GEOLOGICAL SURVEY OF KENTUCKY.

JOHN R. PROCTER, Director.

CHEMICAL ANALYSES.

A

VOL. II

FOURTH, FIFTH, AND SIXTH CHEMICAL REPORTS, AND COMPARATIVE VIEWS OF THE COMPOSITION OF SOILS, COALS, ORES, LIMESTONES, CLAYS, MARLS, MINERAL WATERS, ETC., ETC.

BY ROBERT PETER, M. D., ETC., ETC., CHEMIST TO THE SURVEY, AND A. M. PETER, ASSISTANT.

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GEOLOGICAL SURVEY OF KENTUCKY.

JOHN R. PROCTER, DIRECTOR.

CHEMICAL REPORT

OF THE

SOILS, COALS, ORES, CLAYS, MARLS, MINERAL WATERS, ROCKS, &C.,

OF KENTUCKY,

BY ROBERT PETER, M. D., ETC., ETC.,

CHEMIST TO THE SURVEY.

THE FOURTH REPORT IN THE NEW SERIES AND THE EIGHTH SINCE THE BEGINNING OF THE GEOLOGICAL SURVEY.

PART XIII. VOL. V. SECOND SERIES.

STEREOTYPED FOR THE SURVEY

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INTRODUCTORY NOTE.

CHEMICAL LABORATORY OF KENTUCKY GEOLOGICAL SURVEY,
LEXINGTON, KY., June 10, 1879.

Prof. JOHN R. PROCTER, *Director of Kentucky Geological Survey:*

DEAR SIR: Herewith I respectfully submit to you the results of the chemical work performed in this Laboratory for the Geological Survey since the publication of my last report.

Yours, &c.,

ROBERT PETER.

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CHEMICAL REPORT.

Of the one hundred and fifty-two new analyses reported on the following pages, there are of—

Soils, subsoils, and under-clays	90
Clays and marly clays and shales	25
Limestones	13
Waters	8
Iron ores	6
Coals	5
Silicious residues of soils	5

The soils examined show, as usual, a great variety of composition, as may be seen in the following table of their extremes of variation:

	(*a*) Per cent.	No.	County.	(*b*) Per cent.	No.	County.
Organic and volatile matters vary from	9.305	in 2123	from Fulton .	to 1.840	in 2212	from M'Cr'k'n
Alumina and iron and manganese oxides vary from	14.368	in 2215	from Nelson .	to 2.932	in 2112	from Clinton.
Lime carbonate varies from.	2.465	in 2206	from Madison.	to .070	2212 and 2252	McCracken and Wayne
Magnesia varies from.	.989	in 2206	from Madison	to .052	in 2221	from Pulaski.
Phosphoric acid varies from.	.387	in 2206	from Madison	to .029	in 2253	from Wayne.
Potash extracted by acids varies from	1.097	in 2154	from H'nd'rs'n	to .021	in 2253	from Wayne.
Soda extracted by acids varies from	.657	in 2215	from Nelson .	to traces	in several.	
Water expelled at 380° F. varies from	3.810	in 2123	from Fulton .	to .420	in 2153	from H'nd'rs'n
Sand and insoluble silicates vary from	76.715	in 2206	from Madison.	to 94.590	in 2253	from Wayne.
Water expelled at 212° F. varies from	4.104	in 2123	from Fulton .	to .444	in 2253	from Wayne.
Potash in the insoluble silicates varies from.	2.742	in 2215	from Nelson .	to .327	in 2112	from Clinton.
Soda in the insoluble silicates varies from	1.208	in 2099	from Ballard .	to .101	in 2110	from Clinton.
Gravel varies from.	None	in most	of these soils .	to 34.700	in 2220	from Pulaski.

Columns (*a*) and (*b*) give the chemical composition of very rich and very poor soils; but being made up of extremes from the various soils, they do not represent the composition of any one of them. As may be seen by reference, these extremes are not quite so great as those reported in Volume IV and in the first part of this volume of these Reports.

Summing up all the soil analyses which have been made and reported, by the writer, for the Geological Survey of Kentucky, since its commencement in 1854, under the late David Dale Owen, M. D., to the present time, he finds them to number seven hundred and seventy-two; including soils,

subsoils, and under-clays from eighty-seven counties of the State.

Of these, there were only one sample each from ten counties, two samples each from six counties, and three each from fifteen counties. From twenty-nine counties no samples of soils have as yet been collected. Of those reported in the following pages, nearly one half were collected in the year 1859, from the eastern coal field of our State, by Joseph Lesley, jr., then Geological Assistant in the Survey under Dr. Owen. These specimens of soils, having been carefully preserved in a dry place since the time of their collection, have remained unchanged, and their analyses are interesting, as proving that even in this sparsely settled mountainous region of Kentucky the soil is generally susceptible of profitable cultivation.

It is to be specially noted that, as the greater part of the soils of our State have been produced, in the localities in which they are found, by the disintegration of the superficial rock strata, and are not, like most of the soils of the great territory north and west of us, made up of mixed detritus which has been brought from other regions by the moving force of ice and water, the local character of our various soils is more dependent on that of their rock substrata than in the great territory in question. Hence we generally find our soils to be much richer lying on soft limestone or shaly rock strata than on the hard sandstones or conglomerates of the coal-measure formation Moreover, we find in some of the coal-measure soils a considerable proportion of angular gravel or fragments of soft ferruginous sandstone or sandy-ferruginous concretions; and in some the rounded quartzose pebbles of the millstone grit; while on the extended low plains, called in some parts of the State the "Barrens," because in former recent times they were destitute of trees, the smaller proportion or absence of gravel indicate formation of the soil under comparatively quiet water, by the wash of the finer earthy materials from the adjoining higher lands.

So far as our investigation has been carried, the soils of Kentucky, with the exception of some of those which lie on

the mountain slopes and valleys, especially in the coal-fields, are composed of materials in a state of very fine division; so fine, indeed, that the so called "sand and insoluble silicates," left after the digestion of the soils in chlorohydric acid (specific gravity=1.1), will pass almost entirely through the fine sieve employed, which has 1,600 meshes to the centimeter square. Nowhere in the State have we found soils containing coarse sand, like some of those in the north or northwest of our continent. Hence, in the examination of our soils, "silt analysis," or the separation of the finer from their coarser materials, so useful when applied to some soils, has not been deemed of great importance, and has been seldom resorted to in the processes used.

This high state of comminution of our soils, by increasing the porosity and extent of surface of their materials, also increases their power of absorbing and retaining the fluid, dissolved solid, or the aeriform materials of plant-food, and greatly improves their fertility. Soils of this character could only be formed under quiet waters, or under water at a distance from its shores, or by the disintegration in place of rock strata which had been deposited under these conditions.

In the process of the analysis of these soils, they were digested for seven to ten days, on the sand bath, at a temperature below boiling, in five times their weight of chlorohydric acid, of specific gravity=1.1, a little nitric acid having been added to decompose the organic matters. In all of the soils reported in this, as well as in the two preceding Chemical Reports, the quantities of potash and soda which remained in the silicious residue, after digestion in these acids, was determined by a separate process, viz: that of ignition with a mixture of calcium carbonate and ammonium chloride, &c., according to the method of J. Lawrence Smith. These quantities, as may be observed by reference to the several analyses, are generally quite considerable.

On comparing the proportions of these two alkalies, severally, in the "sand and insoluble silicates" of the soils above mentioned, in number amounting to more than two hundred

and fifty, we find their extremes to be as follows, calculated into the weight of the original soil:

The percentage of *potash* in the silicious residues varies from 2.910 per cent. in No. 2037, from Harlan county, to 0.327 per cent. in No. 2112, from Clinton county.

The percentage of *soda* varies from 1.208 per cent. in No. 2099, from Ballard county, to 0.018 per cent. in No. 1678, from Bell county.

The general composition of several of these silicious residues, as ascertained by complete analyses, by fusion with the alkaline carbonates, &c., is reported under the heads of Fulton and Nelson counties, to which the reader is referred for proof of the statement frequently made by the writer, that in this silicious skeleton of our soils a considerable proportion of silicates are found, which, while they may resist for a time the action of even moderately strong mineral acids, may yet, by a slow process of natural "weathering," measurably renovate the fertility of the soil from their reserved store of essential mineral elements of plant food.

In what form do these silicates exist in our soils, is a question of some interest. It has been known for some little time that silicates of the Zeolite group are found in soils, and that they perform a very important office in that selective, absorptive power which the soil possesses, by which it can withdraw from watery solutions, and hold for the benefit of growing vegetables, many essential elements of plant nourishment which else would be washed away in the drainage. Such silicates, no doubt, exist in our Kentucky soils; but they are known to be readily soluble in, or decomposable by, acids. It would seem probable, therefore, that the silicates, or the partly-weathered remains of silicates, in the silicious residue of our Kentucky soils, which had, to a certain extent, resisted the prolonged digestion in acids, were more of the nature of the minerals constituting the Feldspar group than the Zeolites.

As has been frequently stated in the reports, this silicious residue of our soils frequently left upon the fine sieve more or less of small particles, sometimes rounded, but often some-

what angular in form, which were generally soft enough to be crushed by the fingers into a powder fine enough to pass through the fine sieve. Until recently, the writer believed that these small particles represented, in their form at least, those silicates in the soil which had undergone a partial decomposition in the acid digestion, and which still retained, in their soft silicious skeletons, some of those alkalies which were found in the silicious residues.

But observing that the proportion of these residual soft particles did not bear any constant relation to that of the alkalies in the silicious residue, he was induced to examine, by washing with water, some of these soils, which left, after digestion in acids, the largest quantity of these so-called "partly decomposed silicates," and he was somewhat surprised to find that, in these soils at least, these soft particles were derived from little concretions in the soil, of the nature of so called "shot iron ore," which probably had their origin in the infiltration of dissolved oxides of iron and manganese, or of calcium carbonate, or may have been originally oölitic aggregations in the rocks from whence the soils had been derived. Be this as it may, however, the important fact remains, that in the fine sandy or silicious residue of our soils, after prolonged digestion in acids, there exist potash, soda, lime, magnesia, and even a little phosphoric acid, which materials, although held in pretty firm combination as silicates in the insoluble residue, may prolong the productiveness of the soils under the slow decomposing action of the atmospheric agencies. Another fact is, that these silicates are in a state of as minute division in our soils as the fine silicious sand itself.

Of the eighteen new analyses of *Clays* herewith reported, fourteen are of clays from the tertiary formation, and one from the quaternary of the southwestern extremity of Kentucky, called the "Jackson Purchase." Three are from the Lower Silurian formation in Madison county.

The *tertiary deposits* of the first-mentioned region show considerable variety in their composition and properties. Some

are highly silicious or sandy; some are quite calcareous; and others, containing more alumina, exhibit different varieties of clay, some being of the nature of good fire-clay. Those which contain a considerable proportion of silicious matter, some of which may be in the form of fine sand, and which contain but small quantities of iron oxide, lime, potash, or soda, deserve a trial as glass-pot clay, provided they are sufficiently plastic, or burn sufficiently hard. Others may be available as fire-clay for many other purposes, and several would answer well for the manufacture of different sorts of pottery-ware, terra-cotta, drain-tiles, bricks, &c., according to their nature.

Some of these beds, their material being in a finely-divided state and friable, might be made useful in the manufacture of artificial hydraulic cement, of the character of Portland cement, whenever such an industry may be profitable in this region. Some of these deposits are so highly quartzose that they could be employed in the manufacture of glass. The "loess" from the quaternary may be locally useful as a top-dressing on heavy clay soils, &c.

The *clays* reported from Madison county are too readily fusible to be used as fire-clays, yet are good plastic clays for the manufacture of hard stoneware or some forms of terra-cotta, &c. The marly clays and shales from the Silurian limestone strata are remarkable for their large proportions of potash; the one from the Lower Silurian in Fayette county giving nearly eight per cent. of that alkali. They also have considerable quantities of lime, iron oxide, &c., and no doubt all contain phosphoric acid, so that their use as fertilizing top-dressing on exhausted light soils might be locally beneficial. They are too fusible for some kinds of pottery, yet might be made into drain-tiles and similar products, or, in some cases, into stone-ware.

The thirteen *limestones* reported in the following pages are mostly from Madison county; one only from Franklin county; and are interesting mainly because the composition of several of them indicates their probable availability for the manufacture of *hydraulic cement.* It is true that imperfect trials made

of some of these, in the laboratory, with insufficient appliances, did not give decidedly favorable results in this relation; yet, probably, by a more perfect mode of calcination, adapted to their nature, the hydraulic properties might be developed.

For the purpose of comparison, the writer has appended to the table of the composition of these limestones, at the end of this Report, that of two undoubtedly good hydraulic limestones, copied from previous volumes of Reports of Kentucky Geological Survey.

It seems, however, that although we may learn much from the ultimate chemical composition of limestones, as to their availability for hydraulic cements, there are some necessary conditions to the production of these useful compounds not yet fully understood or appreciated, as is proved by the circumstance that while two different limestones may show, by analyses, nearly similar chemical compositions, they may yet give products, when calcined, which differ greatly in their value as hydraulic cements.

These conditions may possibly be physical, or what is more probable, the silica in the two limestones may be under different chemical relationships. Probably the impure limestone, which gives the best cement by calcination, has its silica already more or less naturally combined with lime or other bases, as silicates or hydrated silicates; while in the other, of similar ultimate composition, the silica may be more in a separated, insoluble state, or in firmer combination with other elements. This supposition is rendered probable by the fact that there are natural hydrated silicates which possess, to an eminent degree, the property of forming good hydraulic cements by simple mixture with pure quicklime and water. The best known of these, the volcanic tufa found near Naples, called Pozzuolana, is found to contain a large proportion of soluble silica in the form of hydrated silicates; and it has been found by experience, that when the water of its silicates is driven off by calcination, it loses its valuable hydraulic properties. Most of these Pozzuolanas contain a considerable proportion of alkalies, varying from more than one to about ten

per cent., and in the artificial compounds of this kind made by calcining certain marly clays, at a heat sufficient to burn lime, it is probable that the well-known large proportion of alkalies generally found in these clays is essential in bringing the silica into a soluble condition.

It is now pretty generally acknowledged by men of science that the property of hardening under water depends on the presence or formation of silicate of lime in the cement. In this connection it may be well to observe, that in the analysis of the hydraulic limestone from Indiana, No. 1068, referred to above, it was found that as much as three per cent. of silica, soluble in a boiling solution of carbonate of soda, was contained in this uncalcined limestone. This amount of silica undoubtedly existed in the rock, in the form of silicate easily decomposable by acids, having been separated by the acids in the soluble or gelatinous form. After the calcination of this limestone, the proportion of the soluble silica was increased to more than fourteen per cent. of the calcined rock. In some of the Ohio Falls hydraulic cement, which had been hardened under water about twenty-eight years before it was analyzed by the writer, he found more than six per cent. of the silica yet in a soluble condition. (See Vol. IV, O. S. Ky. Geol. Reports, p. 190.)

As the property of hardening under water seems to depend on the formation of a silicate of lime, probably also sometimes of silicates of magnesia or of iron, the essential conditions for hydraulic lime are not only the presence of a sufficient amount of silica to form the hard compound which resists the solvent action of water, but also that the silica should be in a form favorable to its combination with the lime or other bases, as well as, most probably, the presence of substances which, like the alkalies, may aid in bringing about this combination. The alkalies, potash, and soda seem to be the best agents in promoting this action, and it has been found by experience, in the manufacture of the celebrated artificial Portland cement, by calcining a mixture of chalk and clay, that the addition of a half to one per cent. of soda is greatly beneficial. Magnesia also seems to exert a favorable action; indeed, some mag-

nesian limestones, which contain but a small proportion of silica, make good hydraulic cement, if calcined at a moderate red heat only; and most of our hydraulic limestones are magnesian. Pure calcined magnesia, one of the most insoluble of the earths, will set quite hard with a proper quantity of water. It is probable, as already hinted, that the oxide of iron may be useful in hydraulic cements, by increasing their hardness and durability, as may also alumina.

In the manufacture of the artificial Portland cement, a mixture of impure carbonate of lime, chalk, and clay from various sources, is finely powdered and intimately blended, and then calcined at a heat sufficient to cause a commencement of vitrification; and the best proportions are found to be from twenty-one to twenty-three of clay to seventy-nine to seventy-seven of chalk. Clay from different localities varies in its proportion of silica as much as from less than fifty to nearly eighty per cent., causing variations in the properties and value of the cement.

A very good cement, of the kind employed at Boulogne, France, is reported to have the following *composition:*

Lime	65.00
Magnesia	trace.
Alumina and iron oxide	8.70
Alkalies	.45
Silica	24.45
Water	.80
	99.40

It is generally said, that if the proportion of lime falls below 39.8 per cent.—equal to 70 per cent. of carbonate of lime in the uncalcined mixture—the obtained cement may harden quickly, but will not be durable.

Another very good artificial cement of this kind, reported by scientific writers, is that made by M. St. Leger, near Paris, France, by calcining an intimate mixture of the chalk of Meudon with 14.3 per cent. of the clay of Vannes. The composition of this, after burning, is reported to be—lime, 75.60; silica, 15.86; alumina, 7.93, and iron peroxide, 1.62 per cent. It is said to be wholly soluble in acids.

These remarks and quotations may aid in estimating the probabilities of the utility of our impure limestones, &c.

BALLARD COUNTY.

SOILS AND SUBSOILS.

No. 2096—SOIL LABELED "*Top soil from the 'Barrens;' four years in cultivation in tobacco, three years in corn, and four in wheat; the last and present year* (1878) *in tobacco. Farm of W. H. Reeves, about six miles north of Blandville.*" *Collected by John R. Procter.*

The dried soil is in friable lumps, of a dirty yellowish-brown color. The coarse sieve* separated a few soft, ferruginous concretions and a small quartz pebble.

No. 2097—"*Subsoil of the field above described. Sample taken twelve to eighteen inches below the surface.*" *Collected by John R. Procter.*

The dried subsoil is in friable clods; its color is somewhat lighter than that of the preceding. The coarse sieve removed from it only a few small, rounded ferruginous concretions.

No. 2098—"*Subsoil of the uplands around Blandville. Taken from eighteen to twenty-four inches below the surface. Characteristic of most of the upland subsoil in the Jackson Purchase. A silicious loam above the Paducah gravel.*" *Collected by Jno. R. Procter.*

The dried subsoil is in pretty firm lumps, of a handsome brownish-buff or ochreous color, mottled with lighter and darker tints. All passed through the coarse sieve.

No. 2099—"*Subsoil or under-clay of the uplands around Blandville. Taken several feet below the surface. It crops out just below the gravel bed, and is several feet thick. It is observed nearly all over the 'Jackson Purchase' where there is much soil.*" *Collected by John R. Procter.*

The dried subsoil is of a brownish-buff color, mottled with somewhat lighter colored, and showing some thin, dark-colored

* The coarse sieve used has about 64 meshes to the centimetre square.

infiltrations of iron and manganese oxides. All of it passed through the coarse sieve.

No. 2100—"*Virgin soil. Top soil of bottom land, near Shelton and Moore's Mill, on Mayfield creek. Said to produce good hay, but to be otherwise unproductive. Primitive growth, black, white, and red oak, sweet gum, elm, persimmon, and hickory.*" *Collected by John R. Procter.*

Dried soil of an umber-grey color, in quite friable clods, apparently containing much fine sand. The coarse sieve removed from it only a few small, partly-rounded quartz particles.

No. 2101—"*Top soil from an old field long in cultivation. Bottom land, on Mayfield creek.*" *Collected by John R. Procter.*

The dried soil is slightly lighter colored than the preceding, and more yellowish. The coarse sieve removed only a few small silicious particles.

No. 2102—"*Subsoil of the next preceding. Bottom land on Mayfield creek.*" *Collected by John R. Procter.*

Clods more firm than those of next preceding, and lighter colored, mottled with lighter colored and ochreous tints. The coarse sieve removed from it a small quantity of small silicious gravel.

COMPOSITION OF THESE BALLARD COUNTY SOILS, DRIED AT 212° F.

	No. 2096	No. 2097	No. 2098	No. 2099	No. 2100	No. 2101	No. 2102
Organic and volatile matters	4.065	2.790	2.185	1.565	3.210	2.565	2.125
Alumina & iron & manganese oxides	5.904	7.597	8.557	7.835	6.150	3.864	5.088
Lime carbonate	1.095	.295	.195	.645	.155	.385	.245
Magnesia	.394	.308	.544	.601	.268	.163	.184
Phosphoric acid (P_2O_5)	.246	.093	.093	.140	.115	.061	.077
Potash, extracted by acids	.289	.449	.131	.175	.203	.319	.276
Soda, extracted by acids	.242	.148	.653	.309	.364	.362	.129
Water, expelled at 380° F.	.935	.760	.450	.435	1.065	.635	.675
Sand and insoluble silicates	87.120	87.395	87.110	87.495	88.890	92.010	91.570
Total	100.292	99.835	99.918	99.200	100.420	100.364	100.369
Hygroscopic moisture	2.000	2.300	2.735	2.300	1.865	1.075	1.125
Potash in the insoluble silicates	1.619	1.482	1.085	2.138	1.659	1.358	1.401
Soda in the insoluble silicates	.680	.674	.536	1.208	1.150	.616	.911
Character of the soil	Surface soil.	Subsoil.	Subsoil.	Subsoil or under-clay	Virgin soil	Old field soil	Subsoil.

Some differences were observed in the silicious residue or sand and insoluble silicates of these several soils, when sifted with fine bolting-cloth, which had about 900 meshes to the centimetre square. For example, while that of Nos. 2096, 2097, 2098 all passed through except very few small hyaline or reddish quartz particles, Nos. 2099 and 2100 left upon the bolting-cloth a considerable proportion of small particles of partly decomposed silicates or concretions; the silicious skeletons, as it were, of these substances, from which most of their soluble ingredients had been removed by the acids in which they had been digested, were generally so soft as to be easily crushed under the finger; after which crushing, they readily passed through the bolting-cloth. The bolting-cloth also separated from them a few small quartzose particles, hyaline, opake, and reddish. No. 2101 left none of these soft remains of decomposed concretions on the bolting-cloth, but a few small quartzose particles; while No. 2102 gave a few of these soft, partly-decomposed particles, and rather more of the small quartzose granules than the next preceding soil.

These Ballard county soils, if well drained, no doubt are good productive soils under good management. In all of them, however, except, perhaps, No. 2096, the proportion of organic and volatile matters is quite small, and this, as might be expected, is particularly to be noticed in the deep subsoil or under-clay, No. 2099; but this deficiency might be supplied by the culture of clover or other green crops, to be plowed under after or without grazing. They all contain enough of lime and magnesia, as well as of potash and soda; some of them, indeed, contain more than the average proportion of these essential alkalies, not only in a condition to be immediately available for plant nourishment, but also as a considerable reserve in the insoluble silicates. Nos. 2097, 2101, and 2102, containing but a moderate proportion of phosphoric acid, would no doubt be greatly increased in fertility by the use of phosphatic fertilizers, such as ground bone, superphosphate, guano, &c. Nos. 2101 and 2102 contain more than the average proportion of fine sand and insoluble sili-

cates, and but a small quantity of alumina, &c., &c., and consequently may be less durable naturally than some of the others; but the state of very fine division of their silicious constituents compensates, measurably, the paucity of the clay ingredients. The so-called "barrens" soil is one of the richest of them all.

CLAYS OF BALLARD COUNTY.

No. 2103—"*Ochreous Clay, from southern part of Ballard county.*" *Collected by John R. Procter.* "*Will it make a good and durable paint? Found in several parts of this county.*"

In friable lumps of a yellow ochre color, with some little infiltration of whitish material. It becomes soft and plastic when placed in water. Mixed up with a large quantity of water, and allowed to stand at rest for a few minutes, a portion of fine sand, equal to about twenty-six and a half per cent., settles to the bottom of the mixture, while the ochreous material remains suspended in the water for a considerable time in consequence of its fine state of division.

This fine sand is composed of small, rounded grains of transparent quartz, colored light buff by a little adhering ochreous material; it contained a few small spangles of mica.

It would be easy, by this simple process of washing, to separate the ochre from the fine sand with which it is naturally mixed. The washed ochre, although not very bright, is of a good color, and could be very well used for a cheap and durable paint for outside work. Calcined in the fire, it becomes of a good Venetian red color.

No. 2104—"*Clay, at least four feet thick, from near Moore's Mill. Base of hill on the north side of the Columbus and Blandville road; one mile southwest of Blandville.*" *Collected by John R. Procter.*

Clay in friable lumps; generally of a very light grey color, nearly white; mottled somewhat with ochreous material. It is quite plastic with water, and calcines of a light salmon color.

Quite refractory before the blow-pipe. Washed several times with water, allowing ten minutes each time for subsidence, it left nearly 48 *per cent. of quite fine white sand*, which was so fine, indeed, that it was somewhat plastic while wet, and adherent when dry.

On comparing the composition of this clay with that of the celebrated German Glass Pot Clay, so extensively imported by our glass manufacturers, a remarkable resemblance is observable. That the comparison may be made by our readers, we copy here the results of two analyses of the German clay, from Geological Reports of Kentucky, Vol. IV, N. S., p. 163, marked H and I, and place them by the side of that of the clay above described, No. 2104, as follows:

COMPOSITION, DRIED AT 212° F.

	No. 2104.	H.	I
Silica, including pure sand	74.460	70.860	73.660
Alumina	18.070	20.900	19.460
Iron peroxide	1.633	1.560	1.560
Lime	.314	.347	.168
Magnesia	.245	.220	.209
Potash	.940	.578	.520
Soda	.021	.112	.046
Water expelled at red heat and loss	4.317	6.800	6.200
Total	100.000	101.377	101.823

If this clay is in sufficient quantity in this locality, it certainly deserves trial in the glass-house for this important use, as the importation of the German clay for glass pots, now considered indispensable, is quite expensive. At all events, this No. 2104 is quite a refractory fire-clay, although it contains more potash than the imported article, which may possibly impair its value in this respect.

Other sandy clays; one from Graves county, No. 2143, and one from Hickman county, No. 2162 of present report, closely resemble this in composition, but containing rather more potash; also deserve trial in this relation.

No. 2105—"*Clay, from the farm of Mr. T. D. Campbell, in South Ballard county.*" *Sent by John R. Procter.*

In a friable lump, as soft as chalk, of a handsome, light purplish-grey color, presenting a somewhat stratified appearance, because of interrupted thin laminæ of lighter material. It shows a few ochreous specks, and appears to be somewhat sandy.

Washed in water, it left fifty-four per cent. of very fine sand of a light lilac color, some more of still finer sand being left in the washings. It is quite plastic, decrepitates strongly when exposed to heat, unless it is thoroughly dry. Calcines hard; of a handsome light purplish-grey color. Before the blow-pipe it proved quite refractory.

COMPOSITION, DRIED AT 212° F.

Silica	67.501
Alumina, &c.	23.051
Iron peroxide	2.109
Lime	.257
Magnesia	.065
Potash	.412
Soda	.020
Combined water, &c., and loss	6.585
Total	100.000

This clay would, no doubt, answer well for many forms of pottery, as well as for fire-bricks. But for the somewhat undue proportion of iron oxide, it might probably serve all purposes of the most refractory clay.

No. 2106—"*Impure sand, from T. D. Campbell, southern part of Ballard county.*"

A dirty, olive-brownish sand, abundantly mixed with ochreous or ferruginous material, mottled with blackish, containing some ochreous sandy concretions.

Digested in chloro-hydric acid, it left nearly ninety-eight per cent. of sand, composed mostly of rounded grains of hyaline quartz, mixed with some very fine sand, and some few rounded pebbles of milky quartz of various sizes. The acid dissolved out of it less than two per cent. of alumina and iron and manganese oxides, with traces of lime, magnesia, &c.

This sand would answer well for the manufacture of the common kinds of glass in extensive use, as well as for mixing with cement and mortar for building purposes, &c.

MINERAL WATERS FROM BALLARD COUNTY.

No. 2107 A—"*Water from the 'Bluff Spring.' On the road from Columbus to Cairo, in the milk-sick region, and supposed by some to cause this sickness.*" *Sent for examination by Hon. S. H. Jenkins.*

The water had deposited a considerable brownish sediment, which did not all dissolve in chloro-hydric acid.

Qualitative analysis showed the presence of some free carbonic acid, much of bi-carbonates of lime and magnesia, some little bi-carbonate of iron, and of chlorine and sulphuric acid in combination.

The water had a slightly alkaline reaction, and the spectroscope showed the presence of a trace of lithium. There is no reason to suppose that this water has anything to do with the causation of milk-sickness.

No. 2107 B—"*Water from the 'Mahon Spring.' Said to be unhealthy, and by some thought to cause milk-sickness.*" *Sent by Hon. S. H. Jenkins.*

Qualitatively examined, it gave similar reactions with the water from the "Bluff Spring," but did not seem to contain as much iron; and there was no brown sediment in the bottle containing it.

A weighed portion of this water, evaporated to dryness, left only 0.36 per thousand of the water of whitish saline residue, dried at 212°. The soluble part of this had an alkaline reaction, and the spectroscope showed the presence in it of soda and lithia.

It seems to be a perfectly wholesome water, although, like the above, somewhat "hard" from the presence of lime and magnesia bi-carbonates. The water A is also slightly chalybeate.

CLARK COUNTY.

No. 2108—"*Water from a bored well, seventy-two feet deep, near Winchester. Bored through limestone and so-called 'soap-stone' (or marlite).*" *Brought by Mr. B. F. Vanmeter, and analyzed for him.*

The water was slightly alkaline in reaction, contained no hydrogen sulphide, and had formed no sediment in the bottle in which it was brought to the laboratory.

Evaporated to dryness, 1000 parts of the water left only 0.5912 part of saline matters, dried at 212° F. These were quite alkaline in reaction, and the spectroscope showed the presence in them of soda, lithia, potash, strontia, and a doubtful trace of baryta.

Qualitative analysis detected much chlorine, some carbonic acid, and a little sulphuric acid, in combination with a considerable proportion of lime and magnesia, as well as with the bases above mentioned, but no sensible quantity of iron.

This water is much more free from saline matters and hydrogen sulphide than what is usually obtained by boring to such a depth in this limestone region.

CLINTON COUNTY.

SOILS.

No. 2109—"*Virgin soil from the farm of Lewis Huff, at the north end of the 'Copperas Knob,' at Huff's coal bank; one mile east from the 'Livingston road' and from Mr. Huff's house; about three miles west of south of Long's Gap. Geological position, on the first terrace above the sub-carboniferous limestone, and the second below coal, and on the steep terrace slopes of the coal-bearing sandstone and shales.*" *Collected by Joseph Lesley, jr., July,* 1859.

The dried soil is friable, and of a dark umber-grey color. The coarse sieve separated from it 22.4 per cent. of irregular, slightly-rounded fragments, some pretty large, of ferruginous sandstone or silico-ferruginous concretions. The analysis given below was of the "fine earth" separated from these fragments by the coarse sieve; and the ultimate value of these soils must therefore be discounted by the amount of these

coarse, rocky fragments thus separated. The bolting-cloth removed from the silicious residue (stated as sand and insoluble silicates) a considerable proportion of small grains of partly decomposed concretions or silicates, easily crushed to fine powder, and a few small, rounded quartzose particles.

No. 2110—"*Surface soil from the same field as the preceding. Was cleared in* 1853. *Has been in corn every year, including the present* (1859)." *Collected by Jos. Lesley, jr.*

The dried soil resembles the preceding; is very slightly darker than that. The coarse sieve removed from it 27 per cent. of ferruginous silicious fragments; some large; not rounded.

The bolting-cloth separated from the sand and insoluble silicates only a small proportion of particles of partly-decomposed concretions or silicates, and a very few small, rounded grains of white quartz.

No. 2111—"*Subsoil of the next preceding*," *&c., &c.*

This subsoil is slightly darker colored than the preceding, which it resembles. The coarse sieve removed from it 14.2 per cent. of irregular fragments of ferruginous sandstone, not much rounded, and a few small, rounded quartz pebbles.

All the silicious residue, from digestion in acids, passed through the bolting-cloth, except a small proportion of soft particles of partly-decomposed silicates or concretions, and very few small, rounded quartz grains.

No. 2112—"*Virgin soil from the farm of John Wade, on the head of Indian creek, on the Monticello and Albany road, sixteen and three quarter miles southwest of the former place, and seven miles northeast of the latter; one mile north of Wade's Gap, and at the south foot of 'Short Mountain.' Geological position, sub-carboniferous limestone.*" *Collected by Joseph Lesley, jr.*

This dried soil is of a light brownish-grey color. It is quite friable and light. The coarse sieve separated from it as much as 29.5 per cent. of angular fragments of chert and somewhat rounded particles of ferruginous sandstone. All of its silicious

residue passed through the bolting-cloth except a small proportion of small, rounded grains of white quartz, and a few particles of partly decomposed silicates or concretions.

No. 2113—"*Surface soil from a field across the road from the place of the next preceding. Now* (1859) *in corn; last year in wheat; year before in grass. Was cleared in* 1803, *and for twelve years was set uninterruptedly in corn, and has been cultivated ever since, with not enough manure to speak of.*" *Collected by Joseph Lesley, jr.*

The dried soil is of a light snuff color, but darker colored and more brownish than the next preceding; friable. The coarse sieve removed only 4.4 per cent. of somewhat rounded ferruginous sandstone fragments, with a few small quartzose concretions. All the silicious residue passed through the bolting-cloth, except a small proportion of small, rounded white quartz grains and a few of partly decomposed silicates or concretions.

No. 2114—"*Subsoil of the next preceding*," *&c., &c.*

This dried subsoil is very much like the soil next preceding, but is of a slightly darker color. It is quite friable. The coarse sieve separated from it 8.2 per cent. of somewhat rounded particles of ferruginous sandstone. All the silicious residue passed through the bolting-cloth, except a small proportion of small rounded grains of white quartz and a few of partly decomposed silicates or concretions.

COMPOSITION OF THESE CLINTON COUNTY SOILS, DRIED AT 212°.F.

	No. 2109.	No. 2110	No. 2111	No. 2112.	No. 2113.	No. 2114.
Organic and volatile matters	6.615	9.275	6.910	3.000	4.320	4.695
Alumina and iron and manganese oxides	5.984	6.687	6.951	2.932	6.129	6.247
Lime carbonate	.405	.620	.480	.080	295	.195
Magnesia	.232	.232	.223	.106	.124	.108
Phosphoric acid (P_2O_5)	.166	.173	.259	.093	.071	.093
Potash extracted by acids	.212	.274	.222	.155	.170	.183
Soda extracted by acids	not est.	not est.	not est.	not est.	not est.	not est.
Water expelled at 380° F.	1.400	1.810	1.665	1.550	1.940	1.500
Sand and insoluble silicates	84 990	81.165	83.365	92.240	86.790	86.790
Total	100.004	100 236	100.075	100.156	99.839	99.816
Hygroscopic moisture	1.585	1.990	1.750	0.900	1 800	1.515
Potash in the insoluble silicates	983	.098	.972	.327	.726	.621
Soda in the insoluble silicates	217	.101	.158	.269	.263	.169
Percentage of gravel	22.400	27.000	14.200	29.500	4.400	8.200
Character of the soil	Virgin soil	Old field.	Subsoil.	Virgin soil	Old field.	Subsoil.

These Clinton county soils are from two different geological horizons; Nos. 2109, 2110, and 2111 being from the coal-measure sandstones and shales, while Nos. 2112, 2113, and 2114 are based on the sub-carboniferous limestone. Strange as it may appear, these coal-measure soils seem to be the richest in essential ingredients. Were it not for the considerable proportion of ferruginous sandstone fragments or gravel contained in these, they might be classed amongst our most productive soils, as their "fine earth," the analyses of which are given above, contains a full average proportion of potash, phosphoric acid, lime, magnesia, organic matters, &c.

The soils Nos. 2112, 2113, and 2114 are somewhat deficient in phosphoric acid, and it is remarkable that No. 1112, the virgin soil of the set, is much poorer than the soil of the old field, No. 2113, which has been in cultivation for fifty-six years, and that it is quite deficient in lime carbonate as compared with that. But this fact, as well as its much larger proportion of gravel, of a different kind from that of the other, and its lighter color, as compared with the soil of the old field and the subsoil, indicate that this and these other soils were derived from different geological sources.

CRITTENDEN COUNTY.

SOILS.

No. 2115—"*Virgin soil; half an inch below the surface. Soil two to four inches deep. Ridge land a mile and a half east of the Sulphur Springs, Crittenden county. Farm of S. C. B. McMican. Soil is derived from sandstone. Supports a growth of black, white, post, Spanish, and some black-jack oaks, poplar, hickory, elm, ash, black gum, dogwood, and some sassafras and papaw.*" *Collected by C. J. Norwood.*

A light soil, of a grey-buff or drab color. It all passed through the coarse sieve except vegetable débris.

All the sand and insoluble silicates left after digestion in the acid passed through bolting-cloth, except a small proportion of soft grains of partly-decomposed concretions, and a very few minute, rounded white quartz grains.

No. 2116—"*Subsoil of the next preceding*," *&c., &c.*

The subsoil is of a brownish-yellow ochre color, in quite firm clods. It all passed through the coarse sieve except some vegetable debris. The bolting-cloth separated from the sand and insoluble silicates more than half its weight of small, rounded particles of partly-decomposed concretions, easily crushed under the finger, and a very few small, rounded grains of white quartz.

No. 2117—"*Surface soil on ridge land; from a field in cultivation for eight years; 1st in tobacco, 2d and 3d in corn, 4th in wheat, 5th, 6th, 7th, and 8th in corn. No fertilizers used. The soil is from three to six inches deep, derived from sandstone. Sample taken one inch from the surface. Same farm as the two preceding.*" *Collected by C. J. Norwood.*

All passed through the coarse sieve except vegetable débris and a few small ferruginous concretions. The bolting-cloth separated from the silicious residue only a small proportion of particles of partly-decomposed concretions, and a very few minute, rounded grains of white quartz.

No. 2118—"*Subsoil of the next preceding*," *&c., &c.*

The dried subsoil is of a greyish-yellow ochre color; lighter than that of the virgin soil. It is in somewhat firm clods, but it all passed through the coarse sieve.

The bolting-cloth removed from the sand and insoluble silicates about half their weight of small soft particles of partly-decomposed concretions or silicates, and only some three or four small, rounded grains of white or hyaline quartz.

COMPOSITION OF THESE CRITTENDEN COUNTY SOILS, DRIED AT 212° F.

	No. 2115.	No. 2116.	No. 2117.	No. 2118.
Organic and volatile matters	2.225	2.950	3.260	2.885
Alumina and iron and manganese oxides	3.629	8.718	4.868	8.173
Lime carbonate	.160	.145	.270	.170
Magnesia	.304	.350	.214	.703
Phosphoric acid (P_2O_5)	.086	.092	.067	.102
Potash extracted by acids	.090	.309	.171	.122
Soda extracted by acids	n. e.	.118	n. e.	n. e.
Water expelled at 380° F.	.875	.925	1.225	.950
Sand and insoluble silicates	92.705	86.665	89.440	86.490
Total	100.074	100.272	99.515	99.595
Hygroscopic moisture	0.890	0.925	1.565	2.000
Potash in the insoluble silicates	1.876	2.023	1.707	1.755
Soda in the insoluble silicates	.896	.750	.694	.588
Character of the soil	Virgin soil	Subsoil.	Old field.	Subsoil.

These soils, although derived from sandstone, and containing a considerable proportion of sand and insoluble silicates; in No. 2115 as much as 92.705 per cent.; may yet be preserved in a fertile condition for an unlimited time by judicious management and the use of appropriate fertilizers. What we denominate "sand," however, in the statement of the composition of these and other soils, is in such a state of fine division as to pass freely through a sieve having 1600 meshes to the centimetre square; and while it renders the soil light and readily permeable by water and the gases, is yet so finely divided as to present in some degree the plastic properties of clay, as well as the property of attracting and holding, with surface attraction, the gases and the fertilizing materials with which it is brought in contact.

The influence of fine division of the soil has been recognized by experience, so that the German and French agricultural chemists mainly disregard the pebbles and coarse sand which enter into the composition of a soil, and estimate its fertility by the proportion and composition of the "fine earth" which it contains. This, indeed, has been the method pursued in this work for the Kentucky Geological Survey.

The soils above described contain quite a sufficient quantity of lime and magnesia, and, generally, a good proportion of potash; the ridge soil, No. 2115, showing, however, a slight deficiency in this respect; but as the phosphoric acid appears to be in rather small amount in them, the use of phosphatic fertilizers would doubtless be profitable; associated, as they always should be, with some nitrogenous material. Their fertility might, no doubt, also be improved by increasing their proportion of organic matters, by the use of barn-yard manure, or plowing under green crops, &c. Deep plowing might also be advantageous, as the subsoil is rather richer than the surface.

FAYETTE COUNTY.

No. 2119—"*Salt sulphur water from a bored well seventy-one feet two inches deep; six feet and a half of which was through soil, subsoil, and under-clay; the rest through the hard limestone rock of the Lower Silurian formation. On the farm of Mr. John C. Innis, on the Russell road, about seven miles north of Lexington.*" *Brought by Mr. Innis.*

The water contained hydrogen sulphide in notable quantity, and carbonic acid. Evaporated to dryness, it left 2.2 parts of *saline matters*, dried at 212°, to the thousand of the water, which gave a slightly alkaline reaction with reddened litmus.

By qualitative analysis the saline matters of this water were found to contain much sodium chloride (common salt); also much lime in combination, some magnesia, and a small quantity of sulphates, &c.; in short, the usual saline constituents of the rocks of this region, which lie below the surface drainage; found in the waters of almost all the deep-bored wells, and brought out in the waters of such deep-seated springs as those of the lower Blue Licks, &c., and which are derived originally, no doubt, from the primeval ocean under which the rock strata were formed.

No. 2120—"*Marly clay, occurring in a bed described as being a foot and a half thick, in the Lower Silurian limestone strata on Elk Lick, between the Kentucky river and the Lexington and Richmond Turnpike, just above the so-called 'petrified falls' of Elk Lick.*" *Collected by Waldemar Mentelle.*

A whitish clay, mottled with brownish ochreous. Quite plastic. Effervesces with chlorohydric acid. At a moderate red heat it calcines (or "burns") of a handsome flesh color, which property might commend it for use for terra-cotta, if in sufficient abundance. Before the blow-pipe it readily fuses into a whitish slag.

COMPOSITION, DRIED AT 212° F.

Silica	53.780
Alumina	23.260
Iron peroxide	1.300
Lime	4.866
Magnesia	.568
Phosphoric acid (P_2O_5)	.191
Potash	7.612
Soda	.550
Combined water, carbonic acid, and loss	7.873
Total	100.000

The considerable proportions of lime, magnesia, potash, and soda account for the fusibility of this clay at a high temperature. It resembles the usual marly clay layers of the Lower Silurian formation, and contains quite a large proportion of combined potash.

FRANKLIN COUNTY.

No. 2121—"*Limestone, supposed to be hydraulic or water lime. Kentucky river bluffs; north side; at the end of Dam No. 4. Bed three to ten feet thick. Trenton Group.*" *Collected by John R. Procter.*

A pretty compact or fine granular rock; not adhering to the tongue. Some layers laminated and slightly adherent. Generally of a dull, dark brownish, olive-grey color. Contains a few indistinct, small encrinital joints in the compact portion.

COMPOSITION, DRIED AT 212° F.

Lime carbonate	70.360 = Lime, 39.401
Magnesia carbonate	6.784 = Magnesia, 3.236
Alumina	5.458
Iron peroxide	1.342
Phosphoric acid	not est.
Potash	1.118
Soda	.281
Silica	14.020
Total	99.363

Some of the rock was calcined at a moderate red heat in the powdered state, for about one hour. It still effervesced a little with acids. Mixed with water into a paste, both with sand added and without, and partly immersed in water, both samples became only moderately hard. A portion was then calcined at a white heat, so that it became partly sintered, but the powdered product did not harden as well even as that which had been more moderately heated. It seems, therefore, that this does not promise well as a water cement when calcined without admixture. Comparing it with the celebrated water cement rock prepared near the Falls of the Ohio, near Louisville (see table at end of this report), we find that, while this Kentucky river rock contains a larger proportion of potash than that, it is relatively deficient in silica as compared with its lime. Indeed, we found that when calcined it slacked hot with water, and showed other properties of "fat" lime.

No. 2122—"*Water from the Kentucky river, collected just below the bridge at Frankfort,*" *by John R. Procter. Brought to the Laboratory in a new, well-glazed stone-ware jug, stopped with a cork.*

The water was slightly turbid, and deposited a light brownish-red sediment on standing, which contained very fine sand and red oxide of iron. It is slightly alkaline in its reaction, and left, on evaporation to dryness, only about 0.13 to the thousand parts of the water of solid saline residue, dried at 212 F. This saline residue was very slightly colored with brownish organic matter, and consisted mainly of carbonates

of lime and magnesia, which were held in solution in the water by carbonic acid; some chlorides, no doubt, of potassium, sodium, &c.; a small amount of sulphate of some of the bases mentioned; a trace of alumina and iron and manganese oxides, and a little dissolved silica.

Were it not for the trace of reddish organic matter in this water, it would be, after its sediment had been deposited by allowing it to stand at rest or removed by filtration, a remarkably good natural water; and it is probable that it would be found more free from saline and other impurities if collected above the limits of the town. It would be interesting and useful more fully to examine the water of this river, as well as of our other rivers, at different seasons of the year, especially because the use of these waters may greatly affect the health of the public; and the successful practice of many of the industrial arts depends on pure water.

FULTON COUNTY.

SOILS.

No. 2123—"*Top soil, from Mississippi bottom land, three miles southwest from Hickman, Fulton county. Principal growth. white oak, hickory, gum, and beech.*" *Collected by John R. Procter.*

The dried soil is in pretty firm clods, of a light yellowish-umber color. The coarse sieve * removed from it only a very small portion of vegetable débris. All of its silicious residue, left after digestion in acids, passed through the fine† sieve, except a small proportion of small particles of partly decomposed concretions, and only one or two small quartz grains.

No. 2124—"*Soil from the surface of a field twelve years in corn without manure. Mississippi bottom land, about two miles south of Hickman. Yield this season* (1878) *over fifty bushels of corn per acre.*" *Collected by John R. Procter.*

Dried soil in friable clods, of an umber color.

* The coarse sieve has about sixty-four meshes to the centimeter square.

† The fine sieve has about 1600 meshes to the centimeter square.

No. 2125—"*Virgin soil, from the land of Dr. G. W. Pascal, half a mile north of Fulton, Fulton county.*" *Collected by John R. Procter.*

The dried soil is in quite friable clods, of a light grey-brown color.

No. 2126—"*Surface soil, from an old field forty years in cultivation. Farm of Dr. Pascal, half a mile from Fulton. Sample taken three to twelve inches below the surface.*" *Collected by John R. Procter.*

The dried soil of a light yellowish grey-brown color. Clods friable.

No. 2127—"*Subsoil of the next preceding. Taken from thirteen to twenty inches below the surface.*" *Collected by John R. Procter.*

The dried subsoil is of a brownish-buff color. The clods are more firm than those of the preceding soil. The silicious residue of this, as well as of the other soils of this locality, described above, all passed through the bolting-cloth, except a very small proportion of small grains of partly-decomposed concretions, and of quartz. The soils all passed through the coarse sieve, with a small residue in some of vegetable débris and small ferruginous concretions.

No. 2128—"*Virgin soil. Farm of Capt. Henry Tyler, three miles southeast from Hickman, Fulton county. Growth: mostly poplar, maple, white and Spanish oaks, and some walnut.*" *Collected by John R. Procter.*

The dried soil is of a brownish-grey color. The clods are friable, and mottled with lighter grey and light ferruginous tints. The coarse sieve separated from it but a small proportion of partly rounded ferruginous particles. Its silicious residue all passed through the fine sieve except a very small proportion of small, rounded particles of partly-decomposed concretions, with no quartz particles.

No. 2129—"*Subsoil of the next preceding, &c., &c.; taken twenty-four inches below the surface.*" *Collected by John R. Procter.*

The dried subsoil is of a grey-buff color. The clods are quite firm, mottled with darker and yellowish tints. The bolting-cloth removed from the silicious residue a considerable proportion of small, soft grains of partly-decomposed concretions, but no quartz sand.

No. 2130—"*Top soil, first ten inches from surface; from an old field near the location of the next preceding soil, on Capt. Henry Tyler's farm, &c., &c. The land is in corn, as it was last year. The yield this year* (1877) *is sixty-five bushels per acre. There is a good deal of soil similar to this on the uplands bordering on the Mississippi river. Noticed similar soil in the western part of Ballard county.*" *Collected by John R. Procter.*

The dried soil is of a dark mouse color. The clods are friable. The coarse sieve removed from it only a little vegetable debris.

The fine sieve separated from the silicious residue, left after digestion in acids, a notable proportion of small, soft, rounded grains of partly-decomposed concretions, and one or two quartz grains.

No. 2131—"*Subsoil of the next preceding; taken carefully from fifteen to twenty-four inches below the surface. The bulk of the sample is from twenty-four inches below the surface.*" *Collected by John R. Procter.*

The dried subsoil is in very firm clods, of a dark mouse color. The bolting-cloth separated from the silicious residue a very large proportion, about one half, of small particles of somewhat rounded, partly-decomposed concretions.

No. 2132—"*Virgin soil; upland. On Capt. Henry Tyler's farm. Timber, proportion in the order named: black walnut, white oak, sugar maple and red oak.*" *Collected by John R. Procter.*

Dried soil in friable clods of a dirty drab color. The coarse sieve separated only a small portion of vegetable debris. All the silicious residue, from digestion in acids, passed through the bolting-cloth, except a single small quartz grain.

No. 2133—"*Subsoil of the next preceding soil, from Capt. Tyler's farm; taken twelve to twenty-four inches below the surface.*" *Collected by John R. Procter.*

Dried subsoil in firm clods, of a dark buff color. All passed through the coarse sieve. The silicious residue all passed through the bolting-cloth, except a small proportion of soft granules of partly-decomposed concretions. It contained no quartz grains.

COMPOSITION OF THESE FULTON COUNTY SOILS, DRIED AT 212° F.

	No. 2123	No. 2124	No. 2125	No. 2126	No. 2127	No. 2128	No. 2129	No. 2130	No. 2131	No. 2132	No. 2133
Organic and volatile matters	9.305	4.725	3.075	2.300	2.535	3.090	2.285	8.375	4.140	2.860	2.165
Alumina and iron and manganese oxides	10.437	5.127	5.335	4.974	8.690	3.825	7.700	6.860	10.560	3.560	6.550
Lime carbonate	1.385	1.045	.360	.190	.195	.395	.145	1.395	.795	.345	.110
Magnesia	.461	.234	.175	.162	.331	.214	.268	.598	.169	.142	.232
Phosphoric acid	.198	.198	.055	.156	.125	.125	.115	.125	.115	.125	.140
Potash extracted by acids	.142	.321	.179	.290	.141	.066	.186	.332	.208	.074	.275
Soda extracted by acids	not est	.419	not est.	.124	.098	not est.	.142	.073	.317	.182	.050
Water expelled at 380° F.	3.110	1.150	1.025	.775	.900	1.050	.840	2.650	1.501	.975	.650
Sand and insoluble silicates	74.840	87.145	89.945	91.745	86.895	91.125	87.795	79.340	82.395	91.740	89.670
Total	99.878	100.364	100.149	100.716	99.910	99.890	99.476	99.748	100.200	100.003	99.842
Hygroscopic moisture	4.100	2.350	1.685	1.400	2.585	1.335	2.610	3.585	3.975	1.000	1.725
Potash in the insoluble silicates	1.889	1.814	1.767	1.664	1.892	1.784	1.675	1.865	1.873	1.969	1.935
Soda in the insoluble silicates	.607	.858	.828	.749	.715	1.208	.893	1.030	.841	.892	.991
Character of the soil	Top soil.	Cultivated soil.	Virgin soil.	Old field	Subsoil.	Virgin soil.	Subsoil.	Old field	Subsoil.	Virgin soil.	Subsoil.

There is a considerable resemblance between the soils Nos. 2123 and 2130. They both seem to be soils of more than average fertility, containing, as they do, large proportions of organic and volatile matters, and, consequently, of hygroscopic moisture; also more than the usual quantities of alumina, &c., of lime, magnesia, phosphoric acid, and the alkalies, and leaving but a moderate quantity of silicious residue when digested in acids. If well drained, these soils will doubtless be of durable fertility.

The soils Nos. 2126, 2128, and 2131 contain more of the silicious material than the above-mentioned, and Nos. 2128 and 2132 seem to be somewhat deficient in immediately available potash; but they contain an average proportion of lime, magnesia, phosphoric acid, and generally a large amount of reserve alkalies in their silicious residues. Moreover, being of a fine texture, their small proportions of alumina, &c., will not be as great a drawback to their productiveness as might be supposed. The other soils take an intermediate position between these two groups mentioned. No. 2125 is to be distinguished by its apparent deficiency of phosphoric acid, which, however, can be easily remedied by the judicious use of phosphatic fertilizers. Organic and volatile matters seem to be in small proportion in Nos. 2126 and 2132. The subsoil, No. 2127, also shows but a small proportion; but this is a common character of subsoils.

Although these soils vary considerably in their natural fertility and probable durability, there is no reason why they all may not be kept permanently productive with judicious management and the timely use of manures.

SILICIOUS RESIDUE OF SOILS.

Desirous of ascertaining whether any notable quantity of phosphoric acid, &c., had resisted the action of the acids used in the ordinary analyses of soils, in addition to the potash and soda, the presence and proportions of which have been determined in so many of these silicious residues, some of them, after thorough digestion in nitric acid, with the addition of a little hydrochloric acid in the process for the determination

and removal of the soluble phosphoric acid, were analyzed by preliminary fusion with the alkaline carbonates and the approved processes, with the following results, viz:

COMPOSITION CALCULATED INTO 100 PARTS OF THE SILICIOUS RESIDUES, DRIED AT 212° F.

	No. 2123.	No. 2128.	No. 2132.	Average composition of 8 of these residues.
Silica	83.931	88.298	90.236	88.460
Alumina, with trace of iron	12.043	6.075	6.689	6.789
Lime	.791	.744	.600	not estimated.
Magnesia	.080	.043	.044	.569
Phosphoric acid	.077	.186	.039	1.151
Potash	2.524	1.947	2.147	3.295
Soda	.808	1.569	1.167	
Total	100.254	98.862	100.922	100.264

It is interesting to note, in these silicates of the soil which have resisted the decomposing action of nitric and hydrochloric acids for a space of seven to ten days in the sand bath, so much of some of the essential elements of plants and animals usually to be found only in small proportion in soils. These, although in this present insoluble state, are, as in all other silicates, subject to gradual decomposition under the ordinary natural agencies, by weathering, as it is termed; and hence may be considered as a reserve store of plant-food, which may prolong the duration of the productiveness of soils. (See, under Nelson county, another of these analyses.)

CLAYS OF FULTON COUNTY.

No. 2134—"*Indurated clay from the bluff at Hickman; forty-five feet above low water.*" *Collected by John R. Procter.*

Clay generally of a grey color, with some light ferruginous stains in the fissures. Lumps quite firm when dry, breaking with an irregular fracture. Quite plastic with water when powdered. It calcines of a light buff color, and fuses before the blow-pipe into a grey slag.

No. 2135—"*Clay from the bluffs at Hickman; ninety-five feet above low water. Is it a fire-clay?*" *Collected by John R. Procter.*

In pretty firm lumps, generally of a light grey tint, but is considerably mottled with light brownish ochreous material.

Quite plastic with water. Calcines of a reddish buff color. It is refractory before the blow-pipe; but sintered somewhat.

No. 2136—"*Clay from Hickman bluff; upper part of the town. First clay beneath the gravel bed; about four feet thick. Tertiary formation.*" *Collected by John R. Procter.*

The dried clay is a light grey tint, colored buff and ferruginous in parts by infiltration. It is moderately plastic, and did not calcine very hard, acquiring a handsome light brick color. Refractory before the blow-pipe.

No. 2137—"*Clay from Hickman bluff, same bed as that of the next preceding, but a quarter of a mile further up the bluff; three to four feet thick.*" *Collected by John R. Procter.*

This clay is somewhat lighter colored than the preceding, and shows very little ferruginous infiltration. It is quite plastic. Burns hard, and of a light greyish-buff tint. Before the blow-pipe it fuses with great difficulty.

No. 2138—"*Clay from Hickman bluff, upper part of the town, about ten feet below the base of the gravel. Bed about four feet thick, with about four feet of potter's clay resting on it. It is probably the same as the clay collected from Hamby Hill. Tertiary.*" *Collected by John R. Procter.*

The dried clay is in pretty hard lumps, of a light grey color, infiltrated somewhat with ochreous material in striæ. Quite plastic. Calcined of a light brick color. Quite refractory before the blow-pipe.

No. 2139—"*Clay above the next preceding; about four feet thick.*" *Collected by John R. Procter.*

The dried clay is in moderately hard lumps, generally of a light lilac-grey, colored on the exterior ochreous and ferruginous. It is quite plastic; burns hard, of a light grey-buff tint. Before the blow-pipe it fuses with difficulty.

No. 2140—"*Clay from Hickman bluffs, upper part of the town, bed about five feet thick, below the next preceding. Tertiary.*" *Collected by John R. Procter.*

Dried clay, of a light lilac-grey color; in moderately hard lumps; stained with ochreous on the exterior. It is quite

plastic. Burns quite hard, and of light brownish-buff tint. Quite refractory before the blow-pipe.

No. 2141—"*Clay; bed about twenty feet thick, or more; above the railroad track. Upper part of the town of Hickman. Tertiary.*" *Collected by John R. Procter.*

Dried clay, in moderately hard lumps; of a pretty uniform light olive-grey color. It calcines quite hard, and of a brownish buff color. Quite refractory before the blow-pipe.

No. 2142—"'*Loess or Bluff*' *from Hickman bluff. Quaternary.*" *Collected by John R. Procter.*

In very friable lumps, of a light grey-buff color. Contains remains of land and fresh water shells. It is somewhat plastic; not very coherent when burnt; acquiring a very light brick color; before the blow-pipe fuses into a light grey slag.

COMPOSITION OF THESE HICKMAN BLUFF CLAYS, FULTON COUNTY, DRIED AT 212° F.

	No. 2134	No. 2135	No. 2136	No. 2137	No. 2138	No. 2139	No. 2140	No. 2141	No. 2142
Silica	64.800	76.860	83 380	71.340	83.500	71.080	74.100	77.960	68.860
Alumina	21.070	14.600	9.800	17.190	9.940	19.050	16.460	13.970	12.980
Iron oxide	5.270	3.020	2.120	2.770	2.500	2.810	2.700	2.390	2.240
Lime	1.400	.425	.963	1.612	.358	.627	.358	.134	9.587
Magnesia	.050	.308	.187	.209	.173	.401	.187	.163	1.182
Potash	.646	.736	.617	.925	.539	.578	.559	.797	1.773
Soda	.202	257	.118	.232	.109	.225	.135	.124	1.278
Combined water and loss	6.562	3.794	2.815	5.722	2.881	5.227	5.501	4.462	2.100
Total	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000

It is evident that the Tertiary bluffs, from which these clays were collected, offer some valuable materials to the industrial arts. Some of these are quite refractory in the fire, especially Nos. 2136, 2138, 2140, and 2141, and would probably make good fire-bricks, &c.; others of them could be employed for terra-cotta work and other forms of pottery; while some of these abundant deposits might, no doubt, be used with advantage, in mixture with the more calcareous soft material found in some of these beds, in the manufacture of hydraulic cement of the character of the celebrated Portland cement. The loess layer material might be made useful as top-dressing to heavy clay soil.

GRAVES COUNTY.

No. 2143—"*Clay, from Wm. P. Arnett's land, on Panther creek. The bed shows eight feet above the creek.*" *Collected by John R. Procter.*

Clay of a uniform grey color, apparently quite sandy. Washed with water, it left about sixty-three per cent. of fine sand of an umber-grey color, containing small spangles of mica and some coarser grains of transparent quartz. It is quite plastic, and burns of a light salmon color; does not become very hard unless exposed to a very high temperature. It is refractory before the blow-pipe.

COMPOSITION, DRIED AT 212° F.

Silica	75.550	Of which 63 per cent. of fine sand.
Alumina	16.751	
Iron peroxide	1.198	
Lime	a trace.	
Magnesia	.144	
Potash	1.094	
Soda	.216	
Combined water and loss	5.047	
Total	100.000	

This clay resembles that from Ballard county, No. 2104, which is compared with the German glass-pot clay; but both this and that contain more potash than the foreign material, which may possibly cause it to be less available to the glass-maker. It could no doubt be made useful for many purposes, as a fire-clay as well as for various pottery applications.

No. 2144—BITUMINOUS SHALE, *labeled "Brown coal, from Mr. Wm. Arnett's land, on Panther creek, six miles east of Mayfield, on the Columbus and Hopkinsville road. Bed showing about three feet above the creek, said to be several feet below that level." Collected by John R. Procter.*

A soft laminated, bituminous shale or clay; of a dark chocolate color, showing numerous impressions of vegetable leaves.

COMPOSITION, DRIED AT 212° F.

Hygroscopic moisture	4.13	Total volatile matters = 20.35
Volatile combustible matters	16.22	
Fixed carbon in the coke	10.25	Total pulverulent coke = 79.65
Light ash, nearly white	69.40	
	100.00	100.00

The ash was found to contain a considerable proportion of alumina, some little lime and magnesia, as well as a trace of phosphoric acid. As this material only contains a little more than thirty-six per cent. of combustible matters, it could scarcely be made available as a fuel. Possibly it may find use as a cheap pigment.

GREENUP COUNTY.

COALS.

No. 2145—"*Coal (No. 3). Splint coal sampled from the stock pile of the Fulton Coal Company.*" *By John R. Procter.*

The coal breaks into irregular laminæ, which have some fibrous coal between them, and some fine, granular pyrites in parts. The fibrous coal shows the shape of portions of reed-like leaves in some of the laminæ. Generally the coal presents a glossy, pitch-like appearance.

No. 2146—"*Coal (No. 4). Cannel coal from Indian Run, Greenup county. Sampled from the stock pile of the Fulton Coal Company.*" *By John R. Procter.*

A very tough cannel coal; imperfectly and irregularly laminated, with no fibrous coal between the laminæ, and very little appearance of granular pyrites. It is generally of a dull black color, but some portions have an ebony-like gloss.

No. 2147—"*Coal (No. 4). Cannel coal from Chinn's Branch, three miles above Greenup. Sampled from the stock pile of the Fulton Coal Company.*" *By John R. Procter.*

This resembles the next preceding, but is not quite so much laminated; some portions give a large conchoidal fracture. It shows very little fibrous coal or granular pyrites.

No. 2148—"*Coal No. 7 (Coalton); from the Fulton Company tract. Sent for analysis by James A. Johnson. Average sample of a barge load.*"

A pure-looking, bright, pitch like coal, quite firm, with much handsome iridescence on some of the surfaces of its cuboid

blocks. It does not break into regular laminæ, although it shows irregular lamination, with very little fibrous coal between, and no visible granular pyrites. Has some bright pyritous scales in some of the joints.

COMPOSITION OF THESE GREENUP COUNTY COALS, DRIED AT 212° F.

	No. 2145	No. 2146	No. 2147	No. 2148
Specific gravity	1.319	1.286	1.331	1.324
Hygroscopic moisture	5.00	2 00	4.80	6.00
Volatile combustible matters	39.00	47.36	36.90	33.48
Coke	56.00	50.64	58.30	60.52
Total	100.00	100.00	100.00	100.00
Total volatile matters	44.00	49.36	41.70	39.48
Fixed carbon in the coke	49.88	38.24	51.20	56.14
Ash	6.12	12.40	7.10	4.38
Total	100.00	100.00	100.00	100.00
Character of the coke	Spongy.	Slightly coherent.	Dense.	Dense.
Color of the ash	Lilac-grey	Grey-buff.	Lilac-grey	Lilac-grey.
Percentage of sulphur	1.986	1.554	3.977	2.330

All of these are valuable coals, more especially Nos. 2145 and 2148, because of their small proportions of ash and sulphur. No. 2147 is nearly as good, but the sample analyzed contained more than the average proportion of sulphur. It is probable, however, that this excess of sulphur was accidental in the sample. The cannel coal, No. 2146, which would burn with much flame, would answer well under the steam-boiler or in the fire-place or cooking-stove.

HARRISON COUNTY.

No. 2149—"*Iron ore; from Thomas Hinkston's land.*" *Collected by John R. Procter.*

Generally in conglomeratic lumps, composed of dark colored, somewhat friable, limonite concretions, with some soft reddish ochreous material interspersed.

COMPOSITION, DRIED AT 212° F.

Iron oxide	21.200 =	14.84 per cent. of *iron.*
Alumina and phosphoric acid	12.870	
Lime carbonate	1.290	
Magnesia carbonate	6.621	
Silicious residue	49.690	
Water, &c., and loss	8.329	
Total	100.000	

It contains too little iron for use as an iron ore.

HENDERSON COUNTY.

SOILS.

No. 2150—"*Virgin soil; woodland pasture; bottom land. Farm of W. Thompson, five miles from Henderson Station, on the L. & S. E. Railroad. Said to be very fertile.*" *Collected by C. W. Beckham.*

The general color of this dried soil is dark drab. It contains some moderately firm clods, which, when broken, show a mottling of light ferruginous and bluish-grey tints.

It all passed through the coarse sieve, except some vegetable débris and a few small ferruginous concretions.

The bolting-cloth separated from the silicious residue, left after digestion in acids, a considerable proportion of small grains, the skeletons of decomposed concretions, with a small quantity of small, rounded white quartz grains.

No. 2151—"*Surface soil from a field fifteen years in cultivation in corn, tobacco, and hay. Same locality as the preceding.*" *Collected by C. W. Beckham.*

The dried soil is of a lighter drab color than the preceding, and the clods are not quite so firm. It all passed through the coarse sieve except vegetable débris and a few ferruginous concretions. Its silicious residue, from digestion in acids, all passed through the bolting-cloth, except a small quantity of small, soft particles of partly-decomposed concretions and a very few small, rounded quartz grains.

No. 2152—"*Subsoil of the next preceding,*" *&c., &c.*

The dried subsoil is in very firm clods, which are of a dark, brownish-drab color on the exterior surface, and mottled with brownish-ochreous and bluish-grey in the interior.

It all passed through the coarse sieve. The bolting-cloth separated from its silicious residue a very large proportion —more than one half of the whole—of small particles, the silicious skeletons of partly-decomposed concretions, which were easily crushed by the finger on paper, after which they passed through the bolting-cloth, leaving only a few small, rounded grains of quartz.

No. 2153—"*Surface soil from an old field twenty-five or thirty years in cultivation; said to be worn out. From the farm of J. D. Robsard, twelve miles from Henderson, on the St. L. & S. E. Railroad.*" *Collected by C. W. Beckham.*

The dried soil is in pretty firm clods, of a dirty brownish-buff color. It all passed through the coarse sieve. The bolting-cloth separated a considerable proportion of small, soft, rounded particles of partly-decomposed concretions from its silicious residue, as well as one or two small, rounded grains of quartz.

No. 2154—"*Subsoil of the next preceding,*" *&c., &c.*

The dried subsoil is in firmer clods than the preceding soil. It is of rather a handsome, warm, brownish-ochre color.

It all passed through the coarse sieve. The bolting-cloth separated from its silicious residue a larger proportion of small, soft grains of partly-decomposed concretions than from that of the preceding soil; but no quartz grains.

No. 2155—"*Virgin soil from woods pasture adjoining the field from which the next preceding two soils were taken. Farm of Mr. Kluté, near Henderson. Quaternary formation.*" *Collected by C. W. Beckham.*

This dried soil is quite friable and light, of a brownish ash-grey color. It all passed through the coarse sieve, except vegetable debris and a small quantity of shot iron ore. The bolting-cloth separated from its silicious residue only a very small proportion of particles of partly-decomposed concretions, and only two or three very small, rounded quartz grains.

No. 2156—"*Surface soil; in cultivation about thirty years; principally in corn, oats, clover, and tobacco. Same locality as the next preceding.*" *Collected by C. W. Beckham.*

The dried soil, also light and friable, is of a somewhat darker color than the preceding. It all passed through the coarse sieve, except a small quantity of shot iron ore and of vegetable debris. The bolting-cloth separated from its silicious residue only a small proportion of particles of partly-decomposed concretions, and a very few small, rounded quartz grains.

No. 2157—"*Subsoil of the next preceding, &c., &c. Used for making bricks.*" *Collected by C. W. Beckham.*

The dried subsoil is of a handsome brownish-yellow ochre color. The clods are very firm. The bolting-cloth separated from its silicious residue a large proportion of small, soft particles of partly-decomposed concretions, and no quartz grains.

No. 2158—"*Virgin soil from woods pasture. Farm of S. H. Busbey, ten miles from Henderson, on the St. L. & S. E. Railroad. Quaternary formation.*" *Collected by C. W. Beckham.*

Dried soil of a brownish ash-grey color. Light and friable. It all passed through the coarse sieve, except a small quantity of shot iron ore and vegetable débris. The silicious residue from digestion in acids all passed through the bolting-cloth, except two or three small particles of partly-decomposed concretions and two or three small quartz grains.

No. 2159—"*Surface soil from a field twenty-five years in cultivation, adjoining the location of the next preceding. Tobacco the only crop.*" *Collected by C. W. Beckham.*

The dried soil is light and friable; its color is slightly more yellowish or light-brownish than that of the preceding. It all passed through the coarse sieve, except vegetable debris and

a very small quantity of shot iron ore. Its silicious residue all passed through the bolting-cloth, except a very small proportion of small grains of partly-decomposed concretions and two or three small quartz grains.

No. 2160—"*Subsoil of the next preceding*," *&c., &c.*

The dried subsoil is of a handsome brownish-yellow ochre color. The clods are quite firm. It all passed through the coarse sieve. The bolting-cloth separated from its silicious residue, left from digestion of the soil in acids, a large proportion of small, soft particles of partly-decomposed concretions, and only two or three very small quartz grains.

COMPOSITION OF THESE HENDERSON COUNTY SOILS, DRIED AT 212° F.

	No. 2150	No. 2151	No. 2152	No. 2153	No. 2154	No. 2155	No. 2156	No. 2157	No. 2158	No. 2159	No. 2160
Organic and volatile matters	4.525	3.150	2.780	2.125	2.900	3.465	3.025	3.290	3.835	2.785	3.350
Alumina and iron and manganese oxides	5.004	3.968	5.879	5.979	10.647	3.113	4.048	9.589	3.364	4.129	9.644
Lime carbonate	.570	.385	.520	.195	.130	.130	.195	.950	.220	.220	.195
Magnesia	.317	.241	.304	.245	.304	.166	.196	.342	.175	.309	.195
Phosphoric acid	.131	.102	.061	.061	.093	.077	.067	.061	.061	.061	.121
Potash extracted by acids	.196	.238	.142	.236	1.097	.363	.550	.429	.371	.382	.357
Soda extracted by acids	.112	.143	not est.	not est.	not est.	.165	not est.	.185	not est.	.123	.109
Water expelled at 385° F.	1.225	.865	.735	.420	.550	.630	.600	.580	.715	.565	.675
Sand and insoluble silicates	87.990	91.315	89.215	90.735	85.365	92.290	91.625	85.040	91.665	91.840	85.890
Total	100.070	100.407	99.636	99.986	100.486	100.359	100.306	00.466	100.406	100.414	100.536
Hygroscopic moisture	1.815	1.200	1.900	1.350	2.575	1.175	1.325	1.850	1.175	1.025	2.100
Potash in the insoluble silicates	1.654	1.619	2.036	1.672	1.755	1.121	1.127	1.278	1.274	1.457	1.573
Soda in the insoluble si icates	.775	.815	.570	.763	.608	.742	.714	.819	.846	.704	.611
Character of the soil	Virgin soil.	Old field	Subsoil.	Old field	Subsoil	Virgin soil.	Old field	Subsoil.	Virgin soil.	Old field	Subsoil.

Although some of these soils contain more than the average proportion of sand and insoluble silicates, and a corresponding small proportion of alumina, &c., these are in such a state of fine division, being fine enough generally to pass through the fine sieve with 1600 meshes to the centimeter square, that this circumstance does not lessen their productiveness as much as might be supposed, while it gives them great permeability. Organic and volatile matters are also in small proportion in them, except in No. 2050, which has an average quantity; but this deficiency can be supplied by the use of barn-yard manure or by plowing under clover or other green crops. They all have more than the average of available potash, which, as well as their light and friable texture, no doubt adapts them to tobacco culture. No. 2154 has much more than the average proportion of this alkali. Their greatest apparent deficiency is of phosphoric acid, which, in Nos. 2152 and 2153 to 2159, inclusive, falls below the average normal proportion in good soils. This defect, however, may find an easy remedy in the application of phosphatic fertilizers, especially bone-dust or superphosphate, &c. The statement that soil No. 2153 is "considered worn out," finds no other apparent verification in the chemical analysis than this deficiency of phosphoric acid, which is also found in the other soils mentioned, except that its organic and volatile matters are in smaller proportions than in any of the other soils, and far below the average.

Notwithstanding these natural conditions, these soils, with good management, drainage where necessary, and the judicious use of fertilizers and a proper rotation of crops, can be made and kept quite productive.

HICKMAN COUNTY.

CLAYS.

No. 2161—"*Clay from chalk bluff, about two miles below Columbus.*" *Collected by John R. Procter.*

In moderately firm lumps, of a light buff and lead-grey color. Has a few ferruginous impressions of vegetable leaves. Seems

to be quite sandy, yet is quite plastic and burns hard, and of a very light cream color. Refractory before the blow-pipe, only sintering a little.

On washing the air-dried clay with water, it left about sixty-nine per cent. of very fine sand, of a drab color, containing a few very small spangles of mica.

No. 2162—"*Clay from the bluffs at Columbus, upper part of the town. Will it make fire-brick?*" *Collected by John R. Procter.*

In somewhat friable lumps, of a very light-grey color; almost white; quite sandy. Very little ochreous stain visible. It is plastic, and burns hard, of a light cream color, and is refractory before the blow-pipe. The air-dried clay, washed in water, left 68.5 per cent. of fine sand of a light-grey color, nearly white, which is composed of very small, rounded grains of quartz, with a few small specks of mica.

COMPOSITION OF THESE HICKMAN COUNTY CLAYS, DRIED AT 212° F.

	No. 2161.	No. 2162.
Silica	76.360	84.918
Alumina	14.951	10.560
Iron peroxide	2.109	1.102
Lime	.325	.572
Magnesia	.173	.108
Potash	1.171	.651
Soda	.125	not est.
Combined water and loss	4.786	2.089
Total	100.000	100.000

No doubt No. 2162, if it will burn hard enough, would make quite refractory fire-brick, and it, as well as the other clay, might be made available for terra-cotta and other forms of pottery ware. No. 2161 is less refractory, because, doubtless, of its larger proportions of iron peroxide and potash.

Under the head of Ballard county, a comparison was made of the composition of one of these refractory clays and that of the celebrated glass-pot clay of Germany, and the main difference between them was in the larger proportion of potash in the Ballard county clay. The same similarity of composition with the glass-pot clay may be observed in some of

the Fulton county clays, as well as in the above described. Whether this somewhat greater proportion of potash would be fatal to the application of these refractory clays in the glass-works, is worthy of practical trial on a small scale.

No. 2163—"*Sand from Columbus; above the town. A very large deposit.*" *Collected by John R. Procter.*

A nearly white sand, made up mostly of small, rounded grains of hyaline quartz, colored very light purplish with iron oxide, and containing a few friable concretions made by infiltration of carbonate of lime.

Washed in water, air-dried, it left 99.40 per cent. of nearly pure white sand. It is no doubt pure enough for the manufacture of any but the very finest kind of glass.

No. 2164—"SOIL, LABELED "*New soil; surface soil; two years in cultivation in corn. Thought to be the prevailing upland soil in the county.*" *Collected by John R. Procter.*

In friable clods of a grey umber-brown color. It all passed through the coarse sieve, and its silicious residue left on the bolting-cloth sieve only two or three small particles of partly-decomposed silicates.

COMPOSITION, DRIED AT 212° F.

Organic and volatile matters	4.140
Alumina and iron and manganese oxides	3.694
Lime carbonate	.495
Magnesia	.232
Phosphoric acid	.156
Potash extracted by acids	.182
Soda extracted by acids	.564
Water expelled at 380° F.	1.010
Sand and insoluble silicates	90.095
Total	100.568
Hygroscopic moisture	1.735
Potash in the insoluble silicates	1.899
Soda in the insoluble silicates	.573

Although the proportion of sand and insoluble silicates is larger than the average, this is a very good soil, containing

full average quantities of alkalies, phosphoric acid, and lime. Like most of our Kentucky soils, the silicious constituent is in such a fine state of division that it has many of the physical properties of fine clay, and would not, in ordinary parlance, be denominated sand.

JEFFERSON COUNTY.

CLAYS.

No. 2165—"*Shaly clay (or clay shale) in the limestone layers of the 'Cincinnati Group.' Lower Silurian. Jeffersontown.*" *Collected by Rev. H. Hertzer.*

A friable shale, generally of a lilac-grey color, but with some whitish portions. When powdered, it is quite plastic with water. It calcines of a light brick color; but before the blow-pipe it fuses into a dark-colored slag.

No. 2166—"*Shaly clay, of the Keokuk Group, from Cox's Knob. Jefferson county.*" *Collected by Rev. H. Hertzer.*

Generally of an olive-grey color. This also is quite plastic when powdered. It calcines of a very light brick color. Before the blow-pipe it fuses into a dark-colored slag.

No. 2167—"*Shaly clay (or clay shale) of the Keokuk Group. From the old Deposit Station. Jefferson county.*" *Collected by Rev. H. Hertzer.*

A friable shale or indurated clay of a light buff-grey color, with ferruginous stains between some of the laminæ.

Quite plastic when powdered. It burns of a light brick color, and fuses before the blow-pipe into a dark-colored slag.

COMPOSITION OF THESE SHALY CLAYS, DRIED AT 212° F.

	No. 2165.	No. 2166.	No. 2167.
Silica	47.960	58.840	61.900
Alumina with phosphoric acid	21.340	19.940	18.520
Iron peroxide	6.600	6.000	6.220
Lime	5.824	3.226	.123
Magnesia	3.524	.857	1.259
Potash	5.264	4.490	4.867
Soda	.250	.685	.612
Carbonic acid, undetermined, and water	9.238	5.962	6.499
Total	100.000	100.000	100.000

These indurated or shaly and marly clays, usually containing a notable proportion of the alkalies, potash and soda, as well as of lime and magnesia, with a variable small quantity of phosphoric acid, might, in some cases, be profitably applied as top-dressing to light soils which are deficient in clay, and which have become exhausted by culture. They could also be used for terra-cotta work, especially those which burn hard and of a handsome color. These might also be used for drain-tiles, flower-pots, and other forms of pottery. At a very high temperature, in the kiln, however, they would soften or melt.

MADISON COUNTY.

CLAYS.

No. 2168—"*Clay; Milton Barlow; from near Bybeetown. Bed four feet thick; in Black shale.*" *Collected by John R. Procter.*

Clay of a light, warm drab-grey color. Irregularly and imperfectly laminated. Quite plastic. Burns of a delicate light, reddish-cream color; nearly white. Before the blow-pipe it fuses into a whitish slag with difficulty.

No. 2169—"*Clay of workable thickness; on the road leading from Waco to R. Oldham's, about a mile and a half from Waco. Probably below the Corniferous limestone.*" *Collected by John R. Procter.*

A compact clay, generally of a light, olive-grey color, stained irregularly with ochreous and ferruginous. Quite plastic. Calcines quite hard, of a handsome light brick color. Before the blow-pipe it fuses into a brownish-grey slag.

No. 2170—"*Indurated clay; farm of C. L. Searcy, near Elliston. Beneath the Corniferous limestone. Bed ten feet thick or more. Makes a good soil.*" *Collected by John R. Procter.*

A light, olive-grey, laminated clay; mottled with ochreous or orange-colored ferruginous infiltrations. The laminæ are contorted. It is quite plastic. Burns of a handsome flesh-color. Fuses into a grey slag before the blow-pipe.

COMPOSITION OF THESE MADISON COUNTY CLAYS, DRIED AT 212° F.

	No. 2168.	No. 2169.	No. 2170.
Silica	62.560	64.566	62.580
Alumina	24.780	20.160	22.940
Iron peroxide	1.800	4.200	3.760
Lime	a trace.	.213	.560
Magnesia	.317	.641	.425
Potash	3.276	5.054	5.280
Soda	.294	not est.	.308
Combined water, &c., and loss	6.973	5.166	4.147
Total	100.000	100.000	100.000

These are good plastic clays for the manufacture of ordinary pottery ware, as well as for ornamental articles of terra-cotta, for which use they are adapted because of the pleasant tints they assume in calcination. They owe these tints to their considerable proportion of iron oxide, which, together with their large proportion of potash, renders them unavailable as fire-clays. This very circumstance, however, may fit them for stone-ware, and for superior kinds of hard, burnt, semi-fused, ornamental pottery in the hands of skillful workmen and artists.

MARLY SHALES OF MADISON COUNTY.

No. 2186—"*Marly shale; on the road near A. Lake's place; Drowning creek. 'Niagara Group.'" Collected by John R. Procter.*

An olive-grey and brownish-grey, somewhat firm shale, mottled in parts; adhering to the tongue. Quite plastic with water when powdered. Calcines of a light brick color. Fuses before the blow-pipe into a dark brown, nearly black slag.

No. 2187—"*Marly shale or indurated marly clay. On the hill two hundred yards north of Dr. Freeman's house. Probably the same bed as No. 2167, beneath the Corniferous limestone. The bed is six feet thick or more, and contains gypsum." Collected by John R. Procter.*

Generally in thin, soft, irregular laminæ, of a light olive-grey color, irregularly varied with brownish yellow or ochre-

ous. It contains gypsum in irregular crystals between some of the laminæ; shows some fossil vegetable impressions, probably fucoid, on some of the layers.

It is quite plastic with water. Burns quite hard, of a handsome light brick color. Before the blow-pipe it melts into a dark brownish-green slag.

COMPOSITION OF THESE MARLY SHALES, DRIED AT 212° F.

	No. 2186.	No. 2187.
Silica	42.300	48.780
Alumina, &c.	20.840	17.320
Iron peroxide	4.120	3.240
Lime sulphate (gypsum)	. . . . .	19.285
Lime	13.320	. . . . .
Magnesia	.461	.496
Potash	2.387	4.768
Soda	.351	.240
Combined water, carbonic acid, and loss	16.221	5.871
Total	100.000	100.000

Because of the large proportion of gypsum (plaster of Paris) contained in No. 2187, and its considerable quantity of potash, it would no doubt prove a valuable top-dressing on soil and crops where the use of plaster is indicated. The shale No. 2186 would be useful on soils principally on account of the lime which it contains, which is equivalent to nearly twenty-four per cent of carbonate of lime.

No. 2188—A. "*Rock impregnated with Epsom salt, &c. C. L. Searcy's farm, near Elliston. Beneath the Corniferous limestone.*" *Collected by John R. Procter.*

A somewhat friable ferruginous sandstone, generally of a dull brown color, variegated somewhat with other tints. Showing minute crystalline specks in the cracks, and between the irregular laminæ. It contains irregular nodules of chert, infiltrated with bright iron pyrites.

B. Brown powder contained in the sample. Supposed to be the result of the disintegration of the rock by the crystalline force of the included salt.

The rock (A), when lixiviated with water, gave a solution which left, on evaporation and drying at the temperature of boiling water, as much as 4.8126 per cent. of the rock of *saline matters*, principally magnesia sulphate (Epsom salt), with small quantities of salts of lime, potash, soda, and iron.

The brown powder (B) was found to contain only 3.840 per cent. of *saline matters*, of similar composition. The rock was not submitted to analysis, but it is pretty evident that the Epsom salt and other sulphates were derived from the reaction of the oxidated iron pyrites on the bases contained in the rock.

LIMESTONES OF MADISON COUNTY.

No. 2189—"*Shelly limestone in the bed of Muddy creek; below J. Q. Compton's. 'Cumberland' shales? Probably Clinton.*" *Collected by John R. Procter.*

Of a dark umber-grey color. Generally quite friable; some portions are compact.

No. 2190—"*Impure limestone; top of the 'Cumberland' shales. Upper twelve inches. From below the mill-dam on Muddy creek, Elliston.*" *Collected by John R. Procter.*

A pretty firm, fine-granular, or compact rock, of a handsome light olive-grey color.

No. 2191—"*Impure limestone. Top of 'Cumberland' shales. From eighteen to thirty inches below the massive bluff limestone of the Upper Silurian on Muddy creek.*" *Collected by John R. Procter.*

Rather darker colored than the next preceding; color inclined to brownish; not so hard as that. It contains no bitumen, but some sulphur.

No. 2192—"*Impure limestone; resting on the top of the 'Cumberland' shales; bottom stratum. From below the mill-dam on Muddy creek.*" *Collected by Jno. R. Procter.*

A granular limestone; somewhat cellular; containing some petroleum, which gives it a brownish color. It weathers ochreous.

No. 2193—"*Impure limestone. Niagara. Top stratum, eight inches thick. From below the mill-dam on Muddy creek. Elliston.*" *Collected by John R. Procter.*

An impure granular limestone; somewhat cellular; dark brownish-grey, somewhat mottled. Contains petroleum, the infiltration of which gave the dark color to the rock. When heated over the spirit-lamp, the petroleum exudes from it. It weathers ferruginous.

No. 2194—"*Impure limestone. Second from the top. From just below the mill-dam on Muddy creek. Elliston.*" *Collected by John R. Procter.*

It resembles the preceding, but is darker colored; it also contains petroleum and some iron pyrites.

No. 2195—"*Impure limestone. Niagara. Third stratum from the top. From below the mill-dam, Muddy creek. Elliston.*" *Collected by John R. Procter.*

Resembles the preceding; rather finer-grained and harder; also containing petroleum. Exterior surface weathered ferruginous.

No. 2196—"*Impure limestone. Clinton Group? From the quarry north of Rogersville. This rock makes good soil.*" *Collected by John R. Procter.*

A compact or fine granular rock; non-fossiliferous; of an olive-grey color; in some parts brownish. Not adhering to the tongue. It contains no petroleum, but some pyrites.

No. 2197—"*Limestone from below the Cauda-galli grit, at the base of the Corniferous limestone.*" *Collected by John R. Procter.*

A fine granular, brownish-grey rock. It gives the odor of petroleum when heated, and probably owes its brownish tint to a small quantity of this substance.

No. 2198—"*Bituminous limestone from above the Corniferous limestone; three to ten feet thick; from near Elliston.*" *Collected by John R. Procter.*

Generally of a dull, brownish-black, or grey-black color. Some pieces with bands of a lighter grey tint. It is a fine granular rock.

No. 2199—"*Impure limestones. Top of the Corniferous limestone. Total thickness fifteen feet; with intercalated beds of purer limestone six inches thick.*" *Collected by John R. Procter.*

A tough, fine granular or compact rock. Samples from different levels are mixed; some of which are brownish-black, some umber colored, and some intermediate in tint.

No. 2200—"*Limestone; on the road one mile south of Mrs. S. J. Embry's; intercalated with the so-called Black Band, or bituminous limestone. To be tested for hydraulic properties.*" *Collected by John R. Procter.*

A dull buff-grey, fine granular rock, with some little infiltration of hydrated iron oxide.

COMPOSITION OF THESE MADISON COUNTY LIMESTONES, DRIED AT 212° F.

	No. 2189	No. 2190	No. 2191	No. 2192	No. 2193	No. 2194	No. 2195	No. 2196	No. 2197	No. 2198	No. 2199	No. 2200
Lime carbonate	48.530	37.760	33.560	45.700	50.860	50.960	51.200	35.160	43.060	41.150	36.580	47.580
Magnesia carbonate. . .	11.790	10.050	6.855	27.475	20.100	27.972	25.124	4.646	9.994	13.908	18.541	17.133
Alumina		17.656	21.256				12.360	10.706				
Phosphoric acid. . . .	10.330	.204	.204	11.360	9.960	5.960	.140	.754	9.420	9.040	4.010	10.980
Iron peroxide. .		3.700	4.120	3.500*	3.900	3.556	4.460	2.000	2.640	1.890	1.540	
Iron sulphide	. . . .	. . . .	. . . .	. . . .	. . . .	.576	. . . .	. . . . .	. . . . .	. . . .	. . . . .	. . . .
Potash	1.696	.458	.578	.501	.276	.276	.287	2.033	.770			
Soda	.347	.090	.045	.088	.054	.087	.049	.586	.149	13.022	7.339	not est.
Bitumen, water, and loss,	. . . .	. . . .	. . . . .	1.396	10.870	6.493	2.460	. . . . .	11.287			
Water and loss	6.567	4.902	4.302	. . . .	. . . .	. . . .	. . . .	4.275	. . . . .	. . . .	. . . . .	6.117
Silicious residue	20.740	25.180	29.080	9.980	3.980	4.120	3.920	39.780	22.680	20.990	31.990	18.190
Total	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000
Percentage of lime . . .	27.173	21.145	18.794	25.592	28.480	28.538	28.672	19.689	24.113	23.044	20.485	26 645
Percentage of magnesia .	5.614	4.785	3.251	13.083	9.608	13.319	11.899	2.212	4.756	6.384	8.781	8.158
Percentage of silica. . .	not est	20.980	22.8 0	not est.	not est.	not est.	not est.	not est.	not est.	not est.	not est.	not est.

* Mostly Ferrous oxide in the rock.

These impure limestones vary considerably in their composition and properties. Nos. 2192, 2193, 2194, and 2195, from the Upper Silurian strata, are quite magnesian, and contain considerable proportions of alumina and iron oxide, with but a moderate quantity of silicious matter. Many of these magnesian limestones make quite good and durable building stone; but this depends greatly on the mechanical structure of the rock. The magnesian limestones also make good quicklime when pure, and when silicious or containing much clay, frequently prove to be good water-limes. A very imperfect trial of No. 2195, by calcining a small quantity, proved that it would harden in contact with water; but whether it would become very hard by time, or prove durable, was not ascertained. Possibly greater care in the experiment, in the burning, &c., with more time, would give a more satisfactory result. Its proportion of silica, however, is quite small.

The rest of these limestones were not tried in this relation, except Nos. 2189, 2190, and 2200, and these did not harden in a satisfactory manner in water. As all of these contain quite a large proportion of aluminous and silicious matters, if they would make water cement at all, it would be of the slowly-setting variety, like the artificial Portland cement, for the manufacture of which, with or without the addition of more lime, they might possibly be made available.

Specimens of Corniferous and Silurian limestones, showing bright olive-green blotches, specks, and grains, were sent to the laboratory to ascertain their nature. This green material, frequently found in a granular form, is the mineral glauconite, the main constituent of the green sand of the cretaceous formation, described in a previous chemical report under the number 2067.

IRON ORES FROM MADISON COUNTY—BOG IRON ORES.

No. 2201—"*Bog ore from near R. Dudley's, half a mile south of the Richmond and Irvine Turnpike. A thick deposit, on the Black Shale formation.*" *Collected by John R. Procter.*

Mostly soft ochreous material of different light tints, mixed

irregularly with some curved laminæ of more compact, dark colored limonite.

No. 2202—"*Bog ore; Black Shale formation; on the lands of T. P. Estill and M. T. Todd. Two hundred yards south of the Richmond and Irvine Turnpike, near Ross' blacksmith shop. Bed of workable thickness.*" *Collected by John R. Procter.*

Resembles the preceding, but is somewhat darker colored, and has more of the hard, irregular limonite layers.

No. 2203—"*Bog ore; on the Black Shale formation; a good deposit. Near Mrs. Tudor's, on the Richmond and Irvine Turnpike.*" *Collected by John R. Procter.*

Resembles the preceding. The samples are from different outcrops of the same bed, which seems to have considerable extent.

No. 2204—"*Bog ore; a thick deposit on the road to Red river, near T. Lewis', half a mile west of Harris' ferry, one mile from Kentucky river. Resting on Corniferous.*" *Collected by John R. Procter.*

Generally of a dull black color, like earthy manganese peroxide, with some little reddish and yellowish ochreous material intermixed.

COMPOSITION OF THESE BOG ORES, DRIED AT 212° F.

	No. 2201.	No. 2202.	No. 2203.	No. 2204.
Iron peroxide	28.440	19.800	30.870	17.300
Alumina and phosphoric acid	5.240	9.880	11.560	14.820
Lime carbonate	.190	.380	.290	.130
Magnesia carbonate	1.279	1.844	.897	1.041
Silicious residue	56.220	62.290	49.980	56.260
Water, alkalies, &c., and loss	8.631	5.806	6.403	10.449
Total	100.000	100.000	100.000	100.000
Percentage of iron	19.890	13.860	21.570	12.110

Generally too poor to be profitably smelted by themselves for iron; although some of them might be used in mixture with richer ores, provided the phosphoric acid is not in too

large proportion. The ore varies considerably in different parts of the bed, and in some localities it might, no doubt, yield material for cheap mineral paint.

No. 2205—"*Ferruginous shale. Labeled 'Black Band ore.' W. B. Combs' Knob. Resting on the top of the coal.*" *Collected by John R. Procter.*

A somewhat compact, ferruginous shale, of a dull brownish-black color, spangled with fine scales of mica. Weathers ferruginous.

COMPOSITION, DRIED AT 212° F.

Iron oxide	19.500,	containing 13.650 per cent. of iron.
Alumina and phosphoric acid	16.360	
Lime	trace.	
Magnesia	trace.	
Silicious residue	39.940,	containing 32.300 per cent. of silica.
Bituminous matter, water, and loss.	24.200	
Total	100.000	

Too poor to be called an iron ore.

SOILS FROM MADISON COUNTY.

No. 2206—"*Top soil from the farm of J. G. Covington, Muddy creek. Probably Clinton shales, above the Cincinnati Group. Has been in cultivation for twenty-six years in corn, with but two crops of small grain. With an average yield all the time of sixty bushels of corn to the acre. Lies above the overflow.*" *Collected by John R. Procter.*

Dried soil of a brownish-umber color; pretty friable. It all passed through the coarse sieve except a small proportion of small ferruginous concretions, and some few small rounded pebbles of reddish quartz. The bolting-cloth separated from its silicious residue a small proportion of small rounded white quartz grains, and very few of partly-decomposed concretions.

No. 2207—"*Subsoil from the same field, taken one foot below the surface,*" *&c., &c.*

The dried subsoil is very slightly darker colored than the surface soil, and the clods are firmer. It all passed through

the coarse sieve except a small proportion of small ferruginous concretions, somewhat rounded. The bolting-cloth separated from its silicious residue a rather larger proportion of small, rounded white quartz grains than from the preceding, but very few grains of partly-decomposed concretions.

No. 2208—"*Bottom clay under the two preceding*," &c., &c.

The dried under-clay is of a handsome brownish-yellow ochre color. It is in pretty firm clods. It all passed through the coarse sieve except a small proportion of small ferruginous concretions, and a few small white quartz pebbles. The bolting-cloth removed from its silicious residue a small proportion of small, rounded white quartz grains, and a few of partly-decomposed concretions; a smaller quantity than from the preceding.

COMPOSITION OF THESE MADISON COUNTY SOILS, DRIED AT 212° F.

	No. 2206.	No. 2207.	No. 2208.
Organic and volatile matters	7.240	7.150	2.950
Alumina and iron and manganese oxides	10.353	10.905	11.032
Lime carbonate	2.485	1.870	.220
Magnesia	.989	.809	.160
Phosphoric acid	.387	.300	.173
Potash extracted by acids	.545	.638	.359
Soda extracted by acids	.162	.....	.....
Water expelled at 380° F.	1.122	1.450	.800
Sand and insoluble silicates	76.715	77.395	84.174
Total	99.998	100.517	99.868
Hygroscopic moisture	3.275	3.775	2.575
Potash in the insoluble silicates	1.949	2.079	1.800
Soda in the insoluble silicates	.206	.281	.407
Character of the soil	Cultivated field.	Subsoil.	Under-clay

The upper soil and subsoil present in their composition all the characteristics of very fertile soil. The under-clay is not so rich as these.

WATER FROM MADISON COUNTY.

No. 2209—"*Sulphur water from a spring on the farm of C. L. Searcy, Elliston. In the Niagara Group.*" *Collected by John R. Procter.*

The water was brought to the laboratory in a jug and bottle, both well corked. It retained a slight odor of hydrogen sulphide, and was slightly opalescent from a light precipitate of sulphur. It had deposited a dark sediment, and the corks were slightly blackened, as from the presence of iron. Testing showed it to be slightly alkaline in reaction.

COMPOSITION OF SALINE CONTENTS OF THIS WATER, in 1000 PARTS.

Lime carbonate	0.2040	Held in solution by carbonic acid.
Magnesia carbonate	.0322	
Iron carbonate and phosphoric acid	.0172	
Silica	.0045	
Lime sulphate	.4301	Left dissolved in the water after long boiling.
Calcium chloride	.0124	
Magnesium chloride	.0920	
Potassium chloride	.0380	
Sodium chloride	.3221	
Soda carbonate	.0937	
Silica	.0018	
Lithium, strontium, and sodium sulphide	traces	
Organic matters and loss	.3294	
Total solid matters in 1000 parts of the water	1.5774	

The water also contained free carbonic acid, and, at the spring, no doubt, a notable amount of hydrogen sulphide; but the quantity of these gases could only be correctly estimated at the source. It seems to be a good saline sulphur water, containing a small quantity of iron, which would add to its medicinal utility.

No. 2210—"*Water from an Artesian well one hundred and twenty-six feet deep. Bored in the rocks of the Upper Cincinnati Group. About one hundred and fifty feet south of the railroad track at Clear Creek Station, and about two hundred and fifty feet west of Silver creek, in a bottom. The water stands in the well at thirty-five feet from the surface.*" *Sent by John R. Procter.*

On evaporation to dryness, this water left 0.4658 of a

gramme of saline matters, &c., dried at 212°, to the thousand of the water.

The *composition* of which saline matter is as follows:

Lime carbonate	0.1550	Held in solution by carbonic acid.
Magnesia carbonate	.0503	
Iron carbonate and silica	n. e.	
Lime sulphate	.0350	
Potash sulphate	.0124	
Soda sulphate	.0096	
Sodium chloride	.1467	
Silica	.0060	
Moisture and loss	.0508	
Total saline matters in 1000 parts of the water	0.4658	

This is what is called a "hard" water; but it contains no organic matters or other injurious ingredient. Its small proportion of sulphate of lime would only tend to form a hard crust in steam-boilers when it was used in them for too long a time without "blowing out."

The water of Silver creek was tested at the same time with the above described; also that of a well in the creek; both at the Silver Creek Distillery, Madison county.

The Silver creek water left, on evaporation, 0.1772 per 1000 of solid saline matters, slightly stained with organic matters.

The well water left 0.2212 per 1000 of the water of saline matters, which also showed a trace of organic matter. The composition appeared to be similar to that of the saline matter of the Artesian well water.

McCRACKEN COUNTY.

No. 2211—"*Fire-clay, three and three quarters miles south of Paducah, on the Mayfield road.*" *Collected by John R. Procter.*

In friable lumps, generally of a very light grey color, nearly white, mottled with a very light ochreous material.

It is quite plastic. Before the blow-pipe it burnt hard, of a light grey color, nearly white, and finally fused with great difficulty.

COMPOSITION, DRIED AT 212° F.

Silica	64.480
Alumina with trace phosphoric acid	24.691
Iron peroxide	1.869
Lime	.448
Magnesia	.137
Potash	1.457
Soda	.083
Combined water and loss	6.835
Total	100.000

While this clay would answer well for the manufacture of ordinary fire-brick, and of rather superior varieties of pottery-ware, terra-cotta, &c., its considerable proportions of potash and iron peroxide might cause it to soften when exposed to a very intense heat.

No. 2212—"*Subsoil from land of Dr. S. B. Caldwell, two miles southwest of Paducah, McCracken county. This earth, when dug up and spread upon the land, produces good results. Quaternary.*" *Collected by John R. Procter.*

The dried soil is friable, and of a light brownish-grey color. The coarse sieve removed from it some friable shot iron ore, and a small silicious fragment. All its silicious residue passed through the bolting-cloth, except a very few small, rounded grains of hyaline quartz.

COMPOSITION OF THIS SUBSOIL, DRIED AT 212° F.

Organic and volatile matters	1.840	
Alumina and iron and manganese oxides	5.883	
Lime carbonate	.070	
Magnesia	.200	
Phosphoric acid	.082	
Potash extracted by acids	.186	
Soda extracted by acids	.314	
Water expelled at 380°	.485	Containing:
Sand and insoluble silicates	90.920	Potash = 1.773
		Soda = .855
Total	99.980	

Hygroscopic moisture = 1.500 per cent.

No reason appears in the chemical composition of this earth why it should act as a fertilizer, except when plentifully applied on poor light soils.

NELSON COUNTY.

SOILS.

No. 2213—"*Soil from a field on the farm of Mr. James R. Ballard, two miles northwest of Rohan's Knob. The field has not been wasted much by cultivation, but in washing away. Timber, mostly white oak and ash. Bed rock, black slate and Corniferous limestone.*" *Collected by John R. Procter.*

The dried soil is friable, and of a reddish, light brownish tint. The coarse sieve separated from it 1.5 per cent. of its weight of small, partly-rounded ferruginous fragments. Its silicious residue, from digestion in acids, all passed through the fine sieve (1,600 meshes to the centimeter square), except a small proportion of small particles of partly-decomposed concretions, and a few small grains of white quartz.

No. 2214—"*Subsoil of the next preceding, ten inches from the surface,*" *&c.*

The dried subsoil is lighter colored and more yellowish than the preceding. Of a light brick color. Its clods are quite firm. The coarse sieve separated from it only 0.5 per cent. of small ferruginous fragments, partly rounded. The fine sieve, with 1,600 meshes to the centimetre square, separated from its silicious residue a considerable proportion of small particles of partly-decomposed concretions, and only one or two small silicious grains.

No. 2215—"*Bottom soil or under-clay of the next preceding, two feet from the surface; not penetrated by roots.*" *Collected by John R. Procter.*

The dried soil is of a handsome light brownish orange-red color, or handsome light brick color. The coarse sieve separated from it 1 per cent. of small irregular quartz pebbles. The fine sieve removed from its silicious residue a small proportion of small particles of partly-decomposed concretions, and of rounded quartz grains, with a few minute silicified joints of encrinital stems.

COMPOSITION OF THESE NELSON COUNTY SOILS, DRIED AT 212° F.

	No. 2213.	No. 2214.	No. 2215.
Organic and volatile matters	3.360	2.990	3.300
Alumina and iron and manganese oxides	7.977	10.349	14.368
Lime carbonate	.270	.245	.880
Magnesia	.166	.187	.809
Phosphoric acid	.108	.061	.102
Potash extracted by acids	.116	.164	.361
Soda extracted by acids	.225	.045	.657
Water expelled at 380° F.	1.215	.900	2.415
Sand and insoluble silicates	86.650	85.075	76.840
Total	100.087	100.016	99.732
Hygroscopic moisture	1.485	2.525	1.129
Potash in the insoluble silicates	1.669	1.835	2.742
Soda in the insoluble silicates	.274	.400	.225
Percentage of gravel	1.400	.500	1.000
Character of the soil	Surface soil	Subsoil.	Under-clay

These soils are of good average fertility, judging from their chemical composition and physical constitution. The only apparent deficiency is of phosphoric acid in the subsoil No. 2214. This, however, is easily to be supplied in phosphatic fertilizers. The under-clay is chemically richer than the upper soil.

Some of the *silicious residue* of the "under-clay" was submitted to analysis by fusion with the alkaline carbonates, &c., with the following results, viz:

CONSTITUENTS OF ONE GRAMME OF THE *SILICIOUS RESIDUE* OF THE UNDER-CLAY, No. 2215, DRIED AT 212° F.

Silica	0.76880
Alumina and iron oxide, &c.	.18920
Lime	.00061
Magnesia	.00569
Phosphoric acid	.00051
Potash	.02742
Soda	.00225
Moisture and loss	.00552
Total	1.00000

This analysis shows that the silicious residue of this under-clay not only contains 2.742 per cent. of potash, but as much

as .05 per cent. of phosphoric acid, besides notable quantities of alumina, lime, and magnesia. Its gradual decomposition by weathering would undoubtedly tend to maintain the fertility of the soil. Under Fulton county the analyses of other silicious residues are reported which gave analogous results.

No. 2216—"*Marly clay at the base of Carboniferous series; probably on the Keokuk horizon. Part of the section contains thin beds of clay iron-stone; but beds of many feet in thickness can be obtained. Nelson county.*" *Collected by N. S. Shaler.*

This clay is quite plastic, when powdered, and calcines of a buff color. Before the blow-pipe it fuses into a dark colored slag.

COMPOSITION, DRIED AT 212° F.

Silica	61.100
Alumina with phosphoric acid	18.200
Iron peroxide	6.000
Lime	4.904
Magnesia	1.542
Potash	4.101
Soda	.821
Combined water, carbonic acid, and loss	3.332
Total	100.000

This clay may be employed for terra-cotta work or other pottery not to be exposed to a very high temperature in burning; but its large proportions of iron oxide, lime, potash, magnesia, and soda cause it to be readily fusible. Its proportion of phosphoric acid was not determined, but its other ingredients, mentioned above, especially the alkalies and lime, may make it a valuable marl for top-dressing light and exhausted soils.

PULASKI COUNTY.

SOILS.

No. 2217—"*Virgin soil from a ridge near the farm of Mr. Taylor, on the London and Somerset road. This ridge divides the waters of Sinking Valley creek. Geological position: one hundred and fifty feet above the Sub-carboniferous limestone, the ridge being formed of the coal-bearing sandstones and slates. Very thin poor land. Scarcely any one is willing to settle on this kind of ridges.*" *Collected by Joseph Lesley, jr., July*, 1859 (*during the former Survey under the late Dr. D. D. Owen*).

The dried soil is of a grey-buff color; friable. The coarse sieve removed from it 31.6 per cent. of irregular fragments of ferruginous sandstone. Only the fine soil, which passed through this sieve, constituting 68.4 per cent. of the whole soil, was taken for chemical analysis. The same practice obtained in all cases.

The silicious residue of this soil, left after digestion in acids, with a view to its analysis, all passed through the bolting-cloth, except a very few small particles of partly-decomposed concretions and of rounded quartz grains.

No. 2218—"*Virgin soil from a ridge dividing Rockcastle from Buck creek waters; Lick creek, Clifty creek, Whetstone creek, and a branch of Sinking creek, all heading in this immediate neighborhood. Geological position: upper part of the coal-bearing sandstones and shales. This ridge extends twenty to twenty-five miles in a southerly direction.*" *Collected by Jos. Lesley, jr., June*, 1859.

The dried soil is of a brownish grey-buff color. It contains few clods, which are quite friable. The coarse sieve separated from it 9.2 per cent. of irregular fragments of ferruginous sandstone, scarcely at all rounded. All its silicious residue passed through the bolting-cloth, except two or three small particles of partly-decomposed concretions, and a few small rounded grains of white quartz.

No. 2219—"*Surface soil from a field now* (1859) *in corn, adjoining the location of the next preceding. It has been cleared eight years. Will produce twenty-five bushels of corn to the acre. Alternation of crops has been attended to.*" *Collected by Jos. Lesley, jr.*

The dried soil is friable, darker colored than the preceding; of a light umber tint. The coarse sieve separated from it 19.2 per cent. of irregular, somewhat rounded fragments of ferruginous sandstone. From its silicious residue the bolting-cloth separated a little more of small, rounded particles of white quartz than from the preceding, but very few of partly-decomposed concretions.

No. 2220—"*Subsoil of the next preceding*," *&c., &c.*

The dried subsoil is of a light brownish or ferruginous grey tint, lighter in color than the preceding. It contains many fragments of rock. The coarse sieve separated 34.7 per cent. of irregular fragments of ferruginous sandstone. The bolting-cloth separated from the silicious residue rather more of small rounded quartz grains than from the preceding, and a few more of small particles of partly-decomposed concretions.

No. 2221—"*Virgin soil from the farm of Owen Hunt, two miles and a half east of Grundy; six miles northeast of Somerset; on Blazed Hollow branch of Pitman's creek. Geological position: slopes formed of Sub-carboniferous limestone.*" *Collected by Joseph Lesley, jr.*

The dried soil is quite light and friable, of a light brownish-grey color. The coarse sieve removed from it 13.8 per cent. of small, rounded quartz pebbles, with a few of small scarcely-rounded fragments of ferruginous sandstone. Its silicious residue, after digestion in acids, left on the bolting-cloth a rather larger proportion of small, rounded grains of whitish and reddish quartz than the preceding soils, also a few particles of partly-decomposed concretions.

No. 2222—"*Surface soil from a field adjoining the locality of the next preceding, which has been in cultivation about seventy-five years; in crops alternating with corn, wheat, and oats; now (June, 1859) in corn, which will yield about thirty bushels to the acre. Cattle have been turned on sparingly. Has been plowed deep for Eastern Kentucky, to the depth of eight to nine inches.*" *Collected by Joseph Lesley, jr.*

The dried soil is of a dark brownish-grey color, darker than the preceding. Friable. The coarse sieve removed from it 15 per cent. of small quartz pebbles and sandstone fragments; the pebbles not being so large proportion as in the preceding soil. The bolting-cloth separated from its silicious residue about the same proportion of small rounded grains of whitish and reddish quartz, and of partly-decomposed concretions, as from the preceding.

No. 2223—"*Subsoil of the next preceding*," *&c., &c.*

The dried subsoil is of a lighter brownish-grey than the preceding. Contains moderately firm clods.

The coarse sieve separated only 3.1 per cent. of small somewhat rounded fragments of ferruginous sandstone mixed with a very few small quartz pebbles. All its silicious residue passed through the bolting-cloth, except a rather small quantity of fine white sand, and rather more of small particles of partly-decomposed concretions than from the preceding.

No. 2224—"*Under-clay taken from below the next preceding to show the clayey nature of the real under-soil of these limestone valleys. Sample taken from the depth of twelve to fifteen inches.*" *Collected by Jos. Lesley, jr.*

This dried under-clay is of a light brownish-ochre color. The clods are quite firm. The coarse sieve separated from it 4.5 per cent., mostly of small quartz pebbles. From its silicious residue the bolting-cloth removed a considerable proportion of small grains of partly-decomposed concretions and a few of reddish and whitish quartz.

No. 2225—"*Virgin soil from the farm of James Denny, on the border of Wayne county, seven miles south of Somerset, one mile from the forks of the main Cumberland and Big South Fork. Geological position: Sub-carboniferous limestone formation. Note: This is a characteristic soil of the 'Barrens' of Pulaski and Wayne counties. The 'Barrens' form a strip of the first great terrace above and south of the Cumberland river, averaging five miles in width and extending lengthwise from the forks of the Cumberland to and beyond Monticello. Fifty years ago they were open prairie, with only occasional high swells, covered with black oak timber; now they are covered, where not cultivated, with a fine 'second growth,' mostly of black oak and hickory, with scattering dogwood and black gum.*" *Collected by Joseph Lesley, jr.*

The dried soil is friable, of an umber-grey color. The coarse sieve removed from it 8 per cent. of angular cherty particles, mixed with a little shot iron ore. All of its silicious residue passed through the bolting-cloth except a small proportion of hard, irregular particles of partly-decomposed concretions, and a small quantity of small, rounded grains of white quartz.

No. 2226—"*Surface soil from a field adjoining the locality of the next preceding. This field has been cleared up three years, and been planted in corn each year; plowed shallow; no manure used.*" *Collected by Joseph Lesley, jr.*

The dried soil is friable, of a light chocolate tint, deeper colored than the next preceding. The coarse sieve removed from it only 1.5 per cent. of cherty particles. Its silicious residue left on the bolting-cloth but a small proportion of small particles of partly-decomposed concretions and of small quartz grains.

No. 2227—"*Subsoil of the next preceding,*" *&c., &c.*

The dried subsoil contains some friable clods. It is of a slightly darker color than the next preceding. The coarse

sieve removed but a very small proportion of small, cherty fragments.

From its silicious residue the bolting-cloth separated a considerable proportion of small, rounded particles of partly-decomposed concretions, mixed with a small quantity of small, rounded grains of white quartz.

No. 2228—"*Surface soil from another field adjoining the locality of No. 2225. This field has been in active cultivation for fifty to sixty years, with the exception of the last two years. It is now* (1859) *in pasture* (*viz: pennyroyal and crab grass*)." *Collected by Joseph Lesley, jr.*

The dried soil is friable, and of a light chocolate color. The coarse sieve removed from it but a very small proportion of shot iron ore, with a few small, cherty particles. The bolting-cloth separated from its silicious residue only a small proportion of small quartzose and silicate grains.

No. 2229—"*Subsoil of the next preceding*," *&c., &c.*

The dried subsoil contains some friable clods. It is darker colored and more reddish than the preceding, being of a warm or reddish-brown color. The coarse sieve removed from it but a very small proportion of small, angular, cherty fragments and shot iron ore. From its silicious residue the bolting-cloth separated a considerable quantity of small, rounded particles of partly-decomposed concretions, mixed with a small proportion of small, rounded grains of white quartz.

A marked difference is observable in the rocky fragments or gravel of these different soils. In the "ridge" soils, Nos. 2217 to 2220, inclusive, these are generally angular fragments of ferruginous sandstone; in the Sub-carboniferous soils, Nos. 2221 to 2224, inclusive, the gravel is mainly quartzose pebbles, with but little of ferruginous sand rock or concretions; while in the "Barrens" soils, Nos. 2225 to 2229, inclusive, the gravel is cherty, and usually in angular fragments.

COMPOSITION OF THESE PULASKI COUNTY SOILS, DRIED AT 212° F.

	No. 2217	No. 2218	No. 2219	No. 2220	No. 2221	No. 2222	No. 2223	No. 2224	No. 2225	No. 2226	No 2227	No. 2228	No. 2229
Organic and volatile matters	3.890	4.200	6.375	3.260	2.135	2.550	2.140	2.225	4.590	5.615	3.790	4.300	3.700
Alumina and iron and manganese oxides.	5.661	5.640	6.726	7.894	4.090	5.109	6.240	7.767	4.938	7.072	7.847	8.282	8.923
Lime carbonate	.125	.095	.345	.095	.170	.245	.170	.195	.220	.295	.130	.310	.220
Magnesia	.088	.070	.124	124	.052	.097	.128	.213	.115	.146	.122	.115	.115
Phosphoric acid	.089	.045	.059	.076	.045	.076	.045	.083	.087	.118	.093	.148	.077
Potash extracted by acids	.345	.222	.277	.066	.147	.151	.217	.351	.145	100	.213	.149	.149
Soda extracted by acids	.027	. . . . .	.139	.256	.071	.060	.083	. . . . .	.089	.084	. . . . .	. . . . .	. . . . .
Water expelled at 380° F	.925	1.000	1.425	.790	.525	.650	.560	.525	1.535	1.985	1.400	1.700	1.550
Sand and insoluble silicates	88.690	88.765	84 350	87.640	92.765	91.240	90.540	88.790	88.340	84.500	86.675	84.990	85.490
Total	99.840	100.037	99.820	100.201	100.000	100.178	100.123	100.149	100.059	99.915	100.270	99.994	100.224
Hygroscopic moisture	0.915	1.315	1.900	1.235	2.135	0.900	0.965	0.775	1.750	1.525	1.200	1.225	1.340
Potash in the insoluble silicates	.642	.927	.852	.878	.778	.967	1.047	1.237	.953	.863	.762	.826	.795
Soda in the insoluble silicates	.205	.287	.139	.220	.260	.349	.340	.289	.223	.199	.230	.167	.160
Percentage of gravel, &c., in the soil	31.600	9.200	19.200	34.700	13.800	15.000	3.100	4.500	8.000	1.500	Sma'l p'n	Small p n.	Small p'n.
Character of the soil	Virgin soil	Virgin soil	Cultivated field.	Subsoil.	Virgin soil	Old field soil.	Subsoil.	Under-clay.	Virgin soil	Cu'tivated field.	Subsoil.	Old field soil.	Subsoil.

When we discount the ridge soil, No. 2217, by the 31.60 per cent. of sandstone fragments which it contains, and which could hardly afford much vegetable nourishment, we see that it cannot be a very durable and productive soil, yet if its local situation were favorable to the cultivation of crops, it might be made durable and profitably fertile with skillful management and the use of fertilizers. The principal deficiency in the fine earth of these soils seems to be of phosphoric acid. Subsoil No. 2220 not only contains a very large proportion of the rocky gravel, 34.70 per cent., but is also deficient in phosphoric acid and available potash. It would not benefit the surface soil to throw up this subsoil. The proportion of alkalies in the insoluble silicates seems to be below the general average of good soils.

Soils No. 2221, 2222, and 2223 also contain but a small proportion of phosphoric acid, but have a larger quantity of potash. Their sand and insoluble silicates are in large proportion. The soils from the "Barrens" are richer than these others, and ought to be quite productive under good management. These subsoils seem to be somewhat deficient in phosphoric acid, which is in good average proportion in the surface soils.

ROCKCASTLE COUNTY.

SOILS.

No. 2230—"*Virgin soil from the nose of the ridge between the East and West Forks of Skeggs' creek, and from the land of Halbert McClure. Geological position: coal-bearing sandstones and shales, one hundred feet above the Sub-carboniferous limestone, from a terrace containing coal.*" *Collected by Jos. Lesley, jr., June*, 1859.

The dried soil is light and friable. It is of a light chocolate yellowish-grey color. The coarse sieve separated from it 14.5 per cent. of small irregular somewhat rounded fragments of soft ferruginous sandstone. All its silicious residue, from digestion in acids, passed through the bolting-cloth, except a very few small grains of partly-decomposed concretions and a few small rounded quartz grains.

No. 2231—"*Virgin soil from a ridge in the northeast corner of Rockcastle county, which divides the waters of Clear and Brush creeks; both tributaries to Roundstone creek. Timber: chestnut oak and white oak, with undergrowth of laurel and some pine. Geological position: Millstone grit, which, on this ridge and on parallel ones in this part of the country, forms the capping.*" *Collected by Joseph Lesley, jr.*

The dried soil is of a grey-buff color; it is quite friable. The coarse sieve separated 21.4 per cent. of irregular fragments of ferruginous sandstone and some small, rounded pebbles of white quartz. The bolting-cloth removed very few small grains of partly-decomposed concretions from its sand and insoluble silicates left after digestion in acids, but a pretty large proportion, about one sixth of the whole, of small, rounded white quartz grains.

No. 2232—"*Virgin soil from the farm of William M. Smith, on the Crab Orchard and London Turnpike, three miles east of Mount Vernon. Taylor's branch of Roundstone creek runs through the field. Geological position: slopes of the Sub-carboniferous limestone. These slopes form the principal part of the farmed land on Roundstone, Skegg's, and Line creeks and their tributaries in this part of Rockcastle county. The northern slopes of the valleys are considered the best.*" *Collected by Joseph Lesley, jr.*

The dried soil is darker colored than the preceding. It is of a brownish grey-buff color. Its clods are friable. The coarse sieve removed from it 12.5 per cent. of irregular, somewhat rounded fragments of ferruginous sandstone. The bolting-cloth separated from its silicious residue but a small proportion of small particles of partly-decomposed concretions and of fine, rounded grains of white and reddish quartz.

No. 2233—"*Surface soil from a field adjoining the next preceding. This field was cleared up thirty years ago, and is now* (1859) *in oats. It was supposed to be worn out when Mr. Smith took it; has been manured, and now yields fifty bushels of corn per acre.*" *Collected by Joseph Lesley, jr.*

The dried soil is darker colored and more brownish than

the next preceding. Its clods are friable. The coarse sleve removed from it 17.4 per cent. of irregular fragments, somewhat rounded, of soft ferruginous sandstone. Its sand and insoluble silicates all passed through the bolting-cloth except a very small proportion of small grains of partly-decomposed concretions and of white quartz.

No. 2234—"*Subsoil of the next preceding*," *&c., &c.*

The dried subsoil resembles the next preceding soil, but is a little darker colored, and its clods are quite firm. The coarse sieve removed from it 12 per cent. of irregular fragments, somewhat rounded, of soft, ferruginous sandstone. The bolting-cloth separated rather more of small, rounded grains of white quartz from its silicious residue than from the preceding, but very few small grains of partly-decomposed concretions.

No. 2235—"*Surface soil of a field in pasture adjoining No. 2233. This field has been cleared up sixty years, and only manured on the very bare spots.*" *Collected by Joseph Lesley, jr.*

The dried soil is of a very light chocolate tint, but somewhat darker in color than the next preceding. The coarse sieve separated from it 29 per cent. of irregular fragments of soft ferruginous sandstone. Its silicious residue all passed through the bolting-cloth, except a few small, soft grains of partly-dissolved concretions, and a very small proportion of small, rounded white quartz grains.

No. 2236—"*Subsoil of the next preceding*," *&c., &c.*

The dried subsoil resembles No. 2232. The coarse sieve removed 28.6 per cent. of irregular fragments of soft ferruginous sandstone, with some fragments of limonite, and a few quartzose pebbles. All its silicious residue passed through the bolting-cloth, except a small proportion of grains of partly-decomposed concretions, and of white quartz.

COMPOSITION OF THESE ROCKCASTLE COUNTY SOILS, DRIED AT 212° F.

	No. 2230	No. 2231	No. 2232	No. 2233	No. 2234	No. 2235	No. 2236
Organic and volatile matters	6.890	4.150	4.950	6.065	4.265	4.500	3.360
Alumina & iron & manganese oxides	7.126	3.877	7.342	8.565	8.490	7.097	7.025
Lime carbonate	.345	.085	.435	.640	.625	.495	.595
Magnesia	.223	.120	.232	.153	.175	.130	.187
Phosphoric acid	.109	.083	.093	.146	.220	.173	.125
Potash extracted by acids	.366	.100	.231	.339	.453	.208	.254
Soda extracted by acids	.093	. . . . .	.008	. . . . .	.125	.002	.031
Water expelled at 380° F.	1.925	.750	1.300	1.650	1.375	1.300	.965
Sand and insoluble silicates	82.690	90.665	85.065	82.040	83.890	85.980	87.640
Total	99.767	99.830	99.656	99.598	99.618	99.885	100.032
Hygroscopic moisture	2.085	0.900	1.775	2.225	1.915	1.510	1 250
Potash in the insoluble silicates	.925	.671	.918	.815	.857	.756	.690
Soda in the insoluble silicates	.128	201	.312	.248	.260	.250	.234
Percentage of gravel, &c.	14.500	21.400	12.500	17 400	12.000	29.000	28.600
Character of the soil	Virgin soil	Virgin soil	Virgin soil	Old field	Subsoil.	Old field	Subsoil.

Of the above described soils of Rockcastle county, No. 2230, based on the coal-measure shales, &c., is quite a good soil; to be discounted, however, by its 14.5 per cent. of ferruginous sandstone fragments or gravel. No. 2231, situated on the Millstone grit, is the poorest of the whole, especially as it contains 21.4 per cent. of this gravel. The other soils described, all based on the Sub-carboniferous limestone formation, are better than the average of good soils; but are also to be discounted by their considerable percentage of sandstone gravel, of which the soil of the old field, No. 2235, and its subsoil, show much the largest proportions. In these old field soils may also be seen the usual results of long cultivation in the diminution of the alkalies, phosphoric acid, &c., as compared with the original virgin soil of the neighborhood. Such a comparison could not be accurately made unless the two soils were similarly located in relation to the action of the atmospheric waters; those on a slope being more subject to their deteriorating, washing influence than those on more level ground. This influence may probably be observed on the relative composition of soil No. 2232 situated on the slopes of Roundstone. The old field soil, No. 2233, is now quite rich.

TRIMBLE COUNTY.

No. 2237—"*A 'chalky substance' sent by Mr. S. E. Hampton for examination.*"

According to his report, it exists in a stratum about two feet

thick, discovered in digging a cistern about five feet below the surface, in a mound-like hill, the highest in the neighborhood, which is in Hunter's Bottom, about five miles below Carrollton.

It is a fine granular rock, soft enough to be scratched by the nail, nearly white, with a very faint yellowish tint. Under the microscope it was seen to be made up of minute, transparent crystals, in form somewhat like those of Aragonite. By tests it was found to be nearly pure carbonate of lime, with a trace of iron oxide.

If in large quantity, as it is said to be by Wm. Hampton, it might be utilized in the manufacture of soda ash from salt, or of glass, or it might be made valuable as an ingredient in the manufacture of Portland cement.

No. 2238—"*By the same person a sample of another white substance was sent, labeled 'Silicious clay,' forty feet thick and a mile wide, from near Milton, Trimble county.*"

Quite a friable concretion, which was found to be nearly pure quartz, with a minute quantity of carbonate of lime. The microscope shows it to be in the form of very minute, transparent, colorless, acicular, prismatic crystals.

This pure silicious deposit, which, like the preceding one of carbonate of lime, is doubtless of more recent deposit than rocky substratum, might be made profitable in the manufacture of glass, of pottery ware, of Portland cement, soluble glass, &c.

WAYNE COUNTY.

SOILS.

No. 2239—"*Virgin soil from the farm of Silas Hansford, in the northeast end of Wayne county, on the Dry Branch of Big Sinking creek, three miles due west from its mouth. This sample is from a piece of woods back of his house. Geological position: upper part of the Sub-carboniferous limestone, on a terrace which has received more or less of the débris from the sandstones and shales lying immediately above it.*" *Collected by Joseph Lesley, jr.*

The dried soil is friable, and of a light greyish-umber color The coarse sieve separated from it 7.5 per cent. of fragment.

of ferruginous sandstone, not much rounded. All of its silicious residue, from digestion in acids, passed through the bolting-cloth, except a small proportion of small, rounded, soft particles of partly-decomposed concretions, and of whitish and reddish quartz.

No. 2240—"*Surface soil from a field next adjoining to the location of the next preceding, which has been cleared two years. Last year it was in turnips; this year* (1859) *is in corn.*" *Collected by Joseph Lesley, jr.*

This dried soil resembles the preceding. The coarse sieve separated from it 4.4 per cent. of small, slightly-rounded ferruginous sandstone particles. Its silicious residue all passed through the bolting-cloth except a small proportion of small, rounded grains of white quartz, and of partly-decomposed concretions.

No. 2241—"*Subsoil of the next preceding,*" *&c., &c.*

The dried subsoil is rather lighter colored and more yellowish than the soil preceding. It contains some pretty firm clods. The coarse sieve separated from it 16.5 per cent. of irregular fragments, some pretty large, of ferruginous sandstone and concretions, some of which show much manganese oxide. The bolting-cloth removed from its silicious residue a smaller proportion of small grains of quartz, and of partly-decomposed concretions than from the preceding soils.

No. 2242—"*Virgin soil from farm of Silas Hansford, &c., &c. From below his house, in a dry, flat, swelling valley. Geological position: about the middle of the Sub-carboniferous limestone formation.*" *Collected by Joseph Lesley, jr.*

The dried soil is like No. 2239, slightly darker colored. It has some friable clods. The coarse sieve removed from it 6.6 per cent. of small, rounded, ferruginous silicious particles, and a few small quartz pebbles. From its silicious residue the bolting-cloth separated a little larger proportion of small, rounded friable particles of partly-decomposed concretions

than from the preceding soil; also a small proportion of small, rounded white quartz grains.

No. 2243—"*Surface soil from a field across the road from the location of the next preceding soil. This field has been in active cultivation for fifty years; mostly in corn; is this year* (1859) *in corn. No manure has been used.*" *Collected by Jos. Lesley, jr.*

The dried soil is like the preceding, very slightly darker colored and more brownish. The clods are a litttle more firm. The coarse sieve separated from it 11.2 per cent. of somewhat rounded, irregular ferro-silicious fragments or concretions. With the bolting-cloth its silicious residue gave similar results with the preceding.

No. 2244—"*Subsoil of the next preceding*," *&c., &c.*

The dried subsoil is of a warm, brownish, dark-grey color. The clods are quite firm and more reddish in their interior than the powdered soil. The coarse sieve separated from it 10.3 per cent. of irregular, somewhat rounded, ferro-silicious fragments. From its silicious residue, after digestion in acids, the bolting-cloth removed quite a large proportion of small, rounded, friable particles of partly-decomposed concretions, and a few small, rounded grains of white quartz.

No. 2245—"*Virgin soil from the farm of John H. Phillips, Newberry Post-office, eleven miles southwest from Monticello, on the road to Albany, one mile west from Otter creek. Timber: white and black oak, hickory, dogwood. Geological position: Sub-carboniferous limestone. Soil: red ferruginous, on the great undulating plateau of Wayne and Clinton counties.*" *Collected by Joseph Lesley, jr., July,* 1859.

The dried soil is of a grey-brown or light snuff color; friable. The coarse sieve separated from it only 1.5 per cent. of small, rounded, ferruginous, silicious particles. Its silicious residue all passed through the bolting-cloth except very small proportions of small, rounded grains of partly-decomposed concretions and white quartz, with a few silicified portions of very small encrinital stems.

No. 2246—"*Surface soil from a field on the same level as the next preceding, cleared about sixty years ago, which was uninterruptedly in corn for the first twelve or twenty years. Of late years more attention has been paid to alternation of crops; but eight out of ten years of the sixty it has been in corn. Now* (1859) *in wheat stubble.*" *Collected by Jos. Lesley, jr.*

The dried soil is friable, and is of a handsome, light, reddish grey-brown color. The coarse sieve removed from it only 1.6 per cent. of small, rounded, ferruginous, silicious particles. Its silicious residue gave the same result with the bolting-cloth as the preceding.

No. 2247—"*Subsoil of the next preceding soil,*" *&c., &c.*

The dried subsoil resembles the soil next preceding, the color being only a light shade darker, being reddish grey-brown. The coarse sieve removed from it 3.2 per cent. of small, rounded, ferruginous, silicious particles and small quartz pebbles. With the bolting-cloth its silicious residue gave similar results with the two preceding soils.

No. 2248—"*Virgin soil from the farm of Hiram T. Hall, on the road from Albany to Monticello, six and three quarter miles southwest of the latter, and half way between Otter and Beaver creeks. Geological position: Sub-carboniferous limestone; red ferruginous horizon. Remarks: This specimen is taken from the so-called 'flat lands' of this county, which hereabout extend over a wide surface, and are estuary-like, being bays between long, low, wide noses which give the country a rolling character. Corn and other grains will not grow on it, although timothy and herd-grass are grown with great success. Timber: White and pin oaks, hickory and sugar maple.*" *Collected by Jos. Lesley, jr.*

The dried soil is friable and of a light ash-grey color. The coarse sieve separated from it only a very small proportion of shot iron ore. Its silicious residue all passed through the bolting-cloth, except very small proportions of small, friable,

rounded particles of partly-decomposed concretions and of white quartz.

No. 2249—"*Subsoil of the next preceding*," *&c., &c.*

The dried subsoil is much lighter colored than the soil next preceding, being of quite a light, yellowish-grey tint. It has some friable clods. The coarse sieve removed from it only a very small proportion of shot iron ore and small, silicious concretions. The bolting-cloth separated from its silicious residue a considerable proportion of small, rounded particles of partly-decomposed concretions and a few of white and reddish quartz.

No. 2250—"*Virgin soil from the red ferruginous soil horizon, or the Sub-carboniferous limestone formation. From the farm of Hiram T. Hall. This soil is a fair average of the farming lands of this portion of Wayne county.*" *Collected by Joseph Lesley, jr.*

The dried soil is friable and of an umber color. The coarse sieve separated from it 5.8 per cent. of angular, cherty fragments. The bolting-cloth removed from its silicious residue only very small proportions of partly-decomposed concretions and quartz grains.

No. 2251—"*Surface soil from a field adjoining the location of the next preceding, which has been in cultivation every year for sixty years, the first twenty years in corn; now* (1859) *in wheat stubble; last year in corn, and the year before in wheat.*" *Collected by Joseph Lesley, jr.*

The dried soil is friable and of a handsome, reddish, light grey-brown color. The coarse sieve removed from it 1.9 per cent. of angular, cherty fragments, and some little shot iron ore. The bolting-cloth separated from its silicious residue a considerable proportion of small, rounded, friable particles of partly-decomposed concretions and a few of small, rounded, white quartz grains.

No. 2252—"*Subsoil of the next preceding*," *&c., &c.*

The dried subsoil is somewhat cloddy. It is of a handsome light-ferruginous or brick color. The coarse sieve separated from it but a very small proportion of small, cherty particles. The bolting-cloth removed from its silicious residue quite a large proportion of small, rounded grains of partly-decomposed concretions and only a few small, rounded grains of quartz.

No. 2253—"*Virgin soil from the ridge between Big Sinking creek and Elk Spring valley, on the property of Edward Morrow, near the water-shed at the road crossing, three quarters of a mile south of Alexander's coal bank, and five miles east from Monticello. Geological position: Coal-bearing sandstones and shales, seventy feet below the main coal.*" *Collected by Joseph Lesley, jr.*

The dried soil is light and friable and of a very light buff-grey color. The coarse sieve separated from it 33.4 per cent. of pretty large, angular fragments of ferruginous sandstone, mixed with some smaller, rounded ones. From its silicious residue the bolting-cloth removed very few small, rounded particles of partly-decomposed concretions and quartz.

No. 2254—"*Virgin soil from a ridge dividing Cedar Sinking creek from Dry valley, near Double-headed Gap, in the north-east portion of the county. Geological position: Coal-bearing sandstones and shales, seventy feet above the top of the Sub-carboniferous limestone.*" *Collected by Joseph Lesley, jr.*

Dried soil friable; of a purplish-grey color: ash-grey. The coarse sieve separated from it 21.2 per cent. of angular fragments of ferruginous sandstone. The bolting-cloth removed from its silicious residue only a small proportion of particles of partly-decomposed concretions and no quartz grains.

COMPOSITION OF THESE WAYNE COUNTY SOILS, DRIED AT 212° F.

	No. 2239	No. 2240	No. 2241	No. 2242	No. 2243	No. 2244	No 2245	No. 2246	No. 2247	No 2248	No 2249	No. 2250	No 2251	No. 2252	No. 2253	No 2254
Organic and volatile matters	5.865	4.985	2.675	4.435	4.710	3.350	4.696	5.310	3.015	4.710	2.300	7.640	3.275	2.925	1.850	5 920
Alumina and iron and manganese oxides	8.089	3 944	4.201	6.347	5.817	8.814	9.151	8.922	8.681	5.140	6.031	8.415	8.215	8.279	2 836	5.703
Lime carbonate	.270	.360	.195	.405	.345	.345	.130	.145	.195	.205	.120	.460	.195	.070	.195	.345
Magnesia	.124	.187	.102	.187	.142	.133	.112	.147	.106	.154	.122	.088	.151	.151	.073	.286
Phosphoric acid	.096	.076	.076	.061	.093	.061	.099	.118	.109	.115	.084	.125	.125	.061	.029	.087
Potash, extracted by acids	.217	.166	.282	.206	.201	.220	.260	.266	.192	.212	.170	.184	.126	.259	.021	. 49
Soda, extracted by acids	.061	. . . .	. . . .	. . . .	. . . .	.014	.059	.011	. . . .	. . . .	.035	.020	. . . .	.072	.050	.069
Water, expelled at 380° F.	1 850	1.200	1.025	1.265	1.265	1.050	2.440	1.565	1.300	2 090	735	3.650	1.240	.615	.500	1.715
Sand and insoluble silicates	83.290	88.990	91.865	87.490	87.130	85.740	83.115	84.265	86.465	87.015	90.615	79.315	86 415	86.990	94.590	85.690
Total	99.862	99.908	100.421	100.396	99.703	99.727	100.061	100 749	100.063	99.641	100.212	99.897	99.742	99.422	100.144	100.064
Hygroscopic moisture	2.025	1.435	0.900	1.560	1.500	1.650	2.335	1.510	1.525	1.560	1.185	3.150	1.475	1.625	0.440	1.565
Potash in the insoluble silicates	.931	.651	.566	.614	.762	.859	.784	.729	.772	.570	.531	1.012	.799	.878	.711	.984
Soda in the insoluble silicates	.279	.196	.168	.159	.199	.183	.284	.289	.199	.127	.227	.262	.199	.161	.152	.274
Percentage of gravel	7 500	4.400	16.500	6 600	11.200	10.300	1.500	1.600	3.200	sm p'n.	sm. p'n	5.800	1.900	sm. p'n.	33.400	21.200
Character of the soil	Virgin soil.	Cult iv'd field.	Subsoil.	Virgin soil	Old field soil.	Subsoil	Virgin soil.	Old field soil	Subsoil	Virgin soil.	Subsoil	Virgin soil.	Old field	Subsoil.	Virgin soil.	Virgin soil.

All of these soils, which are based on the Sub-carboniferous limestone formation, appear, from their chemical composition and physical condition, to be very good and fertile, requiring only good management to make them productive. This is especially the case with No. 2250, said by Mr. Lesley to be a fair average of the farming lands of the red ferruginous horizon, in Wayne county, which may be classed among our rich soils. No. 2248 is said not to produce corn or other grains, but to be favorable to the growth of timothy and other grasses. As no reason for this default appears in its analysis, it is probably due to imperfect local drainage.

In all these soils the subsoils seem to be less rich than the surface soils; so that, for the present at least, no other benefit would result from deep plowing except that of loosening the substratum for more perfect drainage, or the extension of the roots of growing crops.

Soils Nos. 2239, 2240, and 2241, especially the subsoil, show the presence of the débris of the sandstones and shales lying above them; and soil No. 2253, lying on the water-shed of a ridge on the coal-bearing sandstones and shales, which is the poorest of all these soils, shows in a marked manner the deteriorating effects of the wash of the atmospheric waters through it, especially in its large proportions of gravel, sand and insoluble silicates, and its small quantities of organic matters, potash, soda, phosphoric acid, alumina, &c. Soil No. 2254, from a similar geological position and also on a ridge, shows much less of the effects of this surface washing, probably because it may be more favorably located in relation to the drainage, and may be considered a soil of good average fertility, under good management, notwithstanding its 21.2 per cent. of small, rocky fragments of coarse gravel, which diminishes its value about one fifth.

WEBSTER COUNTY.

SOILS.

No. 2255—"*Virgin soil from the farm of Col. Scott, Sebree City, on the L. and S. E. Railroad. Timber: white and red oaks, dogwood, whitewood, black walnut,*" *&c. Collected by C. W. Beckham.*

The dried soil is of a brownish umber-grey or chocolate-grey color. The clods are friable. It all passed through the coarse sieve except a little vegetable débris. Its silicious residue (*i. e.*, sand and insoluble silicates) all passed through the bolting-cloth except a very few small silicious grains.

No. 2256—"*Surface soil from a field seventy-five years in cultivation in corn and tobacco. Same locality as that of the preceding soil, but on a hill fifteen feet above the flats.*" *Collected by C. W. Beckham.*

The dried soil is generally of a dull brownish yellow-ochre color, mottled with reddish in the clods, which are quite firm. It contains fragments of charcoal. It all passed through the coarse sieve except a few small fragments of friable sandstone. The bolting-cloth removed from its silicious residue but a small proportion of small, rounded grains of white quartz and of partly-decomposed concretions.

No. 2257—"*Subsoil of the next preceding,*" *&c., &c.*

The dried subsoil is of a brighter brownish yellow-ochre color than the preceding. Its clods are quite firm. It all passed through the coarse sieve. Its silicious residue gave the same results with the bolting-cloth as that of the preceding.

No. 2258—"*Surface soil from a field more than fifty years in cultivation. Tobacco and corn the principal crops. Farm of Mr. Kaufman, Slaughterville Station, L. and S. E. Railroad.*" *Collected by C. W. Beckham.*

The dried soil is quite friable and of a brownish yellowish dark-grey color. It all passed through the coarse sieve. Its

silicious residue gave the same results with the bolting-cloth as the preceding.

No. 2259—"*Subsoil of the next preceding; used for making bricks*," *&c.*

The dried subsoil is in quite firm clods, of a browish yellow-ochre color. It all passed through the coarse sieve.

No. 2260—"*Surface soil from a field ten years in cultivation; principally in corn and tobacco. Farm of A. G. Brooks, Elmwood Station, L. and S. E. Railroad.*" *Collected by C. W. Beckham.*

The dried soil is of a brownish-drab or dirty-buff color. Its clods are friable. It all passed through the coarse sieve, leaving on it only some vegetable débris. With the bolting-cloth its silicious residue gave the same results as the preceding soils.

No. 2261—"*Subsoil of the next preceding*," *&c., &c.*

The dried subsoil is of a brownish-buff color, brighter than that of the preceding. Its clods are quite firm, and mottled with lighter-buff and ochreous tints. It all passed through the coarse sieve except vegetable débris and a few small ferruginous concretions. Its silicious residue gave the same results with the bolting-cloth sieve as the preceding soils of this collection.

COMPOSITION OF THESE WEBSTER COUNTY SOILS, DRIED AT 212° F.

	No. 2255	No. 2256	No. 2257	No. 2258	No. 2259	No. 2260	No. 2261
Organic and volatile matters	3.975	5.035	3.365	2.610	2.440	3.450	2.210
Alumina & iron & manganese oxides.	4.225	8.480	11.383	4.665	7.661	3.986	5.639
Lime carbonate	.330	1.895	.220	.145	.120	.270	.145
Magnesia	.277	.436	.450	.160	.241	.184	not est.
Phosphoric acid	.140	.285	.157	.125	.054	.094	.0[illegible]1
Potash extracted by acids	.064	.313	.392	.124	.071	.126	.108
Soda extracted by acids	.323	.030	.040	.012	.016	.057	.439
Water expelled at 380° F.	.950	.900	.800	.565	.585	1.250	.775
Sand and insoluble silicates.	89.855	82.940	83.205	91.445	88.755	90.490	90.815
Total	100.139	100.314	100.012	99.851	99.943	99 907	100.192
Hygroscopic moisture	1.680	2.850	3.325	1.200	1.975	1.575	1.365
Potash in the insoluble silicates.	1.697	1.730	1.956	1.544	1.779	1.570	1.750
Soda in the insoluble silicates.	.672	.482	.563	.712	.690	.746	.366
Character of the soil	Virgin soil	Old field soil.	Subsoil.	Old field soil.	Subsoil.	Cultivated field.	Subsoil.

The soil of the old field, seventy-five years in cultivation in tobacco and corn, with its subsoil, Nos. 2256 and 2257, must have been naturally much richer than the virgin soil, No. 2255, of its neighborhood, if the labels accompanying the samples are correct; for, notwithstanding its prolonged use in the production of exhausting crops, it contains much larger proportions of the essential elements of fertility than that, and may yet be classed amongst the rich soils. Most of these described above are at least of average fertility, the only apparent deficiency being of available potash in Nos. 2255 and 2259, and of phosphoric acid in Nos. 2260 and 2261, and in subsoils 2259 and 2261—ingredients which can readily be supplied in appropriate fertilizers. These soils are all in a favorable physical condition, being friable and in a state of fine division, and containing no gravel.

TABLE I. SOILS, SUBSOILS, AND UNDER-CLAYS, DRIED AT 212° F.

Number.	County.	Organic and volatile matters.	Aluminaand iron oxide, &c.	Lime carbonate	Magnesia.	Phosphoric acid	Potash.	Soda.	Water expelled at 380° F.	Sand and insoluble silicates.	Water expelled at 212° F.	Potash in the insoluble silicates.	Soda in the insoluble silicates.	Gravel.	Remarks.
2096	Ballard. . .	4.065	5 904	1.095	0.394	0.246	0.289	0.242	0.935	87.120	2.000	1.619	0.680	. . . .	Top soil Bar's, 4 yrs. in cult.; W. H. Reeves.
2097	Ballard. . .	2.790	7.597	.295	.308	.093	.449	.148	.760	87.395	2.300	1.482	.674	. . . .	Subsoil of the same.
2098	Ballard. . .	2.185	8.557	.195	.544	.093	.131	.653	.450	87.110	2.735	1.085	.536	. . . .	S'bs'l or un'r-clay; uplands around Blandville.
2099	Ballard. . .	1.565	7.835	.645	.601	.140	.175	.309	.435	87.495	2.300	2.138	1.208	. . . .	Sub. or un'r clay, uplands sev'l ft. below surface
2100	Ballard. . .	3.210	6.150	.155	.268	.115	.203	.364	1.065	88.890	1.865	1.659	1.165	. . . .	Virgin soil; bottom land, Mayfield creek.
2101	Ballard. . .	2.565	3 864	.385	.163	.061	.319	.362	.635	92.010	1.075	1.358	.616	. . . .	Old field soil; bottom land, Mayfield creek.
2102	Ballard. . .	2.125	5.088	.245	.184	.077	.276	.129	.675	91.570	1.125	1.401	.911	. . . .	Subsoil of next preceding.
2109	Clinton. . .	6.615	5.984	.405	.232	.166	.212	not est.	1.400	84.990	1.585	.983	.217	22.40	Virgin soil; sub-car. limestone; Lewis Huff's.
2110	Clinton. . .	9 275	6.687	.620	.232	.173	.274	not est.	1.810	81.165	1.990	.998	.101	27.00	Cultiv'd soil; sub-car. limestone; Lewis Huff's.
2111	Clinton. . .	6.910	6 951	.480	.223	.259	.222	not est.	1.665	83 365	1.750	.972	.158	14.20	Subsoil of next preceding.
2112	Clinton. . .	3.000	2.932	.080	.106	.093	.155	not est.	1.550	92.240	.900	.327	.169	29.50	Virgin soil; sub-car. limestone; Jno. Wade's.
2113	Clinton. . .	4.320	6.129	.295	.124	.071	.170	not est.	1.940	86.790	1.800	.726	.263	4.40	Old field soil; sub-car. limestone; J. Wade's.
2114	Clinton. . .	4.695	6.247	.195	.108	.093	.188	not est	1.500	86.790	1.515	.621	.169	8.20	Subsoil of next preceding.
2115	Crittenden .	2.225	3.629	.160	.304	.086	.090	not est	.875	92.705	.890	1.876	.896	. . . .	Virgin soil; ridge; sandst'e; S. C. B. McMican.
2116	Crittenden .	2.950	8 718	.145	.350	.092	.309	.118	.925	86.665	.925	2.023	.750	. . . .	Subsoil of next preceding.
2117	Crittenden .	3.260	4.868	.270	.214	.067	.171	not est	1.225	89 440	1.565	1.707	.694	. . . .	Cultivated field, same locality.
2118	Crittenden .	2.885	8.173	.170	.703	.102	.122	not est.	.950	86.490	2.000	1.755	.588	. . . .	Subsoil of same field.
2123	Fulton . . .	9.305	10.437	1.385	.461	.198	.142	not est	3.110	74.840	4.100	1.889	.607	. . . .	Top soil; Mississippi bottom land.
2124	Fulton . . .	4.725	5.127	1.045	.234	.198	.321	.419	1.150	87.145	2.350	1.814	.858	. . . .	Cultivated soil; Mississippi bottom land.
2125	Fulton . . .	3.075	5.335	.360	.175	.055	.179	not est.	1.025	89 945	1.685	1.767	.828	. . . .	Virgin soil; Dr. G. W. Pascal's.
2126	Fulton . . .	2 300	4.974	.190	.162	.156	.290	.124	.775	91.745	1.400	1.664	.749	. . . .	Old field soil; Dr. G. W. Pascal's.
2127	Fulton . . .	2.535	8.690	.195	.331	.125	.141	.098	.900	86.895	2.585	1.892	.715	. . . .	Subsoil of the next preceding.
2128	Fulton .	3.090	3.825	.395	.214	.125	.066	not est.	1.050	91.125	1.335	1.784	1.208	. . . .	Virgin soil; Capt. Henry Tyler's farm.
2129	Fulton . . .	2.285	7 700	.145	.268	.115	.186	.142	.840	87.795	2.610	1.675	.893	. . . .	Subsoil of next preceding soil; same farm.
2130	Fulton . . .	8.375	6.860	1.395	.598	.125	.332	.073	2.650	79.340	3.585	1.865	1.030	. . . .	Old field soil; Mississippi upland; same farm.
2131	Fulton . . .	4.140	10.560	.795	.169	.115	.208	.317	1.501	82.395	3.975	1.873	.841	. . . .	Subsoil of next preceding; same farm.
2132	Fulton . . .	2.860	3.560	.345	.142	.125	.074	.182	.975	91.740	1.000	1.969	.892	. . . .	Virgin soil; upland; same farm.
2133	Fulton . . .	2.165	6.550	.110	.232	.140	.275	.050	.650	89.670	1.725	1.935	.991	. . . .	Subsoil of next preceding.
2150	Henderson .	4.525	5.004	.570	.317	.131	.196	.112	1.225	87.990	1.815	1.654	.775	. . . .	Virgin soil; woodland pasture; W. Thompson's.
2151	Henderson .	3.150	3.968	.385	.241	.102	.238	.143	.865	91.315	1.200	1.619	.815	. . . .	Cultivated field; W. Thompson's.
2152	Henderson .	2.780	5.879	.520	.304	.061	.142	not est.	.735	89 215	1.900	2.036	.570	. . .	Subsoil of next preceding; W. Thompson's.
2153	Henderson .	2.125	5.979	.195	.245	.061	.236	not est.	.420	90.725	1.350	1.672	.763	. . . .	Old field soil; J. D. Robsard's.
2154	Henderson .	2.900	10.047	.130	.304	.093	1.097	not est.	.550	85.365	2.575	1.755	.608	. . . .	Subsoil of the same; J. D Robsard's.
2155	Henderson .	3.465	3.113	.120	.166	.077	.363	.165	.600	92.290	1.175	1.121	.742	. .	Virgin soil; woods pasture; Mr. Klute.
2156	Henderson .	3.025	4.048	.195	.196	.067	.550	not est.	.600	91.625	1.325	1.127	.714	. . . .	Old field soil; Mr. Klute.
2157	Henderson .	3.290	9.589	.950	.342	.061	.429	.185	.580	85.040	1.850	1.128	.819	. . . .	Subsoil of next preceding; Mr Klute.
2158	Henderson .	3.835	3.364	.220	.175	.061	.371	not est.	.715	91.665	1.125	1.274	.846	. . . .	Virgin soil; woods pasture; S. H. Busbey's.
2159	Henderson .	2.785	4.129	.220	.309	.061	.382	.123	.566	91.840	1.025	1.457	.704	. . . .	Old field soil; S. H. Busbey's.
2160	Henderson .	3.350	9.644	.195	.195	.121	.357	.109	.675	85.890	2.100	1.573	.611	. . . .	Subsoil of the same; S. H. Busbey's.
2161	Hickman . .	4.140	3.694	.495	.232	.156	.182	564	1.010	90.095	1.735	1.899	.573	. . . .	Upland soil, two years in cultivation.
2206	Madison . .	7.240	10 353	2 485	.989	.387	545	.162	1.122	76.715	3.275	1.949	.206	sm. p'n	Top soil, in cult. 26 yrs; on Cumberland shales.
2207	Madison . .	7.150	10.905	1.870	.809	.300	.638	not est.	1.450	77.395	3.775	2.079	.281	sm. p'n	Subsoil of same field.
2208	Madison . .	2.950	11.032	.220	.160	.173	.359	not est.	.800	84.174	2.575	1.800	.407	sm. p'n	Bottom clay, under the preceding.

TABLE I. SOILS, SUBSOILS, AND UNDER-CLAYS, DRIED AT 212° F.—Continued.

Number.	County.	Organic and volatile matters.	Alumina and iron oxide, &c.	Lime carbonate.	Magnesia.	Phosphoric acid.	Potash.	Soda.	Water expelled at 380° F.	Sand and insoluble silicates.	Water expelled at 212° F.	Potash in the insoluble silicates.	Soda in the insoluble silicates.	Gravel.	Remarks.
2212	McCracken	1.840	5.883	0.070	0.200	0.082	0.186	0.314	0.485	90.520	1.500	1.773	0.855	sm. p'n	Subsoil; land of Dr S. B. Caldwell.
2213	Nelson . .	2.360	7.977	.270	.166	.108	.116	.225	1.215	86.650	1.485	1.669	.274	1.400	Cul'd field, near Rohan's Knob; Mr. Ballard's
2214	Nelson . .	2.990	10.349	.245	.187	.061	.164	.045	.900	85.075	2.525	1.835	.400	.500	Subsoil of the same.
2215	Nelson . .	3.300	14.368	.880	.809	.102	.361	.657	2.415	76.840	1.129	2.742	.225	1.000	Under-clay of the same.
2217	Pulaski. . .	3.890	5.661	.125	.088	.089	.345	.027	.925	88.690	.915	.642	.205	31.600	Virgin soil on ridge; farm of Mr. Taylor.
2218	Pulaski. . .	4.200	5.640	.095	.070	.045	.222	. . . .	1.000	88.765	1.315	.927	.287	9.200	Virgin soil on ridge; coal-measures.
2219	Pulaski. . .	6.375	6.726	.345	.124	.059	.277	.139	1.425	84.350	1.900	.852	.139	19.800	Cultivated soil; same locality.
2220	Pulaski. . .	3.260	7.894	.095	.124	.076	.066	.256	.790	87.640	1.235	.878	.220	34.700	Subsoil of next preceding.
2221	Pulaski. . .	2.135	4.090	.170	.052	.045	.147	.071	.525	92.765	2.185	.778	.260	13.800	Virgin soil, on sub-carboniferous limestone.
2222	Pulaski. . .	2.550	5.109	.245	.097	.076	.151	.060	.650	91.240	.900	.967	.349	15.000	Old field, in same locality.
2223	Pulaski. . .	2.140	6 240	.170	.128	.045	.217	.083	.560	90.540	.965	1.047	.340	3.100	Subsoil of the next preceding.
2224	Pulaski. . .	2.825	7.767	.195	.213	.083	.351	. . . .	.585	88.790	.775	1.237	.289	4.500	Under-clay of next preceding.
2225	Pulaski. . .	4.590	4.938	.220	.115	.087	.145	.089	1.535	88.340	1.750	.953	.223	8.000	Virgin soil; sub-car. limestone; "Barrens."
2226	Pulaski. . .	5.615	7.072	.295	.146	.118	.100	.084	1.985	84.500	1.525	.863	.199	1.500	Old field soil; same locality.
2227	Pulaski. . .	3.790	7.847	.130	.122	.093	.213	n. e.	1.400	86.675	1.200	.762	.230	sm. p'n	Subsoil of the next preceding.
2228	Pulaski. . .	4.300	8.282	.310	.115	.148	.149	n. e.	1.700	84.990	1.225	.826	.167	sm. p'n	Old field soil; same locality.
2229	Pulaski. . .	3.700	8.923	.280	.115	.077	.149	n. e.	1.550	85.490	1.340	.795	.160	sm p'n	Subsoil of next preceding.
2230	Rockcastle.	6.890	7.126	.345	.223	.109	.366	.093	1.925	82.690	2.085	.925	.128	14.500	Virgin soil; coal-bearing sandstones and shales
2231	Rockcastle.	4.150	3.877	.085	.120	.083	.100	n. e.	.750	90.665	.900	.671	.201	21.400	Virgin soil; ridge; millstone grit.
2232	Rockcastle.	4.950	7.342	.435	.232	.093	.231	.008	1.300	85.065	1.775	.918	.312	12.500	Virgin soil; slopes of sub-car. limestone.
2233	Rockcastle.	6.065	8.565	.640	.153	.146	.339	n. e.	1.650	82.040	2.225	.815	.248	17.400	Old field soil; same locality.
2234	Rockcastle.	4.265	8.490	.625	.175	.220	.453	.125	1.375	83.890	1.915	.857	.260	12.000	Subsoil of the next preceding.
2235	Rockcastle.	4.500	7.097	.495	.130	.173	.208	.002	1.300	85.980	1.510	.756	.250	29.000	Old field soil; same locality.
2236	Rockcastle.	3.360	7.025	.395	.187	.125	.254	.031	.965	87.690	1.250	.690	.234	28.600	Subsoil of next preceding.
2239	Wayne . .	5.865	8.089	.270	.124	.096	.217	.061	1.850	83.290	2.025	.931	.279	7.500	Virgin soil; sub-car. limestone; upper part.
2240	Wayne . .	4.985	3.944	.360	.187	.076	.166	. . . .	1.200	88.990	1.435	.651	.196	4.400	Cultivated field soil; same locality.
2241	Wayne . .	2.675	4.201	.195	.102	.076	.282	. . . .	1.025	91.865	.900	.566	.168	16.500	Subsoil of next preceding.
2242	Wayne . .	4.435	6.347	.405	.187	.061	.206	. . . .	1.265	87.490	1.560	.614	.159	6.600	Virgin soil; sub-car. limestone; middle part.
2243	Wayne . .	4.710	5.817	.345	.142	.093	.201	. . . .	1.265	87.130	1.500	.762	.199	11.200	Old field soil; same locality.
2244	Wayne . .	3.350	8.814	.345	.133	.061	.220	.014	1.050	85.740	1.650	.859	.183	10.300	Subsoil of next preceding.
2245	Wayne . .	4.695	9.151	.130	.112	.099	.260	.059	2.440	83.115	2.335	.784	.284	1.500	Virgin soil; sub-car. limestone; ferrug. horizon
2246	Wayne . .	5.310	8.922	.145	.147	.118	.266	.011	1.565	84.265	1.510	.729	.289	1.600	Old field soil; same locality.
2247	Wayne . .	3.015	8.681	.195	.106	.109	.192	. . . .	1.300	86.465	1.525	.772	.199	3 200	Subsoil of next preceding.
2248	Wayne . .	4.710	5.140	.205	.154	.115	.212	. . . .	2.090	87.015	1 560	.570	.127	sm. p'n	Virgin soil; sub-car. limestone red fer. horizon
2249	Wayne . .	2.300	6.031	.120	.122	.084	.170	.035	.735	90.615	1.185	.531	.227	sm. p'n	Subsoil of next preceding.
2250	Wayne . .	7.640	8.415	.460	.088	.125	.184	.080	3.650	79.315	3.150	1.012	.262	5.800	Virgin soil; same formation.
2251	Wayne . .	3.275	8.215	.195	.151	.125	.126	. . . .	1 240	86.415	1.475	.799	.199	1.900	Old field soil; same formation.
2252	Wayne . .	2.925	8.279	.070	.151	.061	.259	.072	.615	86.990	1.625	.878	.161	sm. p'n	Subsoil of next preceding.
2253	Wayne . .	1.850	2.836	.195	.073	.029	.021	.050	.500	94.590	.440	.711	.152	33.400	Virgin soil; ridge; coal-bearing sandst & shales
2254	Wayne . .	5.920	5.703	.345	.286	.087	.249	.069	1.715	85.690	1.565	.984	.274	21.200	Virgin soil; ridge; coal-bearing sandst & shales.
2255	Webster . .	3.975	4.225	.330	.277	.140	.004	.323	.950	89.855	1.680	1.697	.672	. . . .	Virgin soil; farm of Col. Scott.
2256	Webster . .	5.015	8.480	1.805	.436	.285	.313	.030	.900	82.940	2.850	1.730	.482	. . . .	Old field soil; same locality.

[illegible]	Webster . .	[illegible]	[illegible]	.220	.450	.157	.302	.040	.800	83.205	3.325	1.956	.563	. . . .	Subsoil of next preceding.
2258	Webster . .	2.610	4.665	.145	.100	.125	.124	.012	.565	91.445	1.200	1.544	.712	. . . .	Old field soil; farm of Mr. Kaufman.
2259	Webster . .	2.440	7.661	.120	.240	.054	.071	.016	.585	88.755	1.975	1.779	.690	. . . .	Subsoil of next preceding.
2260	Webster . .	3.450	3.986	.270	.184	.094	.126	.057	1.250	90.490	1.575	1.570	.746	. . . .	Field 10 yrs. in cultv'n; farm of A. G. Brooks.
2261	Webster . .	2.210	5.639	.145	n. e.	.061	.108	.439	.775	90.815	1.365	1.750	.366	. . . .	Subsoil of next preceding.

TABLE II. CLAYS, DRIED AT 212° F.

Number.	County, &c.	Silica.	Alumina.	Iron oxide.	Lime.	Magnesia.	Potash.	Soda.	Water and loss.	Fine sand.	Remarks.
2104	Ballard. . .	74.460	18.070	1.633	0.314	0.245	0.940	0.021	4.317	48.00	Near Moore's mill, near Blandville; four feet thick.
H	Germany .	70.860	20.900	1.560	.347	.220	.578	.112	6.800	4.00	German glass-pot clay.
I	Germany .	73.660	19.460	1.560	.168	.209	.520	.046	6.200	3.50	German glass-pot clay.
2105	Ballard. . .	67.501	23.051	2.109	.257	.065	.412	.020	6.585	n. e.	South Ballard county; T. D. Campbell's.
2134	Fulton . . .	64.800	21.070	5.270	1.400	.050	.646	.202	6.562	"	Hickman bluffs; indurated clay.
2135	Fulton . . .	76.860	14.600	3.020	.425	.308	.736	.257	3.794	"	Hickman bluffs; ninety-five feet above low water.
2136	Fulton . . .	83.380	9.800	2.120	.963	.187	.617	.118	2.815	"	Hickman bluffs; first beneath gravel.
2137	Fulton . . .	71.340	17.190	2.770	1.612	.209	.925	.232	5.722	"	Hickman bluffs; first beneath gravel.
2138	Fulton . . .	83.500	9.940	2.500	.358	.173	.539	.109	2.881	"	Hickman bluffs; ten feet below the gravel
2139	Fulton . . .	71.080	19.050	2.810	.627	.403	.578	.225	5.227	"	Hickman bluffs; above the next preceding.
2140	Fulton . . .	74.100	16.460	2.700	.358	.187	.559	.135	5.501	"	Hickman bluffs; below the preceding
2141	Fulton . . .	77.960	13.970	2.390	.134	.163	.797	.124	4.462	"	Hickman bluffs; above the railroad track.
2142	Fulton . . .	68.860	12.980	2.240	9.587	1.182	1.773	1.278	2.100	"	Loess or "Bluff;" Quaternary.
2143	Graves . . .	75.550	16.751	1.198	a trace	.144	1.094	.216	5.047	63.00	On Panther creek; W. P. Arnett's land.
2161	Hickman. .	76.360	14.951	2.109	.325	.173	1.171	.125	4.786	69.00	From Chalk bluff, below Columbus.
2162	Hickman. .	84.918	10.560	1.102	.572	.108	.651	n. e.	2.089	68.50	From bluffs, upper part of Columbus.
2168	Madison .	62.560	24.780	1.800	a trace	.317	3.276	.294	6.973	n. e.	Near Bybertown; M. Barlow's.
2169	Madison . .	64.566	20.160	4.200	.213	.641	5.054	n. e.	5.166	"	Near Waco; below Corniferous limestone.
2170	Madison . .	62.580	22.940	3.760	.560	.425	5.280	.308	4.147	"	Indurated clay, near Elliston; Corniferous limestone.
2211	McCracken.	64.480	24.691	1.869	.448	.137	1.457	.083	6.835	"	Near Paducah.

TABLE III. MARLY CLAYS AND SHALES, DRIED AT 212° F.

Number.	County.	Silica.	Alumina.	Iron Peroxide.	Lime.	Magnesia.	Phosphoric acid.	Potash.	Soda.	Water, &c., and loss	Remarks.
2120	Fayette	53.780	23.260	1.300	4.866	0.568	0.191	7.612	0.550	7.873	In Lower Silurian limestone strata.
2165	Jefferson	47.960	21.340	6.600	5.825	3.524	n. e.	5.265	.250	9.238	In limestone layers of Cincinnati Group.
2166	Jefferson	58.840	19.940	6.000	3.226	.857	"	4.490	.685	5.962	In limestone layers of Keokuk Group.
2167	Jefferson	61.900	18.580	6.220	.123	1.259	"	4.867	.612	6.499	In limestone layers of Keokuk Group.
2186	Madison	42.300	20.840	4.120	13.320	.461	"	2.387	.351	16.281	In Niagara Group, on Drowny creek.
2187	Madison	48.780	17.320	3.240	19.285	.496	"	4.768	.240	5.871	Beneath Corniferous limestone; bed six feet or more.
2216	Nelson	61.100	18.200	6.000	4.904	1.542	"	4.101	.821	3.332	At the base of the Corniferous; many feet thick.

* Lime sulphate; gypsum or plaster of Paris.

TABLE IV. COALS, &c., AIR DRIED.

Number.	County.	Specific gravity.	Hygroscopic moisture.	Volatile combustible matters.	Coke.	Total volatile matters.	Fixed carbon in the coke.	Ash.	Character of the coke.	Color of the ash.	Percentage of sulphur.	Remarks.
2144	Graves	n. e.	4.13	16.22	79.65	20.35	10.25	69.40	Pulverulent	Nearly white	n. e.	Bitum. shale; "brown coal;" Panther creek.
2145	Greenup	1.319	5.00	39.00	56.00	44.00	49.88	6.12	Spongy	Lilac-grey	1.986	Splint coal (No. 3); Fulton Coal Co.; stock.
2146	Greenup	1.286	2.00	47.36	50.64	49.36	38.24	12.40	Slightly coherent.	Grey-buff	1.554	Can. c'l (No. 4); Ind'n Run; Ful. C'l Co.; st'k
2147	Greenup	1.331	4.80	36.90	58.30	41.70	51.20	7.10	Dense	Lilac-grey	3.977	Coal (No. 4); Chinn's branch; Ful. C'l Co.; st'k
2148	Greenup	1.324	6.00	33.48	60.52	39.48	56.14	4.38	Dense	Lilac grey	2.330	Coal (No. 7); Coalton coal; Ful. C'l Co.; stock

TABLE V. IRON ORES, DRIED AT 212° F.

Number.	County.	Iron peroxide	Alumina & phosphoric acid.	Lime carbonate.	Magnesia carbonate.	Water, alkalies, &c., and loss.	Bituminous matter, water, and loss.	Silicious residue.	Percentage of iron.	Remarks.
2149	Harrison	21.200	12.870	1.290	6.621	8.329	. . . .	49.690	14.840	Thomas Hinkston's iron ore.
2201	Madison	28.440	5.240	.190	1.279	8.631	. . . .	56.220	18.890	Bog ore on the black shale formation.
2202	Madison	19.800	9.880	.380	1.844	5.806	. . . .	62.290	13.860	Bog ore on the black shale formation.
2203	Madison	30.870	11.560	.290	.897	6.403	. . . .	49.980	21.570	Bog ore on the black shale formation.
2204	Madison	17.300	14.820	.130	1.041	10.449	. . . .	56.260	12 110	Bog ore on the Corniferous formation.
2205	Madison	19.500	16 360	trace.	trace	. . . .	24.200	39.940	13.650	Black band ore; on top of the coal; Comb's knob.

TABLE VI. LIMESTONES, DRIED AT 212° F.

Number.	County.	Lime carbonate.	Magnesiacarbonate.	Alumina.	Iron oxide.	Phosphoric acid.	Potash.	Soda.	Silicious residue.	Percentage of lime.	Percentage of magnesia.	Silica.	Water, bitumen, &c., and loss.	Remarks.
2121	Franklin . .	70.360	6.784	5.458	1.342	n. e.	1.118	0.281	. . . .	39.401	3.236	14.020	. . . .	Kentucky river bluffs; Trenton Group
2189	Madison . .	48.530	11.790		10.330		1.696	.347	20.740	27.173	5.614	n. e.	6.567	Top of Cincinnati Group.
2190	Madison . .	37.760	10.050	17.656	3.700	0.204	.458	.090	25.180	21.145	4.785	20.980	4.902	On the top of Cumberland shales.
2191	Madison . .	33.560	6.855	21.560	4.120	.204	.578	.045	29.180	18.794	3.251	22.800	4.302	On the top of Cumberland shales.
2192	Madison . .	45.700	27.475	11.360	3.500	. . . .	.501	.088	9 980	25.592	13.083	n. e.	1.396	On the top of Cumberland shales.
2193	Madison . .	50.860	20.100	9.960	3.900	. . . .	.276	.054	3.980	28.480	9.608	n e.	10.870	Upper Silurian.
2194	Madison . .	50.960	27.972	5.960	*3.556	. . . .	.276	.087	4.120	28.538	13.319	n. e.	6.493	Upper Silurian.
2195	Madison . .	51.200	25.124	12.360	4.460	.140	.287	.049	3.920	28.672	11.899	n. e.	2.460	Upper Silurian.
2196	Madison . .	35.160	4.646	10.706	2.060	.754	2.033	.586	39.780	19.689	2.212	n. e.	4.275	Clinton Group.
2197	Madison . .	43.060	9.994	9.420	2.640	. . . .	.770	.149	22.680	24.113	4.756	n. e.	11.287	From Canda-Galli grit.
2198	Madison . .	41.150	13.908	9.040	1.890	. . . .	n. e.	n. e.	20.990	23.044	6.384	n e.	n. e.	From above Corniferous limestone.
2199	Madison . .	36.580	18.541	4.010	1.540	. . . .	n. e.	n. e.	31.990	20.485	8.781	n. e.	n. e.	Top of Corniferous limestone.
2200	Madison . .	47.580	17.133		10.980	. . . .	n e.	n. e.	18.190	26.645	8.158	n. e.	6.117	Top of Corniferous limestone.
d 521	Jefferson . .	50.430	18.670		2.930	.060a	.320	.130	25.780	28.290	8.890	22.580	.100	Hydraulic; Falls of Ohio.
e 1068	Indiana . .	45.880	22.911	5 760		.220b	.347	.372	21.520	25.746	10.914	(c)	2.721	Hydraulic; Madison, Indiana.

(d). From Vol. II, first series Ky. Geol. Rep., p. 220, for comparison. (e) From Vol. IV, first ser. Ky Geol. Rep., p. 101, for comparison. * Iron sulphide 0.576 in addition.
(a). Sulphuric acid, 1.580. (b). Sulphuric acid, 0.269. (c). Silica soluble in solution of carb. soda=3.000.