to crush the barytes as fine as to three millimeters in order to separate galena from it.

The separation of barytes and zinc blende by ordinary process is impossible owing to the small difference in specific gravity, that of barytes being 4.2 to 4.5, and of zinc blende 4.05. There are available at present five methods of separation: 1. magnetic; 2. electrostatic; 3. flotation: 4. decrepitation, and 5. leaching. These are of practical application in certain cases only, the best methods in any particular instance requiring determination by actual comparative tests.

Magnetic separation is applicable in instances where the zinc blende contains a sufficient percentage of iron disulphide to be attracted by an electromagnet either before or after roasting (roasting is usually necessary to heighten the magnetic susceptibility). For this purpose magnetic separators of the Wetherill type may be used. This process cannot be applied to Kentucky ores.

Separation by an electrostatic machine such as the Huff separator is possible where there is a sufficient difference in the conductivity of barytes and zinc blende, both of which are non-conductors, but the conductivity of which varies with different ores. The conductivity of the zinc blende may be heightened in any instance by giving a bath of copper sulphate to the pulverized ore thus forming a coating of copper sulphate on the zinc mineral;

after drying the separation is easily effected.* It is claimed that the separator can handle material ranging in size from 1-5 inch to below 200 mesh. If this is substantiated, this should prove a most efficient method of separating the Kentucky barytes and zinc blende. Or separation might be effected by a dielectric process such as the Sutton-Steele (see Bull. 9, this Survey, p. 47.

The decrepitation process will probably prove applicable in many instances. Most, but not all, varieties of the mineral when heated have the property of flying to pieces termed decrepitation, an exception being for example where the barytes is amorphous. Zinc blende also possesses this property, but at a higher temperature than barytes. By heating the crushed mineral on a plate to between 200° and 300° C. the Barytes becomes an impalpable powder and the zinc blende not being affected may be separated by screening.

It is probable that most of the Kentucky barytes will be amenable to this process, although no practical tests have yet been made. The soft barytes (weathered) is likely to be least susceptible and the hard crystalline most so.

Leaching processes may prove practical under certain conditions. They depend on the solubility of zinc blende in acids, while barytes remains inert. Such processes use either sulphuric or hydrochoric acid to change the blende to soluble zinc sulphate or chloride. Either of these solutions may be changed to zinc oxide upon the addition of caustic alkali or may be used in the preparation of lithopone. Waring's process for the making of a pigment of zinc oxide and barium sulphate, described in the next chapter, is an example.

For the separation of iron oxide crusts or pyrite, the roasting of the ore and its subjection to magnetic separation is most efficient.

In order to produce the best bleached barytes it is necessary to consider the following factors: I. Character of original ore: a. Presence of hydrate or anhydrous iron oxides and whether these occur as film-like stain or heavy crust. The hematitic stains will require a larger percentage of sulphuric acid for removal. The method of dealing with iron crusts has been given. b. Clay content. Washing will free the product largely of this, but not of all. c. Manganese content. (Bleaching method given below.) d. Hydrocarbons; these prove a serious detriment; the best means of handling these can be determined only by further tests. e. Extent of leaching. Minute cavities due to leaching give appearance of black specks when examined microscopically. Leaching of strontium sulphate whitens mineral in lump, but powdered, it shows little difference from the powdered hard crystalline. f. Extent of associated minerals. Care in hand sorting and in separating by methods previously discussed is urgent, especially removal of limestone, galena, etc. 2. Fineness when pulverized: Care must be taken to reduce product sufficiently fine to permit thorough access of bleaching solution. 3. Removal of acid used in bleaching. While a slight acid content yields a whiter dry product, after drying in oil the product is likely to prove darker. 4. Staining from dryer-shell rust. This is usually avoided by leaving a thin coat of barytes attached to dryer; an alternative would be the use of an enamel-surfaced dryer. 5. Use of unweathered ores. The use of these ores, found between solid wall rocks, while more expensive to mine, would doubtlessly yield a product requiring a minimum of bleaching. 6. Mixture of milk white and colorless ores. This would prove very helpful, since while the colorless barytes is pure sulphate, the mixture of milk white barytes which would show through the limpid particles would heighten the color of the whole.

To free barytes from ironstain, bleaching with sulphuric acid or an alkaline sulphate is necessary. The size to which it is crushed for bleaching, when not regulated by previous separation processes, depends on the intimateness of the staining. The majority of the mills crush to 3-8 inch, in one instance to 1 inch, while another class pulverize prior to bleaching. The last makes the

*F. S. MacGregor, Huff Electrostatic plant, Engineering and Mining Journal, Vol. 92, p. 1081.
Henry A. Wentworth, Electrostatic separation of minerals in ores, Eng. & Min. Journal, vol. 90, p. 15.

cleanest product, but requires greater cost of installation and treatment.

The product is usually digested with commercial sulphuric acid (66 per cent pure). The amount varies with the iron content and extent of other impurities present that react with the acid. The amount of acid required increases with the per cent of such impurities and the bleaching becomes proportionately less effective also. Iron oxides combine with the acid to form iron sulphate which goes into solution; limestone and calcite change to calcium sulphate, and flourspar forms hydrofluoric acid gas and calcium sulphate. Pratt states that 66.67 lb. of acid, 78 per cent pure (equivalent to 74.3 lb. of 66 per cent acid) is required for each one per cent of iron oxide, which is undoubtedly too much. Steel reports 40 lb. of 66 per cent acid per one per cent of iron used on Tennessee barytes. In Virginia, according to Judd, 18 to 25 lb. of new acid is used per ton after a preliminary bath in previously used acid. At another Virginia plant, 20 lb. of new acid is used per ton for the preliminary bath and 14 to 16 lb. for the finishing bath. In Kentucky, 50 to 60 lb. is required per ton, while Macklind used 120 lb. per ton on Missouri barytes. The smaller the particles to be bleached, usually the greater amount of acid required.

The character and size of the bleaching tanks, the size of charge and time required, vary greatly. The majority of the tanks are round, of wood, and lined with lead. An attempt was made at Mineral Point, Missouri, to substitute special imported earthen tile for the soft sheet lead, since the former would wear better and longer; it must have proven unsatisfactory, for these tanks were later replaced by round concrete lead-lined tanks, set in the ground. The size of the tank per ton of capacity increases, but the size of the charge, and hence of the tank also, decreases with the fineness of the product to be treated. The tanks have capacities ranging from 2 to 25 tons. The number of hours necessary for bleaching varies with the character of the ore and amount of acid used, and is from 12 to 24 hours.

The following notes by Edwin Higgins* describes a typical wooden tank and details of the process where the product treated is coarse:

"The crushed mineral is bleached in circular wooden tanks, lined with sheet lead. Each tank is provided with a 2-inch lead pipe, coiled in the bottom, closed at the end and provided with small perforations, 7 inches apart. Steam escaping from the perforations agitates and heats the bleaching solution. This is sulphuric acid diluted to about 20° to 30° Be. The mineral is charged into tanks to a depth of about three feet, after which the acid solution is run in and steam turned on. The time required to bleach the mineral varies from 6 to 80 hours, depending on the iron content. It is the usual practice to leave the steam on continuously, although good results may be obtained by cutting it off for half an hour at intervals of one hour.

"A tank 4.5 feet high and 8 feet in diameter is a convenient size for bleaching, containing when charged to a depth of 3.5 feet approximately 14 tons. It should be made of stout, well-seasoned wood, preferably cypress, should be well braced on the outside and lined on the inside with heavy sheet lead. Connections should be provided so that either stream or water may be supplied through the perforations in the lead pipes. These perforations are best located at an angle of 45° with the vertical rather than directly on top, in order to prevent clogging of the pipes with fines.

"One of the greatest items of expense in the process is the steam for heating and agitating the bath. This may be greatly reduced by use of an ordinary injector, using a mixture of air and steam instead of steam alone. The amount of air can be easily regulated, so that the acid will not be too much cooled. The temperature may be kept at 200°, better agitation will result, the acid will suffer less dilution from condensing steam, and the steam consumption will be reduced one-half."

Where the product is finely pulverized, the bleaching process does not differ materially.

*Mineral Industry, Vol. XIII, 1905, p. 34.

Where fluorspar occurs mixed with the barytes which is to be bleached, care must be taken by workmen not to inhale the poisonous hydrofluoric acid fumes evolved upon the reaction of fluorspar and sulphuric acid. The resultant mixture of barytes and calcium sulphate must be boiled in fresh water until litmus paper shows no acid reaction.

The use of oxalic acid and salt or of salt alone in connection with sulphuric acid has been tried for bleaching, but it is believed that the extra cost involved is unwarranted considering the results obtained. The use of a larger percentage of sulphuric acid would probably produce better results than the mixture here suggested.

It is necessary to wash from the barytes the acid left from the bleaching process. In case the barytes is bleached coarse, the washing is done in the bleaching tanks, fresh water being used, and sometimes following this by further washing in a slightly inclined lead-lined screw-conveyor from 6 to 12 feet long.

The usual method employed in freeing barytes of sulphuric acid when the bleaching is done after the barytes has been finely pulverized is to place the barytes in a tank and permit a stream of water to flow slowly through it, sufficiently slow to prevent the agitation of the barytes to the extent that it might overflow with the wash water. The disadvantages of this process lay in the uneven washing effected, some of the barytes being overwashed, especially that at the bottom of the tank so that its high color is lost, and it takes considerable time (about 12 hours) to effect the washing.

Drying is necessary to prepare the barytes for the dry pulverizing machines. When bleached coarse, the one drying suffices, but when bleached after pulverization, redrying is requisite. Several different types of driers can be used. To avoid discoloration in drying barytes, it is essential that the coal gases do not come in contact with the mineral (that is pass through the drying chamber) and that the acid be completely removed (to prevent reaction with the drier lining).

Either a double shell drier or a steam-heated sheet drier may be used advantageously in drying coarsely crushed barytes. For pulverized barytes, a drier either of the Macklind type or a steam sheet drier will prove serviceable. Either of last two types may under certain conditions utilize exhaust steam, care being taken however, to prevent back pressure from reducing efficiency of the engine. A small exhaust fan for the removal of moisture and creating a draft would be helpful, directly applicable in the double drier and with provision of a proper hood, with the other types also.

Barytes requires grinding to the finest state practical. It must all pass a 200 mesh sieve. No particle should exceed a length of .003 inch. For pulverizing to obtain this fineness a number of types of machines have been employed, and either screening or the use of air or water flotation in connection is necessary.

The best practice consists in reducing 80 to 95 per cent at one grinding to the required fineness and separating the oversize to be repulverized.

The size of the feed varies from 100 mesh to 3 inches maximum, usually between 1-8 and 1 1-2 inches. Upon this depends the amount of preliminary crushing intermediate between the primary crusher and the pulverizer. The less the number of machines used for the preliminary crushing, the less the amount of wear and power cost usually with appropriate increase of such cost for the pulverizer, so that great care is required in adapting the one to the other in order to obtain the lowest average cost. Many of the machines take a product 1 1-2 to 3 inches and can therefore handle directly the product of the preliminary crusher. Secondary crushing to produce feeds between 3-8 and 7-8 inch requires a maximum of 6 to 8 horsepower per ton.

The separation of the coarse product or oversize produced by the mills from the 200 mesh and finer product, may be accomplished either by water flotation, air flotation, or bolting.

Water flotation has been practiced chiefly in Missouri mills. The barytes is levigated with water in the grinding process as in the Macklind slip mill, then settled in a series of spitzkasten (4 by 4 feet) from which, according to Steel, the oversize is drawn through spigots at the bottom of each box and returned to the slip mills, while the fine barytes overflows opposite the entering stream into settling tanks 7 by 9 feet in size. The clear water is siphoned from these tanks and returned to the slip mills. The thick cream-colored barytes mud containing 25 per cent water is withdrawn through 4-inch plug valves and a rubber hose to one of the bleaching tanks. In this instance there is practically no loss of fines, since the water goes back in the slip mills. No figures were to be had upon the cost of this treatment but it is probably high. A series of 12 iron spitzkasten and 8 settling tanks are required to handle 20 tons of barytes per ten hours. This process yields a product containing particles having a maximum size of .00479 inch. Water flotation is unsatisfactory in connection with cast iron or steel mills.

A satisfactory air flotation is produced by means of the Raymond cyclone separator. This makes a product all passing 200 mesh and the average size maximum particles measured were .00479. This requires about 17.5 horsepower per ton on the basis of a 20 ton output, and higher power for lower tonnages. The Osborne separator it is claimed will accomplish the same results operated by a motor supplying 2 horsepower per ton, but so far as known no tests have been made with barytes. Air flotation is probably the most efficient means of separating oversize from a 200 mesh product.

Bolting with silk cloth on bolting machines has been practiced at some of the mills to separate the fine product produced by the burr mills. Such bolting is unsatisfactory owing both to the high cost and short life of bolting cloth.

Decrepitation may be used in the pulverization of barytes as an aid in obtaining a very finely pulverized product. Heretofore it has not been used for this specific purpose.

For repulverizing the dried barytes following its bleaching in the pulverized state, a hammer pulverizer or a cage disintegrator may be used.

Barytes is packed either in bags or in barrels, chiefly in the former. The cost per ton for barrels is $1.25 and they have the disadvantage of not being returnable. The cost of sacks is about $1.60 per ton with good sacks returnable, the loss being about one-third. Weighing is

usually done on a small truck—or stationary scale; an automatic scale would save time in rehandling the sacks. A belt conveyor for removing the filled sacks would also prove economical.

Accessory apparatus used in the mills, such as screens, storage bins, elevators, settling tanks, tempering and washing tanks, classifiers, spitzkasten, automatic packing machines, pumps, etc., it is unnecessary to treat in detail here.

The cost of mill labor per ten hours varies as follows: Millers $2.00 to $3.33; engineers $1.50 to $2.08; carpenter $2.00; bleachers $1.50 to $1.75; fireman $1.50; stone dressers 1.50; jig-men $1.30 to $1.50; bleacher's helpers $1.25; packers $1, $1.25 to $1.50; pickers, rockmen, common laborers and yardmen, $0.75 to $1.25.

The cost per ton of grinding, bleaching and marketing barytes, estimated on a basis of 20 tons per ten hours is as follows: Crude barytes $4.50; (15 men) $1.00; acid $1.12; coal $0.71; insurance, oil, repairs, etc., $0.50; office expense $0.75; loss on sacking $0.50; freight $3.25; commission $0.83; cash discount $0.33; total $13.49. With an average sale price of $16.50, the profit would be $3.01 per ton. The profit on unbleached barytes is slightly less, and the cost of production is proportionately less as compared with its sale price.

The cost of a well equipped grinding and bleaching plant to produce 20 tons barytes per ten hours is estimated roughly to be between $35,000 and $45,000, this to include separating machinery for separating the limestone. calcite, galena, zinc blende and barytes.

KENTUCKY PLANTS.

The Kissinger plant of the Mutual Mining Co. consists of three divisions: Concentrating mills, lead fume works, and blanc fixe-sodium sulphide works. Only the last is being operated actively. The concentrating mill separates galena from barytes and a fair galena concentrate is made. The mill consists of Gates crusher, two jigs, a Huntington mill, and four Woodbury tables, and it is claimed has a capacity of 40 tons per day. A small smelter was originally installed to convert the lead concentrate into pig lead and litharge, but this has been dismantled and a small hearth and baghouse erected for the preparation of about 2 tons per day of lead fume or lead sulphate. The blanc fixe-sodium sulphide works produced blanc fixe by a combined metallurgical and chemical process whereby sodium sulphide is obtained as a by-product, the output being about ten tons of blanc fixe per day.

The Ohio Lead Mining Co. installed a mill for the concentration of their barytes-calcite-zinc blende-galena product at the Gratz mine. The plant consists of a Huntington mill, two Cooley jigs, and five Woodbury tables. The barytes produced contains practically all the zinc blende, a plant of this character being unsuited to such ore.

The Clinch Valley Barytes Co. shipped their barytes to a plant at Honaker, Virginia where it was crushed, washed, jigged, bleached, dried and ground to pass 200 mesh. This company has ceased to operate.

The ore of the Union Mining Co. was treated at the mill of the Madison Lead Co. at Madison, Ind. This mill was formerly at Paducah, Ky. and as the separation was effected by the use of Krom air jigs, the separation cost was excessive.

The Lead Mining Corporation of America had a milling plant at the Hoosier mine, a great many years ago for the separation of galena and barytes.

The plant of the Central Pigment Co. is located at Nicholasville, Jessamine County. As at present constituted it is used to prepare off-color and best bleached barytes, the general process employed at this plant, being as follows. Barytes is unloaded from the cars to the receiving shed, shoveled on small cars, crushed, washed by log washer, dried by rotary drier, ground and air floated in a Raymond mill, partly stored in storeroom for bleaching or sent direct to burr mills if to produce off-color ground, or if for bleaching, advanced from store-room to three bleaching tanks, washed, dried by rotary drier, and packed in sacks for shipment. Power is supplied by three 125 horsepower boilers and one 300 horsepower engine. The use of the burr mills here is superfluous. Their use has been recently discontinued.

NEEDS OF THE INDUSTRY. The barytes industry of Kentucky needs capital to be invested for development work and for the erection of at least three plants, each equipped for the separation of the minerals, grinding and bleaching barytes, and the manufacture of barium products; the central plant should also be adapted for the separation of lead-zinc white. These plants can be located to best advantage at Frankfort, Lexington, and at Danville or Highbridge (providing the hydroelectric plant contemplated is established); all of these plants have competing freight carries by rail or water, or both. Besides all are centrally located so as to reach the best deposits.

PROPOSED TREATMENT OF BARYTES ORES: The difficulties offered by concentrating processes for the separation of zinc blende from barytes, make it desirable that some use be found where careful previous separation is unnecessary. The manufacture of lithopone suggests itself, but there is no practical process for the direct conversion of barytes and zinc blende so as to yield this product. There is, however, a good and increasing demand for lead-zinc and zinc-lead pigments, the annual American production being 7,000 to 13,000 tons; the average price in 1910 of these products was $90.69. This pigment when mixed with certain other products makes a serviceable and durable paint. The complex lead-zinc ores of the west are now being largely converted into this pigment. It is a process which does not require careful preliminary separation. In the case of the Central Kentucky ores, the lead-zinc minerals may be converted into fume and the residuum (slag) treated with other barytes for the production of barium sulphide.

The most practical treatment of handling the Central Kentucky ores would provide for the grading of the ores into four classes: 1. Best barytes, 2. Off-color barytes. 3. Lead-zinc barytes and 4. Fluorspar-calcite-barytes.

1. BEST WHITE BARYTES. This product would either be sold in lump form for certain uses or else sold as the best grade of ground bleached barytes.

2. OFF-COLOR BARYTES. Part of this would be ground and sold for use in color paints, and as a filler for

certain materials, but the bulk would be used in the manufacture of barium products.

3. LEAD-ZINC BARYTES. This may be treated either by separation processes or else converted into fume for pigment. For the latter purpose the process, briefly stated, would be as follows: The ore would be graded so as to carry a minimum of 30 per cent of the metals in the proportion of one part lead to two parts zinc. After fine crushing it would be roasted until the sulphur content (aside from that combined in the barytes which remains inert) is reduced to 3 per cent. It would be mixed with soft coal slack and oxidized in a special type of oxidizing furnace, the zinc changing to the volatile oxide and the lead to the volatile basic sulphate, while the barytes together with fluorspar, calcite and limestone would remain in the slag. The lead-zinc fume would then pass through cooling pipes and a bag-house, after which it would be reunited in open hearths to rid it of any associated carbon, excess sulphur, hydrocarbons, etc.; it would then be a pure white pigment ready for bolting, bagging and shipment. This process was perfected by Mr. Wm. F. Gordon by combining the Wetherill zinc oxide and the Bartlett basic lead-sulphate processes. The slag would be mixed with off-color or other barytes for the recovery of the barium sulphide. Custom ores could be handled by such a plant by adopting a basis of say 35 per cent (the base price with lead ore at $50 and zinc ore at $40 would then be about $18 per ton), decreasing or increasing the price 50 cents per unit of metal content.

4. FLUORSPAR-CALCITE-BARYTES. This may be sorted into two products, in the one containing considerable barytes, and the other consisting chiefly of calcite and fluorspar. With a large number of the Central Kentucky veins consisting of a mixture of these minerals and the impossibility of the separation of either fluorspar and barytes (usually containing some calcite) or of the calcite and fluorspar, it is necessary to consider the availability of the two groups of products as they stand.

In the first instance, where all three minerals are mixed, if the product has not been affected by weathering, the mixture may be ground for use either in mixed paints or in cold water paints, since both barytes and calcite are

now used in such paints and the use of a small percentage of fluorspar in conjunction would not be harmful, since the fluorspar (except with strong sulphuric acid) like the barytes remains inert, will grind white, and its triangular shaped particles will assist in making a more compact paint film, and besides its specific gravity lies between the other two minerals. As it is translucent to transparent, it would, like the barytes, prove helpful as a color extender in colored paints. In cold water paints, the fluorspar would complement the calcite. In either instance, there may be necessary the addition of a sufficient percentage of calcite or barytes to raise the natural product to the required proportions, especially for use in mixed oil paints. Fluorspar is now used to some extent mixed in the off-color barytes.

In the case of calcite-fluorspar, where a small percentage of barytes is associated, this may be removed by hand picking, and the fluorspar-calcite sold in lump or crushed form as a flux for use in addition to dolomite for foundry practice or with limestone as a flux for open-hearth steel.

CHAPTER VIII.

MANUFACTURE OF BARIUM PRODUCTS.

USES OF BARYTES.

The uses of barytes depend on the following: 1. Chemical characteristics. 2. Weight and inertness and 3. Texture of its powder or artificial precipitate. Its uses are classified accordingly in the statement which follows, and where its use depends on a combination of these characteristics, it is grouped with that class to which it is closest allied:

1. Production of barium compounds—oxide, chloride, sulphide, blanc fixe, etc.; in the manufacture of alumina; in the manufacture of glass; as a reagent. All barium compounds may be derived from those directly prepared from barytes and the processes and uses of each are fully treated below.

2. Loading rope, rubber, putty and fabrics; loading and enamelling paper; adulterating food, paris green and

fertilizers; preventing aeration of certain cheese; dressing for asphalt pavement surfacing, and filler for wood preservatives.

3. Preparation of pigments (white mixed paints, lithopone and blance fixe), and as a base for colored pigments; imitation marble; white figures and jasper ware; and in enamels for porcelain, pottery and enamel-ware.

Consumption and Possibilities.

The following is an estimate of the consumption of barium compounds in the United States: Barium carbonate 2,100 tons valued at $63,000; barium binoxide 3,000 tons valued at $152,400; barium oxide and hydrate 6,500 tons valued at $235,000; blanc fixe 10,000 tons valued at $400,000; barium chloride 2,000 tons valued at $65,000; lithopone 20,000 tons valued at $1,500,000; barium nitrate 350 tons valued at $38,500; other barium salts 500 tons valued at $40,000, making a total tonnage of 44,450 tons valued at $2,493,900. Inclusive of barytes, the total value of barium products approaches $3,000.000 annually. This shows the importance of the industry and with many of the products increasing in demand, the establishment of additional plants to replace imports is fully justified, especially since the profits are in excess of those usually obtained in industrial enterprises.

The erection of a plant for the manufacture of barium products would cost $100,000. For the production of blanc fixe with sodium sulphide by-product, a plant would cost $50,000, while a plant for the manufacture of lithopone would cost a like amount; the production of these products in one plant would require an expenditure of $60,000. The profit per ton in producing 20 tons blanc fixe selling at $40.00 and 10 tons sodium sulphide selling at $30, would be about $13 per ton on the blanc fixe and $10 on the sodium sulphide; however for the latter the demand is small. The profit in producing 10 tons of lithopone selling at $75 per ton would be at least $10 per ton. If operating only one-half time, a ten ton lithopone plant would yield a profit of 30 per cent on the investment, while a blanc fixe-sodium sulphide plant offers a still higher profit. Other barium products yield equally high profits. With the construction of the Dix River dam and hydroelectric power plant, cheap power will be available for the furtherance of the industry; as it is at present, cheap fuel may be had from the Eastern Kentucky coal field which offers good coal within a freight haul of 75 miles from Lexington.

In the manufacture of barium compounds and pigments it is the usual practice to use low grade barytes owing to lower first cost, but this is sometimes balanced by the higher cost of removing impurities from the manufactured product so that it is frequently best to use a better grade of barytes, the quality of the latter being raised by the milling methods described in the preceding chapter.

The principal processes involved in the manufacture of these products are preliminary crushing and mixing of materials, calcining, lixiviation, filtration, precipitation, filter pressing or evaporation, drying, re-roasting, disintegrating, packing, and weighing. Some of the products require the use of all, others of only part of these processes.

The manufacture of these products are covered by innumerable patents. Few of the patents, however, are of real value. Their chief aim usually is to overcome the effect of impurities in the finished products, this being especially true of the lithopone patents. The preliminary removal of impurities, usually by chemical precipitation, from the lixiviated solutions, is necessary for the production of satisfactory barium products.

The preliminary handling of the barytes and other products should be mechanical as far as practical, making use of self-fed hoppers, belt and screw conveyors, automatic feeds, etc. If not already crushed, it is preferable to reduce the barytes, coal, and other products to pass a one-fourth inch ring; this may be accomplished by means of primary and intermediate crushing, as by a jaw crusher and rolls, or directly by a hammer pulverizer, disintegrating rolls, or other sand producing mill. Hopper scales for the automatic proportioning of the several products are necessary. For further comminution and intimate mixing, as for example of coal and barytes, or coal, barytes, and an alkaline chloride, the tube mill has proven serviceable, a small stream of water being introduced with the products, and the pulverized mixture fed by slow-speed screw conveyor directly to the kiln.

For calcination, an electric furnace of special design is used for certain of the processes, while for others either stationary or rotary reverbatory furnaces will answer. In the use of a rotary furnace, Mr. Francis Schuyler recommends a cement kiln rotating one turn per minute with a firebox of special construction, using coal to produce a reducing flame.

For lixiviating and purification, iron, lead, or acid-proof tile lined vats are required. For electrolysis, the character of the diaphragm, cathode, and anode vary with each patent so that no generalization is of value. Various types of filter presses are in use. The drying may be done in hot air rooms but preferably in vacuum dryers. For reroasting, muffle furnaces are employed. For disintegration, anyone of a number of fine grinders may be employed (burr or pebble mills or cage disintegrators are now principally used). The products are shipped in barrels, casks, iron drums, etc., depending on their character.

Barium oxide and Barium hydrate. Barium oxide is composed of barium 89.57 and oxygen 10.43 per cent; the hydrate contains barium 80.16, hydrogen 1.10, and oxygen 18.74 per cent. By passing superheated steam through the oxide it is converted to the hydrate while the latter is converted into oxide by the evaporation of the water. These compounds may be derived from barytes, but also from the sulphide, chloride, carbonate or nitrate. Electrolysis is a necessary factor in several of these processes and in one process the electric furnace is used.

It may also be formed from barytes (or barium carbonate) by passing water gas through its mass in a Bessemer converter, forming barium oxide and hydrogen sulphide (or carbon dioxide).

Barium oxide may be derived from barium sulphide in several ways: Electrolytically, either by dissociating the sulphide in water, forming hydrate and hydrogen sulphide; by making use of iron, nickel, or platinum electrodes which alter by reaction with sulphide to a polysulphide, barium hydroxide crystallizing on one side of a porous diaphram, the mother liquor serving in the one compartment in one operation being serviceable for the other compartment in the next. Or it may be produced by dissociating a mixed solution of barium sulphide and chloride in a diaphragm type of cell, the barium hydrate separating at the cathode and the sulphur at the anode, the hydrate being separated from the electrolyte by a centrifugal machine. By simple chemical reaction it is formed by the addition of a molecular equivalent of zinc or ferric hydroxide (ochre may be used) to the sulphide, forming barium hydrate and a metallic sulphide.

From barium chloride, the hydrate may be derived electrolytically with a zinc anode, the chloride dissolved in two molecular equivalents of water forming the electrolyte.

A very pure oxide used in making peroxide, may be produced by decomposing barium nitrate at a temperature of 1,200°. A saving of the nitrous gases is effected by passing them into pure water or water containing either barium hydrate in solution or barium carbonate in suspension, contained in a vessel into which a rapid succession of electric sparks can be passed.

A practical process for the production of porous anhydrous oxide depends on the decomposition of barium hydrate. The latter is heated to 100 or 150°C., and kept there for some time to drive off water of crystallization. To eliminate the last water, the resultant hydrate is mixed with powdered coke and after heating in cast iron vessels it is heated in a clay or graphite crucible, in a furnace at a temperature of 1200°C. and kept at this temperature for 8 or 10 hours when the oxide results as a grayish porous mass.

Baryta water is prepared by dissolving crystals of the hydrate in 20 parts of cold water at 15°C. or in two parts of boiling water.

Barium hydrate is used in making lithopone, blanc fixe, in the sugar and molasses industries, for purifying and softening boiler water (especially acid waters), and in making certain kinds of glass. It might be used in preparing hides for tanning, together with zinc chloride in altering cellulose, in mercerizing cotton goods, and as a reducing agent in the aniline industry. The porous amorphous barium oxide is largely used in the preparation of barium binoxide.

Barium hydrate or oxide is sold in dry crystalline or amorphous form in iron drums, according to quality at from $35 to $60 per ton.

Baryta may be used as a substitute for either lime or lead to produce an easily fused glass much more brilliant than common glass. The qualities and its usefulness for the various purposes may be modified by using both baryta and lime in varying proportions. According to James Patton, there seems little doubt that baryta will occupy an important place in the future of the glass industry.

Barium hydrate is also used both for clarifying sugar and for recovering uncrystallized sugar from molasses.

BARIUM PEROXIDE OR BINOXIDE. This contains barium 81.11 and oxygen 18.89 per cent. It is derived from the porous amorphous barium oxide (strontium oxide is not serviceable for this purpose) by heating it, preferably under pressure, in a current of air freed from moisture and carbon dioxide; or by subjecting baryta heated to a red heat in a current of ozone or ozonized air. It is also produced from the nitrate. The peroxide usually produced is about 92 per cent pure. Its import value is $177.25 per ton inclusive of duty. Transport is made in iron casks.

It is used in producing oxygen and oxygenated water, the last being in demand as an antiseptic and for bleaching. About 11,000 tons of barium peroxide constitutes the word's annual production, most of this being produced in France. The output annually of oxygenated water is 3,000 tons, one-third of which is produced by France.

BARIUM NITRATE. This consists of barium 52.55, nitrogen 10.74, and oxygen 36.71 per cent. It is prepared from the oxide, chloride, sulphide or carbonate (also from the oxalate or phosphate), by the addition of dilute nitric acid or a hot saturated solution of sodium nitrate; or by heating the sulphide or hpdrosulphide with calcium nitrate or nitrite under pressure. On cooling the larger proportion of barium nitrate crystallizes from the mother liquor, and evaporation of the latter yields the remainder.

It is used chiefly in making hydrate and peroxide of barium (see previously). It is also used to produce barium nitrite which is used both in pyrotechny for blue and green fire and in the explosive, saxafragin. The nitrate is also converted into barium manganate, an emerald green powder termed Cassel's green and usually substituted for the poisonous Scheele's green. Nitrate can be used for preparing barium carbonate or oxychloride. The barium nitrate is sold in powdered form in casks at $110 to $125 per ton.

BARIUM SULPHIDE. This consists of barium 81.13 and sulphur 18.87 per cent. It may be derived from the hydrate or sulphate. Its production from barytes is the most practical method; this involves the reaction of one molecule of barium sulphate with four of carbon from which one molecule of barium monosulphide and four of carbon monoxide result.

This is usually brought about by calcining a pulverized mixture of five parts of barytes and one of coal in a reverbatory furnace. Coal for this purpose should cake well, should not contain over 3 per cent ash, nor be too volatile; this last condition may be remedied by mixing a small proportion of hard coal or coke. Common salt is usually added, in proportions varying from 1-10 to twice the quantity of barytes used, since the salt assists fusion, the use of the minimum quantity being probably in accord with the best practice. The furnaces require for firing, coal amounting to 20 to 30 per cent of the quantity of barytes furnaced.

Carbonate begins to form as soon as sulphide appears so that roasting must not be unduly protracted.

The resultant mass is gray to white, has a hepatic odor, and alkaline taste, and will contain 60 to 70 per cent barium sulphide, 15 to 20 per cent barium carbonate, the remainder consisting of coal coke and silica. The sulphide is soluble in water, the carbonate in hydrochloric acid, and the remainder is insoluble. The barium sulphide is lixiviated in a series of iron tanks (which may be provided with mechanical stirrers to good advantage) placed in terraces, the water running from the highest to the ones set at lower levels until the solution is of the desired strength, and from this barium sulphide may be crystallized but is usually stored in tanks for the manufacture of other compounds. The acid soluble carbonate is usually converted into barium chloride, sometimes to nitrate by treatment in acid-proof tanks.

Barium sulphide may also be obtained by treating powdered barytes in a stream of coal gas, hydrogen, or hydrogen and carbon bisulphide vapor.

A stream of hydrogen sulphide passed through barium hydrate solution gives barium sulphide in solution.

Barium sulphide is used in making lithopone, blanc fixe, barium hydrate, carbonate, nitrate, chromate, and minor compounds; as a depilatory, insecticide, and luminous paint.

As a depilatory, it has the advantage of being less injurious to the skin than any other. The phosphorescent material, Bolognian Phosphorus, is a sulphide of barium obtained by heating 6 parts of blanc fixe with powdered charcoal over a gas flame for one-half hour, igniting for ten minutes over the blowpipe, and sealing while still hot in glass tubes. After exposure to the suns rays or any light rich in ultra-violet rays such as that emitted by burning magnesium wire or the electric arc, it phosphoresces in the dark with a brilliant orange-colored light. Luminous paint manufactured from this product is used for coating clock-faces, match boxes, etc., the surface being protected by a thin film of varnish. Barium sulphide may be substituted for barium chloride in the manufacture of the chromate (see under chloride).

Barium carbide is prepared (W. J. Claude, U. S. Pat. No. 680.050) by mixing barium sulphide, carbon, and a metal capable of forming a sulphide, stable at the temperature of the operation, in an electric furnace. This can be used in the Frank-Caro process of the fixation of atmospheric nitrogen, but calcium carbide being cheaper is used instead.

BARIUM CHLORIDE. This consists of barium 65.97, and chlorine 34.03 per cent. It is derived from barytes, the sulphide, hydrate, or carbonate. It is usually formed from the sulphate by the formation of sulphide and its interreaction with an alkaline or metallic chloride, yielding a sulphide by-product. This is accomplished by fusing a pulverized mixture consisting of 5 parts of barytes, 2 parts coal, and 3 parts of calcium chloride (proper proportion of magnesium, manganese, zinc, sodium or potassium chloride may be substituted). Fusion is facilitated by the addition of one part of limestone, and sometimes a little sand is also added. The resultant blackish-gray clinker is treated in the same manner as in lixiviating barium sulphide.

When barytes is heated in an autoclave with magnesium chloride, barium chloride is produced in solution, hydrogen sulphide gas is evolved and magnesia is precipitated. Or barytes may be dissolved in fused calcium chloride (French Patent No. 420,498-1909) and the material after the removal of impurities is run in water. A solution of barium and calcium chloride is thus obtained with a residue of the corresponding sulphates. The barium chloride is separated from the solution by crystallization and calcium chloride is recovered by evaporation. Pure barium sulphate is obtained from the residue by treatment with hot dilute hydrochloric acid to dissolve the calcium sulphide and leaving the acid for reuse.

From barium sulphide, the chloride may be obtained by adding an equivalent of calcium chloride and passing a stream of carbonic acid into the mixture, whereby calcium carbonate is precipitated.

From barium hydrate, sulphide, or carbonate, the chloride may be obtained by the addition of two parts of dilute hydrochloric acid.

The addition of a little barium sulphide or an excess of barium carbonate and a little baryta water, will precipitate any foreign metals present in a barium chloride solution. The latter after filtration may be neutralized with hydrochloric acid and the salt crystallized and refined by recrystallization. It is usually barreled in crystal form and is worth $32.50 to $37.50 per ton.

Barium chloride is used in the manufacture of blanc fixe, lithopone, barium chromate, tungstate or permanganate for preventing the incrustation of steam boilers by decomposing the gypsum of hard waters; in the preparation of lake pigments; in the manufacture of wall papers; in Heinzerburg's chrome process; 1 to 2 per cent is used to fix tanning stuffs; as a reagent especially for the detection and estimation of sulphuric acid; and to some extent, fused barium chloride has been used for tempering tool steel.

BARIUM CARBONATE. This occurs as the mineral Witherite but is of rare occurrence in the United States, and except possibly in minute films on weathered barytes, is unknown in Kentucky. It consists of barium 69.60, carbon 6.08, and oxygen 24.32 per cent. It is usually artificially prepared from barium sulphide or chloride, but may also be produced from the hydrate, nitrate or sulphate. It may be obtained from any of these by heating with calcium, sodium, potassium or ammonium carbonate.

It is usually prepared from barium sulphide (or the by-product sulphide obtained in the manufacture of baryta) by heating in earthenware retorts into which a quantity of moist carbon dioxide is passed, thus converting it into the carbonate; it may be prepared similarly from the hydrate.

From barytes it is prepared directly by fusion with two parts of sodium or potassium carbonate, potassium or sodium sulphate resulting as a by-product. Or by treating pulverized barytes with sodium or potassium carbonate largely in excess, in an autoclave under pressure or boiling directly with sodium carbonate for an hour, under similar conditions, and adding fresh sodium carbonate until all is converted to carbonate.

Barium carbonate may be had either in lump form or as a dense white powder, the former when 80 to 90 per cent pure being worth $26 to $35 per long ton, while the precipitated 96 to 98 per cent pure is quoted at $31 to $33

per long ton. It is used in the manufacture of cyanides, lithopone and bricks; to impart luster and brilliancy to glass; for producing light green fire in pyrotechny; as rat poison; and in the preparation of barium chlorate; also in preparing the following minor barium compounds; perchlorate, bromide, fluorides, monometaphosphate, manganate and titanite.

It is used in the manufacture of bricks to prevent red bricks from showing a white efflorescence, and to prevent white bricks from turning green. According to A. F. Greaves-Walker, 100 lb. of barium carbonate should be added to the clay for each 1,000 brick to prevent efflorescence, the soluble compounds being thereby converted to barium sulphate. Barium chloride may be used instead but requires a close chemical check since a slight excess over theoretical requirements would itself form a scum.

Barium chlorate is best prepared from barium carbonate, though it can also be derived from the hydrate. The carbonate is treated with a neutralizing solution of chloric acid, and the resulting chlorate is evaporated to the boiling point. It is used to prepare green stars in pyrotechny, and is worth 15 to 17 cents per pound.

BARIUM SULPHATE OR BLANC FIXE. This consists of barium 58.91, sulphur 13.75 and oxygen 27.34 per cent. In its natural form it is the mineral Barytes. It is prepared artifically in an amorphous state usually from barium sulphide, chloride, or hydrate, but also from the nitrate or carbonate, upon reaction with sulphuric acid or its alkaline salts (those of sodium being commonly used owing to cheapness), the normal sulphate or sulphite, or with ammonium sulphate. From barium chloride, it may be formed by reaction with sulphates (calcium, magnesium, zinc, or aluminum) with the production of the corresponding chloride. By heating barium sulphide to redness in the presence of aqueous vapor, sulphate also results.

The more commonly employed processes are the following:

To a 10 per cent solution of barium chloride, sulphuric acid having a strength of 20° B. is added with continual stirring, the result being a fine amorphous precipitate (blanc fixe); stronger barium chloride solution would result in a coarser precipitate having less covering power.

In the use of sodium sulphate (Glauber salt) either the mineral mirabilite, or the artificial sulphate (known as salt cake when obtained as a by-product in the manufacture of crude sodium carbonate, or as nitre cake when it is a by-product in nitric acid manufacture) is serviceable. A mixture of solutions of this salt and barium chloride gives a precipitate of barium sulphate and sodium chloride as a by-product in solution. With barium sulphide, sodium sulphide is the by-product. With barium hydrate, sodium hydroxide is the by-product. By subjecting a mixture of 141 parts of sodium sulphate with 196 parts of barium carbonate to pressure, barium sulphate is also produced.

Precipitated barium sulphate or blanc fixe is sold dry in barrels at $55 to $80 per short ton and in paste form either in barrels or casks at $40 to $43 per short ton.

The following brief note on the use and value of sodium sulphide, a profitable by-product in the manufacture of blanc fixe in certain processes, will be of interest:

The chief use of sodium sulphate is to remove hair from hides. For this purpose it possesses several distinct advantages over other depilatories and is frequently used in conjunction with lime. It is more active than lime alone and requires but a small portion of the time required to make lime effective. It is not as poisonous as arsenic nor does it decompose rapidly like calcic sulphyhydrate and gas-lime containing the latter is of too uncertain strength. Sodium sulphide is chiefly suitable in connection with the common classes of leather, and is shipped in crystalline form in iron casks; where 32 per cent pure, the usual quality, it is worth $20 per short ton, higher grades bringing a proportionately higher price.

The following minor barium compounds may be derived from barium sulphate: barium sodium sulphate, barium disulphate, acetate, selenide, selenate, selenite, thiosulphurate, etc.

In the manufacture of glass, barytes can be used to advantage:

1. In the manufacture of ordinary glass either barytes, barium carbonate or hydrate may be used (see under last).

2. In making flint glass, if boracic acid is used, zinc oxide may replace the red lead, and barytes the carbonate of potash, the result being a glass suitable for tableware or optical purposes, and remarkable for limpidity, whiteness and brilliancy.

3. In making cheap green glass bottles, some German manufacturers use 100 parts sand, 30 parts limestone, 15 parts alumina, 150 parts wood ashes, and 10 parts barytes.

Barytes may be used in the manufacture of alumina from Bauxite (see under barium carbonate).

In the manufacture of rubber, it is claimed barytes adds to its resiliency, to be of service in objects of bulky shape, (as for example in carriage and other forms of springs), and when thickness is required to fill inequalities between joint faces and to prolong the life of the sheet packing so employed after the rubber and cloth insertion have become deteriorated by time and heat. It is incorporated in the rubber dough as a filling and off-color barytes is chiefly used for this purpose.

In loading hemp, sisal, jute and manilla rope, its object is two-fold, adding stiffness and weight.

Pulverized barytes or blanc fixe may be used instead of whiting with linseed oil in the preparation of putty. The higher cost makes their use for this purpose usually prohibitive. However, for a high grade pure white putty, blanc fixe would serve splendidly, since it possesses plastic properties of the second class of plasticity.

Blanc fixe may be used for stiffening calicos, muslins, etc. by mixing with the starch, and assists to fill pores, etc. It may also be used for white prints on calicos or as a base for pigments used in printing colored calicos.

Barytes amounting to several thousand tons annually was formerly consumed by the packing houses in the preparation of a yellow paint (off-color barytes 40 parts and zinc oxide 60 parts) which was used for coating the canvas casings of hams and dried beef. It had the advantage of making a rather germ and air proof package, but as it added often as much as one pound and a half to the weight, it was costly to the consumer who necessarily paid for it at the price of meat. Competition has resulted in the use of unweighted canvas for the better class of meats, therefore its use is now restricted to the cheaper grades.

Both barytes and blanc fixe are used to a large extent in loading and enamelling papers; for the better grades the blanc fixe is used (except for the finest writing paper), while barytes is used for the cheaper grades, while for the cheapest papers kaolin is used. Both barytes and blanc fixe are also used as a filling and pigment for wall papers. These products are not used as an adulterant in paper but fill the pores and permit it of taking a better surface under the calender; blanc fixe gives a beautiful finish to satin and ordinary glazed papers.

In the manufacture of white or colored papers, either product may be mixed with 25 to 30 per cent water and with soluble dyes when desired, and applied as a paste to the surface of the paper. This metohd is objectionable since much paper is wasted in passing through paper machine wire, sand traps, etc. However, the entire product of a large blanc fixe producer is said to be used in this manner.

For thoroughly mixing and incorporating barium sulphate with the material stuff or fiber, the following method has been employed: To 1,000 parts half stuff in beating engine 30 parts of aluminum sulphate solution or other soluble sulphate is added and then a paste of 35 parts barium chloride solution, thus precipitating barium sulphate intimately throughout the paper stuff. For colored papers, the acil coal tar dyes are dissolved in the aluminum sulphate solution prior to mixing it with the paper stuff. The colors are well fixed by this method and beautiful glazed surfaces are obtained, especially with napthol dyes which form a perfect solution with sodium or aluminum sulphate.

Barytes was formerly much used as an adulterant in powdered sugar, candy, flour, etc. owing to its weight and inertness. While non-poisonous, because of its inertness it doubtless possesses a harmful physiologic effect on the

system if used in sufficient amount, clogging kidneys, etc. Fortunately, its use has been directed into legitimate channels.

Barytes has been used as an adulterant of Paris Green, in quantity ranging from 11 to 50 per cent. Its use in Paris Green is objectionable for all purposes, except that used for paint. With barytes costing less than one cent per pound and Paris Green 26 cents, the reason for its use is readily understood.

Barytes has been used in quantities of 2 per cent and upwards in fertilizers, as an adulterant; with the close supervision now given the sale of such products its use for this purpose is greatly restricted. Its use crushed to sand to prevent packing of clayey soil would prove advantageous, but its price would make its use for this purpose prohibitive.

In Italy a thick crust of finely ground barytes is given gorgonzola cheeses, since the barytes has the property of affording just sufficient protection from aeration.

Barytes is sometimes employed as a top dressing before rolling for asphalt streets, acting both as a stiffener of the surface coating and to whiten its color.

It may be used for tarring and stiffening tarred ropes. It would doubtless prove helpful in wood preservatives to assist in filling the pores perfectly.

An imitation statuary marble may be produced according to Leonce Beaumel by dissolving alum in water and heating it to the boiling point, then adding a solution of barium sulphate, subjecting the whole to evaporation to increase its density, cooling it under constant agitation, until it assumes a pasty constituency and allowing the mass to harden.

Abroad it has been used to reflect the colors of oxides used as staining for differently tinted jasperware. It has also been used at certain potteries to produce white patterns on a colored background.

Barium sulphate is serviceable for wholly or partly replacing white lead in enamenls, producing an equally fine and white enamel. It is preferable in making enamels for porcelain, china, and enamel hollow ware, owing to its non-poisonous character. It is used also as a base for colors for colored enamels.

THE USE OF BARYTES AND BLANC FIXE IN PAINTS. Barium sulphate has been used in paints in Europe for several centuries. About 1850, barytes was first used in America, as an adulterant of white lead. Barytes and blanc fixe are both recognized now as having distinct advantages for use in paints when used in proper proportions. This legitimate use has naturally been retarded owing to the previous use as an adulterant. The paint trade uses all grades of barytes and blanc fixe. Fully 80 per cent of the barytes produced is used in paints.

Owing to its possessing insufficient body or opacity, and its coarsely crystalline texture, the particles being of irregular shapes and sizes when pulverized, barytes is not suitable for use alone for paint, but must be mixed with other pigment. Blanc fixe is an amorphous powder, consisting of uniform minute microscopic particles, mixes uniformly, possesses greater opacity and more covering power, but is also best adapted for mixing with other pigments.

Barytes has been used in mixed paints in proportions varying from 4 to 75 per cent. Mixed in the proportions of one, two, and three parts to one of white lead (basic carbonate), it has been sold respectively under the names of Venice, Hamburg and Dutch white. Masury's "Railroad Lead" consists of 57.7 per cent zinc oxide with barytes constituting the remainder. Freeman's non-poisonous white lead consists of equal proportions, white lead, zinc oxide and barytes. But, as explained below, the best mixed paints contain only from 4 to 13 per cent barytes.

The white pigment, blance fixe or precipitated barium sulphate is known to the trade as Permanent white, Constant white, Barytic white, Enamel white, etc. The process of preparing it has already been fully described.

Compared with pure zinc oxide, the standard of opacity among white pigments, barium carbonate, blanc fixe and barytes are all exceedingly translucent, having an opacity of only 4 per cent. This makes them defective in hiding power, and when used excessively, also increases the whiteness of the paint.

This defect makes them of value in increased amount in colored paints since they take color, stain uniformly and permit the color to appear through them.

Excessive use of barytes produces checking of a distinct nature, being generally forked but having no definite striation. Barytes while adding strength, when used in excess decreases elasticity. In common with all pigments save basic lead sulphate, it does not penetrate the surface painted. The use of barytes greatly increases the abrasive resistance of a mixed paint. Barytes forms a stiff paste with 7 per cent of linseed oil, white lead requiring $7\frac{1}{2}$ and zinc oxide 22 per cent.

In short, the use of barytes in proper proportions adds to the chemical stability, strength, abrasive resistance, and medium hardness of a paint film, and in colored paints has an additional value as an extender of the colored pigment. Blanc fixe used in connection adds to these qualities. The temperate use of barytes and blanc fixe adds much to the life of a paint.

To take advantage of the good qualities of barytes and blanc fixe, the best white mixed paints should contain 4 to 13 per cent of each; for colored paints a somewhat larger percentage may be used.

Barytes acts as a base for aniline and certain other pigments. Impurities present in the lower grades of barytes, such as limestone, calcite, gypsum, etc., do not take color stain uniformly nor do they permit of so small a quantity of a decided color to cover as much surface, therefore the better the grade of barytes, the more serviceable will it be as a base for other colors.

LITHOPONE. Lithopone as originally produced consisted of barium sulphate and zinc sulphide as a simple mixture. This was soon improved by obtaining them as a double precipitate. Since, a number of methods for its production and improvement have been devised, so that now it may consist of barium sulphate with either zinc sulphide or oxide or both, and in addition at times also barium carbonate, and these in most any desired proportions; further, there may be added a small percentage of barium and other compounds to insure stability to light. The product in all processes is a mixed precipitate and the by-products may be the same as those obtained in the manufacture of blanc fixe. Adulteration by kaolin and some other white products is sometimes practiced and must be guarded against.

Lithopone was introduced into England under the name of Charlton White, and was also known in the trade as Orr's White or Griffith's White. Pigments of this character are now commonly termed lithopone or lithophone, although some of the American companies have trade names for their product as Becton White, etc.

The best grades of lithopone are white, while inferior grades are grayish, brownish or yellowish, due to the presence of carbon or iron and other metallic oxides.

The simplest method of preparing lithopone, and this is the method usually adopted, is by mixing solutions of barium sulphide and zinc sulphate, 51 parts of the former to 49 parts of the latter, when by interchange of chemical constituents, barium sulphate and zinc sulphide are precipitated.

The methods employed in the preparation of the barium sulphide solution have been described fully previously.

It is essential that the zinc sulphate solution shall be rid of all impurities prior to its being mixed with the barium sulphide.

Ordinary lithopone is unstable to light, becoming dark on exposure to sunlight but changing to white again when returned for a sufficient time to the shadow.

The following additional facts regarding lithopone manufacture, etc., are abstracted by permission from an article copyrighted by and appearing in the Oil Paints and Drug Reporter of Nov. 20, 1911:

"The materials used in a successful lithopone plant comprise barytes (crude), coal, spelter, oil of vitriol, common salt, sal ammoniac, sodium phosphate, chlorate of potash, calcium chloride, and caustic soda. Taking the average figures for several years, the percentages by weight of the consumption of these materials, are as follows: Crude barytes, 37.30 per cent; bituminous coal, 26.59; spelter or scrap zinc, 9.63; oil of vitriol (sulphuric acid), 22.05; rock salt, 3.39; sal ammoniac, 0.44; sodium phosphate, 0.14; chlorate of potash, 0.31; calcium chloride, 0.13; caustic soda, 0.2 per cent. The average yield of lithopone from this material was 41 per cent of a normal grade averaging 29.85 per cent zinc sulphide, 1.63 per cent zinc oxide, and 68.52 per cent barium sulphate.

"The cost of manufacture depends upon the situation of the plant, a plentiful supply of water, as enormous quantities are required for the washing of the product; facilities for discharging the materials from railroad cars or boats, economical methods of handling the same, up-to-date crushers, mills, and furnaces. Neither must the placing of levigating tanks, filter presses and drying ovens or kilns be lost sight of and it will be noted that it requires quite a plant full of apparatus to manufacture a paying quantity of lithopone. To run it most economically means going day and night with double shifts of men and only shutting down when it becomes necessary to clean out and repair furnaces, etc., because every shutdown means an extra expense and a liability to produce inferior products until the plant is again in normal working order. Without going into minute details we may say that for a plant with a capacity of 10 tons every 24 hours, a building at a cost of \$25,000 fitted out with apparatus costing as much more is required. (The apparatus required for manufacture is then briefly summarized and it is stated that 30 vats are required for washing the product.) Where perfectly clear water can not be had, large tankage for filtering the water for levigating is absolutely needed."

"The barium sulphide solution and the zinc sulphate solution should be of a concentration of 60 per cent and at a temperature of 140 to 150 deg. F., when they are poured together, and the zinc solution should be poured at double the rate of the barium solution, in which case a precipitate is obtained that can be filtered and dried."

"It is evident that when zinc dross is used and in any case unless refined spelter is employed, the zinc solution must be treated with a compound that will eliminate all traces of iron and other foreign materials. For this purpose chlorate of potash is added. The precipitate after being filtered and dried is placed in muffled furnaces and heated at as high a temperature as 900 deg. when it is suddenly plunged into cold water. In calcining in the muffled furnace, sal ammoniac to about 1 per cent of the dry weight is added to assist fusion. When the material is thus prepared it is carried to the burrstone mills by means of centrifugal pumps and pipes, or by other mechanical appliance and there ground in the pulp state to the standard degrees of fineness, and then conveyed to the washing tanks where it is washed over as often as necessary to eliminate all traces of impurities, free sulphur, iron, etc. This often requires as many as 12 to 15 washings and sodium phosphate and caustic soda are added in small portions to assist in the process. Calcium chloride is also added as a bleaching agent when the whiteness is defective. A minute quantity of ultramarine blue is also one of the ingredients to assist in eliminating a too creamy cast. When the test shows the pigment to be thoroughly washed, it is filter pressed, the cakes so formed are placed on wooden trays, the trays stacked up on suitable trucks and these put into drying rooms usually built of metal and heated by exhaust steam which is aided by jets of olive steam. When the cakes of lithopone have dried, they are fed into the hopper of a disintegrator, which pulverizes the lumps into a powder of uniform fineness, and when this powder has been put up in barrels or casks of suitable size, the product is ready for the market."

The one great feature about the manufacture of lithopone, as compared with that of white lead, is in its quick manufacture, for a working batch of lithopone can be turned out in three or four days, whereas even quick-process white lead will require at least one month from the time the pig lead is unloaded, with one single exception that of the so-called mild process of white lead. It stands to reason that the capital tied up in a lithopone plant is much smaller than in the case of white lead manufacture. Another advantage of the process as against that of white lead making is that the health of the workmen is not so much in danger, though the work is by no means pleasant on account of the vapors and the heat."

"The product is chiefly serviceable for colored exterior paints, and white interior paints, and is especially used in the flat coat paints now so much in demand. The lower grades are used by the shade cloth makers, the finished body being underburned, lacks body and color resisting properties, is thicker and requires cheap thin-

ners to spread. The relative oil absorption of lead carbonate is 9 per cent, of lithopone, 13 per cent and of zinc oxide 17 per cent. Lithopone is not subject to change like lead carbonate nor is it brittle like zinc oxide."

As a result of tests made by the Paint Manufacturers' Association, the following facts regarding lithopone have been gathered: Under the microscope, it has a flocculent, non-crystalline appearance, and its specific gravity is 4.25. It is excellently suited for interior use, in the manufacture of enamels, flat coat and other wall finishes, but not as a pigment for outside work, since it becomes chalky and affected by light. White lead can not be used in conjunction with it as lead sulphide forms which gives a black appearance. The use of calcium carbonate and zinc oxide in connection with lithopone is helpful in some instances, and the use of a varnish-like vehicle in combination with these may facilitate its use for exteriors.

In short, lithopone is largely used for painting interiors since it possesses good color and covering power and is unaffected by sulphides; in enamels it gives most body and color; in the manufacture of oil cloth and linoleum it gives body and enamel surface; in white rubber and especially rubber tires it gives elasticity, tensile strength, and color; as a filler for soaps; for coloring and printing fabrics and as a permenent discharge for wool or half-wool materials, it is replacing zinc white, since the fabrics prepared with it can be subjected to acid bath without injurious effects and the material is kept nice and white. It lacks tinctorial body, unless underburned. There is a difference of opinion as to its suitability for enamels for metals, some authorities claiming that it blisters and scales off.

The present (1912) quotations for normal lithopone in the United States range from $70.00 to $80.00 per short ton, the price ranging higher or lower with varying percentage of the zinc sulphide. It is shipped in dry or in paste form either in barrels or in casks.

There are nine companies producing lithopone in the United States with an annual production of 11,500 tons. Since the consumption amounts to 20,000 tons, the remainder is necessarily imported from Europe, chiefly from Germany. The outlook for an additional plant, possibly two plants, to be established in Central Kentucky is good.

STRONTIUM COMPOUNDS.

SEPARATION OF BARIUM AND STRONTIUM SULPHATES. The separation of strontium and barium sulphates will probably depend as suggested by Dr. A. M. Peters (private communication) upon digesting the mixture with ammonium carbonate at ordinary atmospheric pressure which reacts with the strontium to form strontium carbonate leaving the barium sulphate unaffected. He states that the reaction of the sodium carbonate on strontium sulphate is more rapid than that with the barium sulphate and since sodium carbonate is much cheaper, a commercial method might be obtained using this as a basis. The strontium carbonate thus obtained would be converted into chloride and thence either into nitrate or hydroxide by methods similar to those employed in converting barium carbonate to similar salts.

Owing to its less poisonous character, strontium hydroxide is preferable to barium hydroxide in purification of sugar and molasses, and for this purpose a plant for its separation would doubtlessly prove profitable. Furthermore strontium nitrate used for producing red fire could be produced in sufficient quantities to supply the market.

APPENDIX I.

GENERAL OCCURRENCE OF BARYTES; COMPETING DISTRICTS.

GENERAL OCCURRENCE.

Barytes forms in fissure veins, metasomatic deposits, breccias, caves and geodes. The first three types are the commercially important ones. Fissure vein deposits are usually continuous vertical tabular deposits, while those of the metasomatic type are irregular scattered pockets or beds. Caves are open filling deposits of irregular

horizontal tabular form. Breccias occur sometimes associated with fissures but are at a disadvantage on account of the inclusion of country rock (limestone, sandstone or quartzite in Kentucky) fragments. Geodes are of scientific interest only. Barytes deposits are associated with sedimentary and basic igneous rocks; rarely or never with acid igneous rocks. In addition, there are the residual barytes masses through clay which may be derived from any of the foregoing types.

The ultimate source of barium is usually the basic igneous rocks, the element appearing as a constituent of certain feldspars, biotite, and their alteration products. Barytes is not not a rock making mineral and is only deposited from rock making solutions.

Among general mineral associations of barytes in veins, we find among gangue minerals calcite and fluorspar, occasionally siderite, and to a less extent gypsum and celestite; among the sulphides of the metals are those of iron, lead, zinc, copper, silver, gold, cobalt, nickel.

Fluorspar, calcite and barytes have certain chemical qualities and affinities in common, which partially at least explain their common association in mineral deposits. Each has an alkaline earth base. Fluorite and calcite have calcium, and barytes barium, so that their chemical reactions would be similar in many instances. The association of fluorine and barium in primary rock minerals such as biotite is notable. The ready interreaction of calcium sulphate and barium bicarbonate to form calcium carbonate and barium sulphate is also suggestive.

The relationship of barytes with the sulphides of the metals depends primarily upon the fact that barium bicarbonate or chloride is deposited as sulphate upon reaction with sulphide solutions. Its association in marked quantity with galena may be due partly to the relative insolubility of the two minerals.

Beck-Weed describe deposits in which barytes plays an important part as a gangue mineral under the following heads: 1. Pyrite and barite deposit. 2. Spathic copper veins having a gangue of various carbonates with barite and sometimes fluorspar. 3. Barytic lead veins with fluorspar, quartz and calcite; also pyrite, zinc blende, etc. 4. High grade silver-copper veins with quartz, earthy carbonates and barite. 5. Rich silver-cobalt ores with barite, fluorspar, quartz, etc. 6. Silver-gold veins with quartz, carbonates, and rarely barite. The first type is rare. The fourth, fifth and sixth types with one exception carry only minor amounts of barytes. The nearly pure barytes veins are usually modifications of the second and third types and form the commercial sources of barytes. The third type is the most important and it is to this type that the Kentucky deposits belong.

American barytes deposits are found at four stratigraphic horizons:

Triassic sandstones associated with trap dikes: East of the Blue Ridge, Virginia; and Cheshire, Connecticut.

Mississippian limestone: Western Kentucky.

Cambro-Silurian limestones:Central Kentucky, Central Missouri, Tennessee, Valley region of Virginia, Georgia, Pennsylvania, and Cuba.

Precambrian: Nova Scotia, Ontario, Piedmont region of Virginia, North Carolina.

The bulk of the commercial deposits are derived from the last two horizons, the Cambro-Silurian horizon being much the more important of the two.

There appears to be a fluoritic-barytic province in the eastern United States, of which both the deposits of the Mississippian limestones of Western Kentucky and of the Cambro-Silurian limestones form a part. This was subject to an era of deposition primarily by ascending fractures along fault and fracture planes in Post-Carboniferous time. The structural differences in the deposits depended primarily on local differences in the character of the strata in which deposition took place. The extent of residual deposits and the present depth of the fissure depend on the local structural and topographic conditions such as govern the rapidity of erosion.

OCCURRENCE IN COMPETING DISTRICTS.

The competing districts are in Western Kentucky, Missouri, Tennessee, Virginia, North Carolina, Georgia, Canada and Germany. Deposits are also known to occur in the following states, but few of these deposits give

commercial promise: Alabama, California, Colorado, Cuba, Idaho, Nevada, New Jersey, New Mexico, New York, South Carolina, Utah and Wisconsin.

WESTERN KENTUCKY DISTRICT. For a general description of the lead, zinc and spar veins of this district, reference should be made to Bulletin No. 15 of the Kentucky Geological Survey.

It is sufficient for present purposes to note that the barytes occurs in veins one to four feet wide, partly of the best grade, and partly associated with fluorspar and to some extent with calcite and zinc blende, very rarely with galena. These veins are of the shift fault type and cut limestones of Ste. Genevieve-St. Louis age. Deposits also occur in normal faults as local variations in the fluorspar veins and in this instance one of the wall rocks may be limestone and the other shale or quartzite of Chester age; deposits of this character are known to occur 20 to 25 feet wide, and have a minute amount of fluorspar intimately intergrown as well as some zinc blende; the most notable deposits of this type being those of the Commercial shaft on the Tabb vein and the Bibb deposit, either of which would be suitable for the manufacture of barium compounds.

The barytes deposits are incidental to the fluorspar deposits of Western Kentucky just as fluorspar deposits are of secondary importance in Central Kentucky.

The most important barytes deposits of Western Kentucky are the following: Commercial shaft, Meyers, Sullenger and Bibb in Crittenden county; the Lindley, Stone and Bradshaw in Livingston county; and the Satterfield, Ray and Lowery in Caldwell county. These mines and prospects are described in Chapters VII and VIII of Bull. 15, previously cited. The royalties on barytes range from 10c to 50c per ton.

APPENDIX II.

NOTES ON SOME KENTUCKY LEAD, ZINC AND OTHER PROSPECTS OUTSIDE THE CENTRAL KENTUCKY BARYTES DISTRICT.

BOONE, GALLATIN, CARROLL, TRIMBLE AND OLDHAM COUNTIES.

These contain no barytes veins. Some notes follow on unimportant lead and zinc prospects in Carroll and Oldham counties.

CARROLL COUNTY.

Reynolds Prospects. One half mile to the left of the railroad, one mile north of English, Carroll County, fossils contain a little zinc blende, calcite, and fluorspar in cavities.

OLDHAM COUNTY.

Northeast of Lagrange, four beds of magnesian limestone occur between the Richmond formation and the Ohio shale, and all of these beds except the third from the bottom, contain calcite usually of a pinkish color, both in seams and in segregations, especially in the uppermost bed. With this calcite, pyrite and zinc blende, and possibly also barytes occurs, but nowhere in quantity ample for mining. There are no indications to warrant the suggestion that copper occurs in this region.

CASEY COUNTY.

In Casey county prospects are limited to a calcite-gypsum geodes in Devonian limestone and to narrow veins in the Ohio black shale, such veins usually consisting of fibrous quartz and pyrite, but in one instance of black barytes.

CLINTON COUNTY.

In the vicinity of Forest Cottage, the Keokuk quartz geodes contain pyrite, barytes and zinc blende.

ESTILL COUNTY.

In this county, three types of prospects occur, none of which are of commercial interest: 1. Segregations and narrow seams containing galena, zinc blende, barytes and calcite in the Boyle limestone immediately beneath the Ohio Black shale on Station Camp, near Noland on Crooked Creek and at other points where this limestone is exposed. 2. White to pink barytes occurs cementing Keokuk limestone breccia which caps the knob at Knob Lick, an occurrence originally noted by David Dale Owen, and is similar to that on Gladie Creek, Menifee county. 3. According to Mr. C. W. Hundeley, of Irvine, narrow veins of galena occur in the Mississippian limestone 400 yards beyond Sinco on Miller Creek, and again about eight miles further north. These, while not examined, are probably of no value.

GRANT AND PENDLETON COUNTIES.

Only minor shearing of the rocks are noted in these counties, and the only mineralization was in magnesian limestone beds in lower Point Pleasant and Greendale limestones where geodes occur containing calcite, gypsum and barytes, which have no value. The extensive shale beds of the Eden probably were a bar to the formation of veins. Some little cave calcite was seen on the McKinneysburg road, one mile northeast of Falmouth.

LEWIS COUNTY.

Zinc blende occurs in segregations in the West Union magnesian limestone immediately beneath the Ohio black shale, but with one possible exception, none of these deposits are likely to prove of value. For details, see the bulletin to be issued by the Survey on the Economic Geology of Lewis and Rowan counties.

MARION COUNTY.

This county is marked by the Kentucky anticline which strikes almost east-northeast, and the Rolling Fork syncline which parallels it on the south. In southwestern Marion county, on the most northerly monocline of the north limb of the syncline, in Keokuk limestone, a breccia up to 30 inches wide occurs; this is cemented with calcite and partly replaced by gypsum and pyrite. This was supposed to carry gold values but the prospect is unfavorable. Other breaks and faults occur along other small folds, one seam showing calcite and fluorspar and possibly also lead and zinc, but these are unimportant.

MENIFEE COUNTY.

Three miles above the mouth of Gladie Creek on the land of John Klaber, a bed of magnesian limestone, of Keokuk age and occurring 18 feet above the Waverly shales, is brecciated and cemented with crystalline barytes, but the occurrence is not of value. In a bed of Waverly sandstone below, a large gastropod fossil is common in which small segregations of galena, zinc blende, pyrite, and calcite, and possibly also chalcopyrite appear, but this occurrence likewise fails to be of commercial value.

METCALFE COUNTY.

Nothing of interest was noted in this county. An attempt to prospect for lead, four miles from Center proved fruitless; sinkholes occur here but nothing to indicate a lead vein.

MONROE COUNTY.

A prospect on the Kidwell land on the bank of Big Sulphur creek showed a zone striking N. 20° E. in a dove colored compact limestone of unknown age. The zone is 10 feet wide and contains 4 to 30 inches of breccia cemented with a little fine-grained zinc blende, less galena and some calcite, but it is not sufficiently mineralized to warrant working.

NELSON COUNTY.

Zinc prospects were examined in a number of localities in the Boyle and upper Richmond limestones. In the former, the zinc occurs as zinc blende, with calcite in small bunches through the rock. In the Richmond limestone, cavities occur lined with zinc blende, pyrite, and calcite and in some instances zinc blende has been altered to zinc carbonate as at the Bardstown quarry. None of these prospects merit development.

ROCKCASTLE COUNTY.

At Dudley, east of the railroad, is a bed of Keokuk limestone, brecciated and cemented with barytes, but the latter does not occur in quantity sufficient to repay working. Further details regarding this occurrence will be found in the Survey bulletin on the Geology and Resources of Rockcastle county.

SHELBY COUNTY.

No prospects of importance occur in this county. A fault striking northeast was found near the base of Jeptha Knob, five miles southwest from Shelbyville. On the Shattuck land, three miles east of the same town, a little galena and zinc blende with calcite occur lining fossil cavities in Cynthiana limestone.

APPENDIX III.

THE GREAT CALCITE VEIN OF MERCER COUNTY.

A careful investigation of the great vein of calcite in Mercer county, often called the Million Vein, was made. Results show that the probable tonnage of high grade calcite in the vein, which is nearly vertical, is very large. The deposit is best exposed on the Chinn Mineral Company's properties, where, also, practically all systematic openings in it have been made. The probable minimum amount of 98 per cent. pure calcite in the vein within the limits of that company's properties alone, above the level of the Kentucky River, is estimated to be nearly 200,000 short tons, the width of the vein averaging 4 to 6½ feet. This calcite is suitable for making whiting of any grade of superior whiteness and quality and bringing from \$9.00 to \$18.00, or an average of about \$11.00 per ton; or for making putty of the best grade bringing an average price of at least \$34.00 per ton and as high as \$40.00 per ton.

The vein is especially well exposed for study, and for working as well, on the Million, Conder and Hensley lands, nine miles northeast of Harrodsburg. These lands are 4¾ miles by road from High Bridge station on the Cincinnati, New Orleans & Texas Pacific railroad; a distance that could be shortened by at least a mile. The Million land borders on the Kentucky river, and an adit has been driven in the vein at the river front. The distance from this point to High Bridge by river is 9½ miles; to the mouth of the Kentucky River at Carrollton, 125 miles; to Louisville, by the Kentucky River, 185 miles; and to Cincinnati, by those rivers, 200 miles.

The essential topographic features of the area under consideration are four hills, rising from 250 to 300 feet, or more, above the Kentucky River. One of these hills is on the Million land, one on the Conder, and the others on the Hensley. The Kentucky River borders the Million land on the north; Shawnee Run is on its west side and Pound Mill branch on the south, the last two streams separating the Million from the Conder tract. Pound Mill branch borders the Hensley land on the east.

CHARACTER AND EXTENT OF VEIN. The vein is a southward continuation of the Chinn or Twin Chimney vein. It has a general strike of nearly north, but on the Million, Conder and Hensley lands it has a N. 15° W. course, with local strikes of N. to N. 4° E. and N. 5° W. The inclosing wall rock is Tyrone limestone near the tops of the hills and Camp Nelson limestone lower down. The vein dips 82°-85° east. On the Million and Conder lands the filling is almost wholly of calcite, while on the Hensley land, some parts of the vein carry marked percentages of fluorspar.

The calcite partly replaces a zone of sheeted limestone partly filling an open fissure; it is due to this fact that the vein has such width. There are occasional small seams of fluorite and barytes in the calcite but on the Million and Conder lands these are insignificant. A little unreplaced limestone is found in proximity to the walls and if this be included in the calcite prepared for market it would lower its grade 2 to 4 per cent, owing to the magnesian character of the limestone, but most of this is thrown out by hand picking.

The vein varies in width from 1 foot to 10 feet 8 inches, the average width being 6 feet 6 inches. The vein has been opened at a number of points on these lands as is evident from the accompanying longitudinal section and sketch map; the section gives details of the width at various points.

PROBABLE CALCITE TONNAGE. The length of the vein at river level is approximately as follows: Million land 1,500 feet, Conder 825 feet and Hensley 1,650 feet. The tonnage above adit level for the Million was based on 4,000 square feet of surface lengthwise and a width of 6½ feet, which is a fair average width. This gives 416-000 cubic feet, from which there must be deducted, allowing for a five-foot surface covering, 32,500 cubic feet, leaving a net of 383,500 cubic feet of calcite. The tonnage between present adit level and river level was based on 130,000 square feet surface lengthwise and a width of 5 feet, making 650,000 cubic feet of calcite. A cubic foot of calcite in the solid based on a special gravity of 2.71 (the powder has a specific gravity of 2.724) weighs 169.2 lbs. Allowing 5 per cent for air spaces, etc., a cubic foot would weigh 160.7 lb. Then we have 383,500 cubic feet equal to 30,814 tons, the tonnage above water level, and 650,000 cubic feet equal to 52,228 short tons from adit level to river level on the Million property.

In a like manner it was found that on the Conder land above Cave level, assuming an average of 6 feet, there was 19,477 tons, and on the basis of a 5-foot width, there is 44,594 tons below Cave level.

On the Hensley, while part of the vein above the Million adit level is pure calcite, another part of it partly calcite and partly fluorspar, hence no calcite tonnage is allowed for this property except below adit level, where while some fluorspar may exist, the bulk will be largely calcite. There is then for the 150 feet below adit level (allowing 4-foot width) on the Hensley about 79,546 tons of calcite.

Summing the tonnage, we find the following:

Property	Tonnage above Adit Level	Tonnage between Adit and River Level	Total Tonnage
Million	30,814	52,228	83,042
Condor	19,477	44,594	64,071
Hensley	....	79,546	79,546
Total tonnage	50,291	176,368	226,659
Deducting 20 per cent for voids, net calcite tonnage	40,233	141,094	181,327

CHARACTER OF CALCITE. The calcite is colored milk-white and occurs as an aggregate of rhombohedral cleavages. The physical characteristics of the ground products are discussed under Uses, Technology and Sources of Competition.

As no fresh faces were available for analysis, samples were collected from such faces as were exposed, the freshest being No. 3098 taken at the breast of the adit. These weathered samples show higher in silica owing to the flow over them of surface and soil waters, and hence are of lower quality than may be expected where the mineral is obtained in mining. Concerning the sample where the limestone was partially leached it is hard to say whether the calcite with unaltered limestone fragments in it will prove better or worse. The following are analyses of samples collected on the Million property, the analyses having been made by Mr. J. S. McHargue, Survey chemist:

Laboratory No. 3098.—Average sample of calcite from breast of vein in cut of adit. Vein 3 ft. 6 in. wide when sample was taken. White calcite with rhombohedral cleavage, very little limestone on east edge of vein. (Station No. 1 on plat.)

Laboratory No. 3099.—Average sample from open cut in side of hill from 50 feet above adit level. Vein 6 ft. 8 in. wide, consisting of calcite with minute seams of barite; surface of vein partly covered with moss. (Station No. 2 on plat.)

Laboratory No. 3100.—Average sample of the west 5 feet 10 inches of the vein outcrop on the north side of Goddard's path. Sample collected was weathered and consisted of clear white calcite except for a seam of fluorspar up to $1\frac{1}{2}$ in. wide. A little limestone is included at the west edge of the vein. (Station No. 4 on plat.)

Laboratory No. 3101.—Average sample of east 3 ft. 6 in. of the vein outcrop on the north side of Goddard's path. This part of the vein is honeycombed from leaching the limestone, but on the east edge there still remains considerable included fragments. (Station No. 4 on plat.)

ANALYSES OF CALCITE FROM VEIN ON MILLION LAND.

Laboratory No.	3098	3099	3100	3101
Ignition	43.80%	44.14%	43.10%	43.32%
Silica	None	0.03	None	0.90
Alumina	0.65	0.10	0.71	0.42
Ferric oxide	0.12	0.11	0.12	0.13
Calcium oxide	55.40	55.70	55.40	53.88
Magnesium oxide	Trace	Trace	0.56	1.07
Barium sulphate	....	0.04	....	0.45
Total	99.97	100.12	99.89	100.17
Calcium carbonate equivalent of the oxide	98.97	99.46	97.51	96.21
Calcium fluoride	....	....	1.41	....
Specific gravity of powder	2.724	....	....	....

The average calcium carbonate content as shown by the above analyses is 98.04 per cent. The average silica content is 0.23 per cent, of ferric oxide 0.12 per cent and of alumina 0.47 per cent. The average magnesium carbonate content is 0.85 per cent. The percentage of calcium carbonate will be increased by hand picking to above 99 per cent, whereas the silica content will be less than 1 per cent, and the iron, alumina, and magnesium carbonate will be proportionately reduced. The silica content in the specimens analyzed is largely due to the fact that they were collected from weathered surface faces. The magnesium carbonate content comes almost entirely from included fragments of Camp Nelson limestone.

USES AND TECHNOLOGY.

The uses of calcite depend on the following:

1. Its white-color and body: for water paints, calcimine and white wash; wall paper prints; putty; modification of the shade of other pigments; crayons; tooth powder; polishing powder for glass and metal; filler for rubber; paint for insulated wire.

2. Its neutralization of acid whereby calcium acetate, sulphate, etc., are formed: for purification of wood alcohol and petroleum (in all paints); and for medical purposes.

3. Its chemical composition: for manufacture of lime, carbonate of soda, carbonic acid gas and many other chemical compounds; by potteries.

4. Its formation of silicate: for manufacture of Portland cement; as a basic flux.

5. Its lime content action as cement, and power of moisture absorption: for agricultural lime.

For uses under the first and second headings finely ground calcite or chalk, having a calcium carbonate content of upward of 95 per cent, known under the name of Whiting, is employed; this grade is also necessary in the manufacture of carbonic acid gas and certain chemical compounds. For the other purposes, calcite of inferior quality may be employed, either in lump or gravel form, except in the case of agricultural lime, where a ground product is necessary; for the last purpose, however, the cost of manufacture from calcite would exceed what the product would bring.

The lower grades of whiting usually carry about 95 per cent of the calcium carbonate and not much above 3 per cent of silica. The better grades carry 98 per cent or upward of calcium carbonate. The commercial and gilders whiting, because of their coarseness, mix best with oils and find their chief use in making putty. The better grades are used for paints, rubber filling and carbonic gas manufacture; the finely divided chemical by-product is also used for these purposes, but it has less body and hence is not as desirable for paints. Marble dust and pure oolitic limestone is little used in this country for whiting, the former more than the latter, and

such as is sold goes chiefly for the manufacture of carbonic acid gas.

Whiting is used as a base for water paints as, for example: "Marble lime" color for outside work consists of cassein soluble in alkali 100 parts; caustic lime for marble 100 parts; Whiting 800 parts; borax one part; ultramarine 2 to 2½ parts. Calcimine consists of a mixture of Whiting, glue and water.

In making putty, whiting is simply ground by means of a putty chaser with oil, either mineral, corn, cottonseed, or raw linseed oil; boiled linseed oil is used when a quick drying putty is desired or litharge or other driers may be added to a raw linseed oil putty. Jeweler's putty or putty powder and plaster putty are entirely different products, as is stove putty.

SOURCE OF COMPETITION, PRODUCTION, IMPORTS, ETC.

Whiting made from calcite must meet the competition of whiting made from the great chalk beds of the Cretaceous in England and France and a recently discovered chalk deposit of immense size in Mexico; of whiting made from marble and pure oolitic limestone; and of that obtained artifically as a by product in many chemical processes, for example from the residue of paper pulp. However, the bulk of whiting used is made from slightly impure chalk.

Owing to the difference in ocean and inland freights and also the difference in first cost of product, Kentucky whiting could not compete with coast whiting except with the higher grades.

While there are a large number of companies manufacturing putty, it is believed that owing to the high grade character of the product and availability of source of supply, as regards transportation to market centers, successful competition can be entered into without cutting prices.

MANUFACTURING WHITING AND PUTTY FROM CALCITE.

Character of Processes.—After fine grinding by the Raymond Mill, it is air floated by the Raymond air separator. This gives a whiting suitable for sale for paints and saleable as extra gilders and paris white equal to that of the best English cliffstone. The fine grinding to 200 or 240 mesh overcomes the crystalline texture just sufficiently to make it a highly desirable product for such use. The unusual whiteness of the product, good body and purity makes it equal to or better than that obtained from the best chalk.

To obtain the proper physical characteristics for grinding with or to make putty, the use of a buhr mill grinding the calcite to 85 mesh fineness is proposed. The putty chaser will then further reduce the product alleviating any sharp edges, and preventing a mushy product from being formed, as would be the case if a finely ground product were used direct. The use of this mill for finer grinding, say to 100 mesh, will give a product of gilder's grade. The commercial and gilders grade whitings made from the calcite will be superior to that made from chalk because of their greater purity and whiteness.

RESUME OF PROPERTIES AND APPLICATION OF CALCITE WHITING.

The best grade is nearly chemically pure, 99.46 per cent. The second, or off-color grade, 96.21 per cent, is purer than the best commercial chalk whiting. It is valuable for medicinal purposes, in oils and petroleums, and for soils, to correct acidity. It would also be of service for wood alcohol. It is too costly for use on soils. It is as good a product as can be obtained for the manufacture of carbonic acid gas and other calcium compounds. The best grade will be saleable for use in the manufacture of the best grades of glass. For this purpose, because of its purity, it will replace marble dust, which is contaminated with silica, etc., and while silica is not a harmful constituent in making glass, it can be bought cheaper separate from the whiting.

It could be used in the manufacture of lime, mortars, cement, the Leblanc, cryolite and caustic soda processes, in the manufacture of bleaching powder, but for most of

these purposes, except for special grades, it is too costly. The same is true of its use for flux.

It consists of minute rhombohedral cleavages, angular and sometimes broken. This gives tooth and makes it valuable for base coats for gilding and for loading wall papers. The maximum particles are 1-300 inch, and from that on down. This and the angularity makes against marked plasticity. The theoretical weight per cubic foot of the dry product is 165 lbs. The actual weight about one-third less; the chalk whiting about the same. The calcite whiting's translucency is greater than of any of the other forms of whiting, hence it is far the best for extending colors in colored water paints, and may be used, but not to excess, to good advantage in colored oil paints. It requires 20 to 25 per cent less oil for grinding into putty than chalk whiting, hence can be produced and sold cheaper. The plasticity will be less than for chalk putty, but the color cream white as against gray. It will make a better putty than some sold recently for putty of the best grade, and found to consist largely of marble dust, gray in color and of not as great plasticity, the largest particles 1-100 inch long.

Owing to the translucency and the size of the particles calcite whiting has no body for oil paints, but for most calcimines and cold water paints will make a whiter paint than the best gilders chalk whiting. It has, however, slightly less covering power than the latter.

The off-color calcite whiting can be used as a filler for the cheaper grades of rubber and gutta percha. The coarseness of the particles may be against its use alone for the better grades, as it does not give sufficient homogeneity. Calcite whiting has a hardness of 3 and can be used in polishing mixtures for metals and in tooth powders. Chalk whiting is slightly softer, and not as angular.

In order to correct the lack of plasticity, it should be used in connection with precipitated calcite whiting (precipitated from cold solutions). This is a by-product whiting which sells at $2.00 per ton in bulk. It consists of microscopic rhombohedral crystals measuring .000745 mm. maximum, the average being .00039 or less. The fineness makes for plasticity and by putting up a considerable number (it would take 20 to make the thickness of an average paint coating .003 inch) the translucency is greatly reduced, and the covering power is considerable.

Its absorbent power is so considerable that it would require too much oil to make putty, but the putty would be very white. By mixing a by-product whiting with calcite in certain proportions a product may be obtained which will be superior to any whiting on the market for use in oil paints, water paints, white or colored calcimine, putties, rubber filling, or polishing powders. By-product whiting is now sold by one large company in New York City chiefly for rubber filling and carbonic acid manufacture, and it would no doubt welcome the opportunity to extend the use of its product. The mixed product can be sold as cheaply as chalk whiting. Calcite is also being used, to some extent, for glazing papers.