SECOND CHEMICAL REPORT

OF THE

ORES, ROCKS, SOILS, COALS,

MINERAL WATERS, &c.,

OF KENTUCKY,

BY

ROBERT PETER, M. D.,

CHEMICAL ASSISTANT TO THE GEOLOGICAL SURVEY

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INTRODUCTORY LETTER.

CHEMICAL LABORATORY OF THE KENTUCKY GEOLOGICAL SURVEY,
Lexington, Ky., December 8th, 1856.

D. D. OWEN, M. D.:

Dear Sir—In accordance with your instructions I transmit to you my second report of the Chemical Analyses of Kentucky Ores, Soils, Mineral Waters, &c., &c., made at this Laboratory, for the Geological Survey, since the preparation of the first report.

Within about two hundred and twenty-two days, with the occasional aid of an assistant in the minor processes under my immediate supervision, we have succeeded in determining the composition of two hundred and six different objects, and thus, although, as you will discover, the several analyses have been made more minute and accurate; we have increased the amount done, in proportion to the time employed, more than one-sixth over that exhibited in the first report.

The subjects of the analyses reported in the following pages may be summed up as follows:

48 iron ores of the limonite variety.
22 iron ores of the carbonate variety.
43 soils, sub-soils, and marls.
31 limestones.
30 coals.
16 mineral waters and salts.
4 copper and zinc ores and bitumens.
4 iron furnace slags.
4 sandstones.
2 pig iron.
2 shales and slates.

206

The greater portion of the large and very interesting collection of soils and sub-soils, made by you during the past summer, amounting to nearly one hundred specimens, sent to this Laboratory for examination, have not yet been analyzed, but the labor will be resumed as soon as possible after the completion of this report.

In regard to soil analysis, a considerable difference of opinion exists in the minds of the agricultural public. When the fact began to be appreciated, that certain organic and mineral substances resident in the soil were essential to its fertility, because they were necessary elements of vegetable and animal tissues, it was natural that the enlightened agriculturist should look to the chemical analysis of the soil, which would give the proportions of these ingredients, as the best index of its value and its adaptedness to his various crops; and full experience, under the proper conditions, will demonstrate that this expectation will not be disappointed. But, when at the demand of the farmer, who perhaps knew little or nothing of the true theory of agriculture and nothing of chemical philosophy, *cheap and superficial analyses* were made, exhibiting only the proportions of the grosser materials of the soil—as of the *sand* and *silica*, *alumina*, *oxide of iron*, *carbonates of lime*, and *magnesia*, and even, perhaps, of the *organic matters*, without showing the amount present of the more valuable and essential ingredients, as the *phosphoric* and *sulphuric acids*, the *potash* and *soda*—this information, purchased by the practical farmer from the scientific man, at however low a price, was found to be dearly bought, and of little real value.

All soils, without exception—the most fertile as well as the most sterile—contain large proportions of *sand* and *silica*, *alumina* and *oxide of iron*, and they may contain these as well as notable proportions of *lime*, *magnesia*, and *organic matters*, and yet be sterile to the highest degree; for, although these, with the exception of alumina and sand, enter into vegetable and animal composition, and are essential to their structures, they are of no value in the support of plants, without the aid of the alkalies and the phosphorus and sulphur contained in the phosphoric and sulphuric acids of the soil. These latter ingredients, almost universally found in very small relative proportions in soils, and much more difficult to estimate in a chemical analysis than the preceding, are the elements of the soil, the proportions of which it is most necessary to ascertain, in order to get a proper idea of its value

and relationships to the operations of the agriculturist. But these, in consequence of the difficulty of the processes, and the time and care necessary to their estimation, have been generally neglected in ordinary soil analyses. No wonder, therefore, that the practical man, and even some chemists, have begun to doubt whether the so called teachings of science, in this relation, are of any real service.

A full analysis of a soil, giving the correct proportions of all its ingredients, and their various states of combination, is a labor of considerable magnitude, requiring, if the time be devoted to only one soil at once, from ten to fifteen days of work, and demanding in the operator as much special training as to learn to play well on a difficult musical instrument; the farmer, therefore, can never be expected to be able to perform this nice and troublesome operation for himself, any more than he could be expected to make or repair his own watch or time-piece; but he can, by acquiring the necessary elementary knowledge to appreciate the results of chemical analyses, derive great practical advantages from them, and save a great deal of time, labor, and money. He could, it is true, with the aid of his experience, and by the trial of experiments in cropping, ascertain the value of a soil almost as well as it could be set forth by a good chemical analysis; but, in commencing on an unknown specimen, the chemist could, in one week's labor, arrive at results, which could be attained by the practical farmer only at the expense of years of costly agricultural experiments.

The system in which you have collected the specimens of soils, for analysis will aid greatly in giving a practical demonstration of the value of soil analyses. Usually, instead of collecting a single specimen from each locality, you have procured, for *comparative analysis*, specimens of—1. The *Virgin soil;* 2. The *same soil from an old field long in cultivation;* 3. The *sub-soil;* and 4. The *deeper sub-soil*, or *underlying rock stratum.*

By the correct examination of these the following important facts can be ascertained: 1. The change which the soil has undergone under the influence of cropping; and hence the knowledge of what would be necessary to restore it to its original condition, and keep it fertile. 2. What benefit or injury may result from deep sub-soil ploughing or trenching the ground. 3. What influence may be exerted on it by the underlying rock or other *sub-strata.*

By the critical examination of the comparative analyses of soils, &c., &c., already given in this and in the preceding report, it will be observed that chemical analysis is competent, in these respects, to ascertain and report faithfully on changing conditions of the soil in relation to agricultural operations. It will be noticed, in particular, that in every instance where the comparison is made of the proportion of the phosphoric and sulphuric acids, potash, and soda, between the virgin soil, and similar soil which has been long in cultivation, a marked diminution of these most essential ingredients is to be noticed in the old soil. And thus, it is proved, that by careful chemical analysis we can note and estimate the gradual but certain approach to sterility, of soils once very fertile, under the influence of unscientific and thriftless cropping.

The *knowledge* of a defect must naturally precede all efforts for its removal. The full appreciation of the fact, that in yielding its products the soil always gives up a certain amount of its most valuable elements, which are carried off in the crops removed, and which must in some way be restored to it, if it is to be maintained in a fertile condition, is sure to lead, in the end, to an improved system of agriculture, if the education of the people of our state is made to keep pace with the general march of improvement.

The completion of the analyses of the soils of Kentucky, or even of those already collected, ought to exert a beneficial influence on the prosperity of the State. The real agricultural value of the land in its various districts will be to a certain extent demonstrated, and it will be shown more fully, as it is already to some extent exhibited in the analyses given in this and the preceding report, that a great body of lands in the central, eastern, and southern part of the state of Kentucky, held now at prices below, or not much above that of government land in the far west, may be made as valuable as those, to the farmer; whilst, in some localities, they offer superior advantages in the greater proximity of fuel in the form of coal or wood.

These results may, perhaps, help to stimulate our people to endeavor to supply a great necessity of the state, which now operates as an immense incubus on its growth and developement, viz: a chain of great public improvements through the interior, to afford means of communication and channels of commerce, which may bring to the doors of the farmer or manufacturor, who may engage in the business of de-

veloping its great mineral and agricultural resources, the markets of the world. The want of these improvements confines the growth of Kentucky, in commerce and the manufactures, mainly to her river banks, and restricts her agriculture to its richest regions, to the neglect of mineral wealth greater than that which has been the basis of the power of England, and a large body of land very susceptible of cultivation. On the other hand, the policy of supplying these public improvements, in the net-work of railroads intersecting the western country, constructed mainly under the patronage of the general government, and with the proceeds of large grants of the public lands, has aided greatly in inviting to its cultivation the hardy yeomanry of the older states, who are tempted to leave their native homes by the inducements of rich soil, at a moderate price, accessible markets for their products, and a prospect of the rapid growth and improvement of the country.

That the reader of this report may be enabled to compare the soil of the fat lands of the western prairies with some of those of Kentucky, usually considered much less valuable to the agriculturist, an analysis of Illinois prairie soil is introduced at the latter end. It will be seen that this prairie soil, now so rich in organic matters, may be considered as the reverse of the heavy *red sub-soil* of some of the southern portions of Kentucky;* in this respect, in particular, in that, from its large proportion of fine *sand and silica*, and small relative amount of *alumina and oxide of iron*, it holds, with a weak affinity, those organic matters derived from the remains of the herbage of thousands of years; and hence gives abundance of rich food to the crops which it supports; until, in the course of time, this deposit is diminished or exhausted. On the other hand, the large proportion of oxide of iron and alumina, of the heavy red sub-soil—which both have a powerful affinity for organic matters—holds them with great tenacity, and thus, under the action of water containing carbonic acid, which is the natural solvent of the mineral and organic matters in the soil employed in vegetable growth, this red sub-soil gives up but a small quantity of solid nutritious matter, especially if there is but a trace of lime or magnesia present. The prairie soil could be rendered more durable, but perhaps less *immediately* fertile, by admixture with clay, containing alumina and oxide of iron, whilst, other things being equal, the heavy

*See Sherpet county;

red soil would be made more fertile by the addition of fine sand and lime.

The addition of lime to this heavy red soil, which contains a large proportion of alumina and peroxide of iron, may be beneficial in more than one way: it would not only assist in the solution of the other nutritive elements locked up in the soil, and tend to render it lighter, but from its constant action on the oxygen and nitrogen of the atmosphere, in causing them to combine in the form of nitric acid, soluble nitrates are always present in soil containing much lime or carbonate of lime, which aid in its disintegration, and increase the solubility of its valuable mineral ingredients, besides furnishing a supply of dissolved nitrogen to vegetable roots.

On this principle Leibig has explained the fact, that in the island of Cuba a soil containing a very large proportion of carbonate of lime, can annually produce, without the application of nitrogenous manures, large crops of tobacco—a plant peculiarly rich in nitrogen,—and for the same reason the nitrate of lime, (easily convertible into salt-petre,) is continually formed and effloresces on the porous limestones of the so-called salt-petre caves of Kentucky.

The seventy iron ores which have been analyzed at this Laboratory, since the preparation of the last report, have, with very few exceptions, proved to be rich and valuable, as well those of the *Limonite* variety, composed of hydrated oxide of iron in various states of purity, as the *carbonates of iron*; and afford still further illustration of the great wealth of Kentucky, in ores of this most useful and valuable of metals, and of the fact that a large amount of capital and labor might find room for employment in our state, in the developement of her rich mines, and in the supply of the increasing demand for iron in all its various forms. The analyses of these ores, and of the limestones, &c., which accompany them, will greatly assist the manufacturer in the apportion of his fluxes for the most economical production of the metal.

Amongst these ores are some which doubtless would be found well adapted to the manufacture of steel, and in some localities the association of an easily smelted ore with beds of suitable coal, may induce capitalists to endeavor to supply the very large demand for *cheap* iron for railroads and other purposes.

The thirty kinds of coal which have been examined have been analyzed with more than usual minuteness and labor. Not only have

all, not previously analyzed, been submitted to *proximate analysis*, to ascertain their proportions of *moisture*, *volatile matter*, *ashes*, and *coke*, but by separate operations their proportion of *sulphur* and the chemical composition of their *ashes*, have been ascertained; they have also been all submitted to *ultimate* or *organic analysis*, to determine their relative proportions of *carbon*, *hydrogen*, *oxygen*, and *nitrogen*, &c., in which analysis, as one of the ingredients—oxygen—is always estimated by the *loss*, or negatively, and therefore, the *control* of the equality of the weight of the sum of the elements found, with the weight of the original compound which was submitted to analysis, being wanting, it was necessary to secure accuracy by a repetition or repetitions of the process; so that the ultimate analysis of these thirty coals required no less than seventy-nine operations of organic analysis. The whole number of analyses of these thirty coals amounted to one hundred and sixty-one. In these various processes several of the most promising of these coals were submitted to destructive distillation, at a heat gradually raised to redness, to ascertain their relative products of *bituminous oils*, *paraffin*, *gas*, &c. In these trials the Breckinridge cannel coal maintained its superiority for this manufacture; but the approach of the Haddock's cannel coal, of the Kentucky river, to it in this respect, encourages the belief that in the course of your investigations amongst the Kentucky coals, especially amongst the cannel coals and bituminous schists, other specimens may be found which may be equally valuable for these products with the Breckinridge coal.

The peculiarity in composition, of the coals which yield the greatest amount of oily and waxey matters on distillation, appears to be the presence, in them, of a larger proportion of hydrogen to the carbon than exists in the *coking coals* or *soft bituminous coals*, which are preferred by the blacksmith and for the manufacture of coke and gas; and of a smaller amount of oxygen than is contained in the *dry coals* or *splint coals*.

It will be seen that the coal fields of Kentucky furnish all these varieties. For the purpose of comparison with the coking varieties of Kentucky coal, an analysis of the Youghiogheny coal of Pennsylvania is given at the end of the report; and to enable the enlightened reader to compare the Breckinridge coal with the celebrated Scotch Bog Head coal, also much used for the production of oils, &c., its or-

ganic analysis is stated in connection with that coal, under the head of Hancock county.

The process of *organic analysis* employed may be briefly described. The powdered coal, previously dried at 212° F., was introduced into the hard glass combustion tube, in a small tray of platinum, and submitted to the action of a stream of pure oxygen gas from a gas-holder, dried by passing it through chloride of calcium and dry hydrate of potash; the combustion tube was heated over charcoal, in a common Liebig's furnace; to secure complete combustion of the carbon, the front portion of the tube was filled either with oxide of copper, mixed with copper turnings, or with a tight rolled cylinder of copper gauze which had been previously oxidated at a red-heat in a stream of oxygen. The products of combustion were collected in the usual chloride of calcium tube and potash bulbs; a small tube being interposed to absorb any sulphurous acid, and a *dry* potash tube attached to the bulbs to absorb all the carbonic acid, and prevent the escape of moisture in the stream of dried gas. Thus the proportions of carbon and hydrogen were obtained.

An attempt was made, by collecting the residual gases—mixed nitrogen and oxygen—which passed through this train, and by the removal of the excess of oxygen, by explosion with hydrogen in the *Endiometer*, to estimate, by the same operation, the proportion of nitrogen; but it was soon found that with whatever care the oxygen was procured, the proportion of nitrogen left after the explosion was not constant, and on reflection on the known properties of gases, and the force with which they penetrate each other and porous substances generally, the reason of the failure of this promising process became obvious. The water introduced into the gas-holder to expel the oxygen, contained nitrogen, which gas diffused itself through the atmosphere of oxygen in the gas-holder, and thus, in proportion to the quantity of water forced into it, did the oxygen in it contain more and more nitrogen, as was verified by experiments with the Endiometer. Nor was it found possible, even with the use of a smaller oxygen gas-holder, and of distilled water covered with oil, boiled to expell the gas, wholly to prevent this cause of irregularity, so that the proportion of the nitrogen in the coals was necessarily obtained by a separate process of combustion, by the method of Will and Varrentrapp.

Amongst the limestones and sandstones examined are some quite valuable for building purposes; and others which will be found useful as hydraulic cement, and for agriculture. The magnesian limestone, from Grimes' quarry, and from other neighboring quarries, on the Kentucky river, may be considered one of the best and most durable building stones of the whole country at large, and some others from the Upper Silurian Formation resemble it somewhat closely in composition. The Birds-eye limestone, characterized by its great brittleness, contains but little carbonate of magnesia, and would burn into quite a pure lime; whilst the very fossiliferous limestones of the Blue Limestone Formation, (Lower Silurian,) easily disintegrating and containing, in addition to *lime* and *magnesia*, all the other mineral elements necessary to vegetable nutrition, although they make but poor building stones, are invaluable to the agriculture of the country where they exist, by the enriching influence, on the superincumbent soil, which they exert under the slow solvent action of the natural surface waters, which always contain carbonic acid, and which convey into the soil their valuable ingredients. The waters of such regions are *hard* from this cause, but under their influence the soil is, to a certain extent, constantly renovated.

The sixteen mineral waters, &c., examined, are, mainly, only from one of the Kentucky watering places. The mineral springs of the state are numerous and valuable, and will doubtless repay, in the future, the labor of their exploration.

All of which is respectfully submitted,

ROB. PETER.

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A SUMMARY

OF THE

CHEMICAL ANALYSES

OF

ORES, ROCKS, SOILS, COALS, MINERAL WATERS, &c.,

OF KENTUCKY,

MOSTLY PROCURED BY DAVID DALE OWEN, M. D., PRINCIPAL GEOLOGIST OF KENTUCKY, AND ANALYZED BY ROBERT PETER, M. D., CHEMICAL ASSISTANT TO THE STATE GEOLOGICAL SURVEY.

ARRANGED IN THE ALPHABETICAL ORDER OF THE COUNTIES IN WHICH THEY WERE OBTAINED.

ADAIR COUNTY.

No. 233—Soil. *Labeled "Soil from Shaly Geodiferous Limestone, at Clayton Miller's farm, four miles south of Columbia, Adair county, Kentucky."* (*Sub-carboniferous Sandstone, or Knob Formation.*)

Growth hickory, sugar-tree, white oak, dog-wood, white walnut, and elm.

Color of the dried soil very dark grey. Sifted through a seive, of one hundred and sixty-nine apertures to the inch, it left about one-fifth of its weight of irregular pebbles of ferruginous sandstone. Carefully washed with water it left about fifty-seven per cent. of *sand*, of which 42.3 per cent. is fine enough to pass through fine bolting cloth, of about five thousand apertures to the inch; and 14.7 per cent. is coarser sand, consisting principally of rounded particles of quartz, *hyaline*, and of various shades of yellow, red, and brown, with some few crystalline particles.

One thousand grains of this soil, (air-dried,) digested for one month, in a closely stopped bottle, at a temperature not exceeding 120° F., in water saturated under pressure with carbonic acid gas, gave up to the acidulated water nearly two and a half grains of *solid matter*, which was found to have the following composition, dried at 212° F., viz:

	Grains.
Organic and volatile matters,	1.150
Alumina, oxides of iron and manganese, and trace of phosphates,	.317
Lime,	.447
Magnesia,	.106
Brown oxide of manganese,	.019
Sulphuric acid,	.068
Potash,	.098
Soda,	.024
Silica,	.140
Carbonic acid, chlorine, and loss,	.102
	2.471

The air-dried soil lost 2.50 per cent. of *moisture* when dried at 400° F.

Dried at this temperature its *composition* was found to be as follows, viz:

Organic and volatile matters,	4.440
Alumina and oxides of iron and manganese,	4.841
Carbonate of lime,	.196
Magnesia,	.046
Phosphoric acid,	.065
Sulphuric acid,	.232
Chlorine,	.005
Potash,	.075
Soda,	.092
Sand and insoluble silicates,	90.446
	100.438

As explained in the preceding report, the process of digesting the soil for a length of time, in water containing carbonic acid, at a temperature not exceeding that to which it naturally attains under the influence of the sun's heat, is used to ascertain and estimate the proportion contained in it of soluble nutritious matter, *immediately available* for the support of vegetation. In this manner, endeavoring to imitate the usual mode by which these necessary ingredients of organic

structures are dissolved out of the soil, and conveyed into the tissues of growing plants in the great operations of nature.

Pure water exerts but little solvent action on the carbonates or phosphates of lime or magnesia, but when it is combined with carbonic acid it takes them up in considerable proportions, and especially when aided by the humic acids, so called, which result from the decomposition of vegetable or animal bodies on the soil, and by the small amount of acids of nitrogen which the atmosphere yields under favorable circumstances, it not only brings these and the oxides of iron and manganese and silica to a soluble condition, but also acts gradually on the *insoluble silicates*, to release their lime, magnesia, potash, &c., &c., for vegetable nourishment. These, then, are the solvents which, by their continual action on the soil, and with the aid of frost, slowly disintegrate its hard particles, and gradually dissolve out its available materials. All rain water, and surface water in general, contain more or less carbonic acid, with occasional traces of the acids of nitrogen; and the water acquires in the soil the organic acids which are produced there by the decomposition of vegetable and animal matters

Although this soil contains a larger proportion than the average of *sand* and *insoluble silicates*—more than ninety per cent.—and less than the usual quantity of phosphoric acid and potash contained in very fertile soils—.075 and .065—it yet contains a pretty large proportion of vegetable nourishment in a *soluble condition*, so that it gave up more than the average quantity of nutritious matter to the carbonated water in which it was digested. Without judicious management—by a course of constant cropping, without returning to it the *essential ingredients* of vegetable nutrition—this soil will more speedily become deteriorated in productiveness, than others which have less sand and less *soluble matters*.

ANDERSON COUNTY.

No. 484—Limestone. *Labeled "Rock under White Oak Ridge, Mr. Hall's farm, Anderson county, Ky." (Lower Silurian Formation.)*

A grey, granular rock, made up of a confused mass of crystalline grains of calcarious spar. No fossils apparent in the specimen sent for analysis.

Composition, dried at 212° F.—

Carbonate of lime,	96.65	= 54.23 *Lime.*
Carbonate of magnesia, not estimated.		
Alumina and oxides of iron and manganese,	1.26	
Phosphoric acid,	.92	
Sulphuric acid,	.25	
Potash,	.67	
Soda,	.39	
Silex and silicates, insoluble in hydrochloric acid,	.88	
	100.92	

The air-dried rock lost .30 per cent. of *moisture* at 212°, F.

No. 485—LIMESTONE *Labeled "Leptæna Limestone," road from Mr. Alexander Julian's to Lawrenceburg, Anderson county, Kentucky. (Lower Silurian Formation.)*

A very fossiliferous limestone, of a grey and buff-grey color in the interior; weathered surfaces of a dirty buff colored. Powder light yellowish grey.

Composition, dried at 212° F.—

Carbonate of lime,	83 95	= 47.11 *Lime.*
Carbonate of magnesia,	.91	
Alumina, and oxides of iron and manganese,	2.23	
Phosphoric acid,	.25	
Sulphuric acid,	.34	
Potash,	.38	
Soda,	.47	
Silex and insoluble silicates,	11 28	
Loss,	.19	
	100.00	

The air-dried rock lost .30 per cent. *moisture* at 212° F.

No. 486—LIMESTONE. *Labeled "Road from A. Julian's to Lawrenceburg, Anderson county, Kentucky." (Lower Silurian Formation.)*

A bluish-grey limestone, very full of fossils—Pleurotomaria, Bellerophon, Orthocera, portions of Encrinal stems, &c. Weathered surfaces of a dirty buff color. Powder light grey.

Specific gravity,		2.663
Composition, dried at 212° F.—		
Carbonate of lime,	86.45 = 48.52 *Lime.*	
Carbonate of magnesia,	1.57	
Alumina, and oxides of iron and maganese,	1.83	
Phosphoric acid,	.12	
Sulphuric acid, a trace.		
Potash,	.62	
Soda,	.11	
Silex and insoluble silicates,	9.57	
	100.27	

The air-dried rock lost .10 per cent. of *moisture* at 212° F.

BALLARD COUNTY.

No. 218—Sub-soil. *Labeled "Sub-soil in heavily timbered land, southern part of Ballard county." (Quaternary Formation)*

The dried soil is of a light yellowish grey-brown color. Carefully washed with water, one thousand grains of it left about five hundred and ninety-two grains of *sand* of a brownish-grey color, of which only about two grains was too coarse to pass through bolting cloth of five thousand apertures to the inch. The coarser particles were generally rounded, some few angular, consisting of hyaline and milky quartz, with some particles of iron ore.

One thousand grains of this soil, dried at the ordinary temperature, and digested in water containing carbonic acid, for one month, yielded less than *one* grain of *soluble matter*. This dissolved solid extract was found, on analysis, to have the following composition, when dried at 212° F., viz:

	Grains.
Organic and volatile matters,	0.200
Alumina, oxide of iron, and trace of phosphates,	.097
Lime,	.064
Magnesia,	.033
Brown oxide of manganese,	.047
Potash,	.060
Soda,	.023
Silica,	.180
Sulphuric acid, carbonic acid, and loss,	.029
	0.733

The air-dried soil lost 1.80 per cent. of *moisture* when dried at 380° F.

Dried at this temperature, its *composition* was found to be as follows, viz:

Organic and volatile matters,	2.11
Oxide of iron,	2.24
Alumina,	2.58
Brown oxide of manganese,	.09
Carbonate of lime,	.15
Magnesia,	.86
Phosphoric acid,	.41
Sulphuric acid, not estimated.	
Potash,	.12
Soda,	.02
Sand and insoluble silicates,	91.72
	100.30

The analysis of this sub-soil may be compared with that of corresponding surface-soil given on pages 259 and 379 of the preceding report, (No. 1.) It will be seen, that whilst it has pretty nearly the same proportions of sand and insoluble silicates, of alumina and oxide of iron, it contains more potash, phosphoric acid, lime, and magnesia, and less of organic and volatile matters, than the surface-soil. It also contains less soluble matter immediately available for the nourishment of vegetables—the surface-soil, No. 1, having yielded 1.53 grains of *solid extract* to water containing carbonic acid, while this sub-soil gave only 0.733 of a grain.

No. 219—Sub-soil. *Labeled "Sub-soil from the north-western part of of Ballard county, Ky., from near Col. Gholson's." (Quaternary Formation.)*

Color of the dried soil rather darker than that of the last described, with more of a reddish tinge. Carefully washed with water one thousand grains of it left about 546½ grains of brownish-grey sand, of which all but about eight grains would pass through fine bolting cloth. The coarser particles, under the microscope, appeared to consist principally of rounded fragments of iron ore, mixed with some particles of hyaline and milky and red quartzose mineral.

One thousand grains of this sub-soil, dried at the ordinary temperative, digested for one month, in water containing carbonic acid, as be-

fore described, gave up 1.293 grains of *solid extract*, which, dried at 212° F., was found to have the following *composition*, viz:

	Grains.
Organic and volatile matters,	0.340
Alumina and oxide of iron,	.047
Lime,	.300
Magnesia,	.090
Brown oxide of manganese,	.077
Phosphoric acid,	.011
Sulphuric acid,	.067
Potash,	.110
Soda,	.040
Silica,	.190
Carbonic acid and loss,	.021
	1.293

The air-dried sub-soil lost 2.14 per cent. of *moisture* when dried at 375° F.

Dried at which temperature it was found, on analysis, to have the following *composition*, viz:

Organic and volatile matters,	2.92
Oxide of iron,	3.39
Alumina,	2.25
Carbonate of lime, a trace.	
Magnesia,	.47
Brown oxide of manganese,	.36
Phosphoric acid,	.18
Sulphuric acid, not estimated.	
Potash,	.19
Soda, a trace.	
Sand and insoluble silicates,	90.21
Loss,	.03
	100.00

On comparing this analysis with that of the *surface soil* from the same locality, No. 2, as given on pages 261 and 379 of the preceding report, it will be seen that they present nearly the same differences of composition as were noted in the remarks on the preceding *sub-soil*, (No. 218,) viz: that there is less of *organic and volatile matters*, and less of the nutritious substances soluble in carbonated water, in the *sub-soil*, and rather a larger proportion of phosphoric acid, potash, and magnesia, than in the surface soil.

BARREN COUNTY.

No. 225—SOIL. *Labeled "Soil from Mr. Barlow's farm, Barren county, Kentucky." (Sub-carboniferous Limestone Formation.)*

Said to be the best producing soil in the county. Color of the dried soil warm dark grey. On sifting it some cherty fragments were found in it. On carefully washing it with water 45.70 per cent. of *sand*, of a dark brownish grey color, was separated, of which 4.30 per cent. was too coarse to pass through bolting cloth. The coarser sand, examined with the glass, was found to consist of rounded particles of hyaline, milky and red quartz, with some ferruginous mineral.

One thousand grains of the air-dried soil, digested in water containing carbonic acid, as before described, yielded nearly four grains of *solid extract*, dried at 212° F., of which the *composition* is as follows, viz:

	Grains.
Organic and volatile matters,	1.660
Alumina, oxide of iron, and trace of phosphates,	.288
Carbonate of lime,	1.111
Magnesia,	.046
Brown oxide of manganese,	.019
Sulphuric acid,	.112
Potash,	.144
Soda,	.080
Silica,	.200
Carbonic acid and loss,	.212
	3.872

The air-dried soil lost 2.34 per cent. of *moisture*, when dried at 365° F.; and was found to have the following composition, when thus dried, viz:

Organic and volatile matters,	5.200
Alumina,	3.460
Oxide of iron,	2.206
Carbonate of lime,	.366
Magnesia,	.205
Brown oxide of manganese,	.234
Phosphoric acid,	.159
Potash,	.197
Soda,	.090
Sand and insoluble silicates,	87.686
Sulphuric acid and loss,	.197
	100.000

The cause of the fertility of this soil is obvious, in the large proportion of *soluble matter* which it yields to the water containing carbonic acid, and to the considerable, (although not *large*,) amount of organic and volatile matters, and of phosphoric acid, sulphuric acid, potash, lime, and magnesia, which it is found to contain, in proportion to the sand and insoluble silicates; the alumina and oxide of iron also are in such quantities as to give the proper consistence to the soil.

No. 227—SUB-SOIL. *Labeled "Sub-soil between Big Sink and Bear Wallow, near Mr. Barrow's farm, Barren county, Kentucky."* (*Sub-carboniferous Limestone Formation.*)

Color of the dried soil dull greyish-red, or brick-red. Careful washing with water removed from this soil nearly thirty-nine per cent. of reddish sand, mostly very fine, of which about seven per cent was coarser sand, containing rounded particles of hyaline and milky quartz, and of some ferruginous mineral.

One thousand grains, dried at the ordinary temperature, and digested for a month in water containing carbonic acid, gave up less than a grain of *solid extract* dried at 212° F., of which the composition was as follows, viz:

Organic and volatile matters,	0.210
Alumina, oxide of iron, and trace of phosphates,	.179
Brown oxide of manganese,	.033
Lime,	.077
Magnesia,	.040
Sulphuric acid,	.075
Potash,	.023
Soda,	.044
Silica,	.139
	0.820 of a gr.

The air-dried sub-soil lost 3.90 per cent. of *moisture* at 360° F.

The *composition*, thus dried, is as follows, viz:

Organic and volatile matters,	4.730
Alumina,	10.380
Oxide of iron,	6.398
Brown oxide of manganese,	.256
Carbonate of lime,	.096
Magnesia,	.522
Phosphoric acid,	.075
Sulphuric acid.	.466
Potash.	.142
Soda,	.082
Sand and insoluble silicates,	77.067
	100.214

BRECKINRIDGE COUNTY.

No. 487—BITUMEN OR MINERAL PITCH. *Labeled "Bitumen from Mrs. Jackson's spring, one mile east of Tar Springs, Breckinridge county, Kentucky."*

Resembles the bitumen from Tar Springs in Edmonson county. Color dull brownish-black; of the consistence of soft pitch; soft enough to be easily moulded in the fingers; containing some involved sand.

The proximate analysis is as follows, viz:

Moisture,	2.40
Volatile combustible matters,	36.50
Carbon, in the fixed residue,	7.30
Ashes, sand, &c.,	53.80
	100.00

No. 312—SHALE. *Labeled "Shale and Marl under the Archimedes Limestone, at Ryan's, four to four and a half miles east of south of the Breckinridge coal mine, Breckinridge county, Kentucky."* (*Subcarboniferous Limestone Formation.*)

A dark olive-grey friable shale, containing ferruginous concretions. Rubbed up in a mortar, and washed with water, it left about seventeen per cent. of very fine sand, of which only 0.20 per cent. would not pass through the bolting cloth. These coarser particles, examined with the aid of the glass, were found to be flattened rounded particles of ferruginous sandstone and round particles of hyaline quartz.

One thousand grains, dried at the ordinary temperature, gave up nearly two grains of *solid extract*, when digested for a month in water

containing carbonic acid, of which the *composition*, dried at 212°, is as follows, viz:

	Grains.
Organic and volatile matters,	0.309
Alumina, oxides of iron and manganese, and trace of phosphates,	.030
Carbonate of lime,	.627
Magnesia,	.199
Sulphuric acid,	.287
Potash,	.062
Soda,	.051
Silica,	.210
	1.775

The air-dried shale lost 6.72 per cent. of *moisture* at 400° F.; and when thus dried has the following *composition*, viz:

Organic and volatile matters,	7.040
Alumina and oxides of iron and manganese,	12.170
Carbonate of lime,	.976
Magnesia,	.413
Phosphoric acid,	.101
Sulphuric acid,	.198
Chlorine,	.002
Potash,	.556
Soda,	.190
Sand and insoluble silicates,	78.680
	100.326

This shale might be usefully applied, as a top dressing, to light and sandy soils, but could not be profitably carried to any great distance. Exposed to the air, water, and frost it would soon be disintegrated into a fertile soil. Its large proportion of potash would make it good for the tobacco or potato crop.

BULLITT COUNTY.

No. 488—CARBONATE OF IRON. *Labeled "Kidney ore, over the sheet ore," Bellemont Furnace, Bullitt county, Ky. (Sub-carboniferous Sandstone Formation.)*

A dull, dark grey, fine granular mineral; not adhering to the tongue. Exterior surface and fissures reddish and yellowish-brown. The specimen appears to be a portion of a kidney-form mass. Powder yellowish-grey.

Specific gravity,		3.446
Composition, dried at 212° F —		
Carbonate of Iron,	57 59	= 32 62 per cent of *Iron*.
Oxide of iron,	7.77	
Carbonate of lime,	6.28	
Carbonate of magnesia,	11.76	
Carbonate of manganese,	1.32	
Alumina,	1.55	
Phosphoric acid,	.71	
Sulphur,	.29	
Potash,	.75	
Soda,	.27	
Silica and insoluble silicates,	11.18	
Loss,	.53	
	100.00	

No. 489—LIMONITE. *Labeled "Iron ore, in the building stone, not used at Bellemont Furnace, found seventy feet above the black shale, Bullitt county, Ky."* (*Sub-carboniferous Sand-stone Formation.*)

Interior of the ore dull reddish and yellowish-brown, glimmering with minute spangles of mica; exterior ochreous; adhering but slightly to the tongue. Powder of a light brown color.

Specific gravity,		2.984
Composition, dried at 212° F.—		
Oxide of iron,	62.01	= 43 46 per cent. of *Iron*.
Alumina,	.68	
Brown oxide of manganese,	.78	
Carbonate of lime,	.18	
Magnesia,	1.02	
Phosphoric acid,	.89	
Sulphur,	.58	
Potash,	.36	
Soda,	.20	
Silica and insoluble silicates,	21 18	
Combined water,	12 00	
Loss,	.12	
	100.00	

The air-dried ore lost 2.00 per cent of *moisture* at 212° F.

This ore is richer in iron, and more silicious than the preceding one, and would require a larger proportion of limestone, in smelting, than that; both contain rather more than is desirable of sulphur and phos-

phorus; the former, however, can be mainly removed by proper roasting of the ore, and the use of a sufficient amount of limestone; and the latter will not seriously injure the iron, in its ordinary applications in the form of cast-iron.

No. 490—LIMESTONE. *Labeled "Limestone used as a flux at Bellemont Furnace, (in the Black Devonian Shale Formation,") Bullitt county, Ky.*

A fine granular limestone, with bands of bluish and yellowish-grey, containing diffused pyrites, (sulphuret of iron,) and glistening with calcarious spar. Powder white, with a slight greyish tinge.

Specific gravity, - - - - - - - - -	2.766	
Composition, dried at 212° F.—		
Carbonate of lime, - -	63.13 =	35.43 Lime.
Carbonate of magnesia, - -	27,76 =	13.22 Magnesia.
Alumina, and oxides of iron and manganese, - - -	4.34	
Phosphoric acid, - - -	.19	
Sulphuric acid, - - -	3.77 =	1.51 Sulphur.
Potash, - - - - - -	.44	
Soda, - - - - - -	.15	
Silica and insoluble silicates, -	1.63	
	101.41	

The air dried rock lost 0.20 per cent. of *moisture*, at 212° F.

The apparent excess, in the above summary of the analysis, is doubtless due to the oxidation of the sulphur and iron, which were in the form of sulphuret of iron in the mineral, and which are estimated as oxide of iron and sulphuric acid in the analysis. The presence of the sulphur, in notable proportion, in the limestone used as flux, generally exerts an injurious influence upon the iron produced.

No. 491—IRON FURNACE SLAG. *Labeled "Purple Cinder, made when the furnace is producing the best quality of soft grey iron, Bellemont Furnace, (Patterson, Moore & Co.,) Bullitt county, Ky."*

A glassy slag, appearing almost black in the mass; of a dark greyish purple, as seen through the thin edges; containing but few air-bubbles. Before the blow-pipe it fuses pretty readily, with the formation of many minute bubbles.

Composition, dried at 212° F.—

Silicic acid,	54.60	Containing oxygen,		28.35
Alumina,	15.90	"	7.43	
Lime,	11.93	"	3.39	
Magnesia,	8.09	"	3.57	
Protoxide of iron,	3.29	"	1.10	
Protoxide of manganese,	1.08	"	.24	
Potash,	4.25	"	.72	
Soda,	1.31	"	.33	
	100.45		16.78 :	28.35

The oxygen in the bases is to that in the silicic acid, as 1 : 1.69

No. 492—Iron Furnace Slag. *Labeled "Olive-green Cinder, produced when the Furnace is making good forge iron, and yields more, but not so soft iron, as when purple cinder is made, Bellemont Furnace, Bullitt county, Ky."*

An opaque slag, of a dirty olive-green color; full of air bubbles. Before the blow-pipe it behaves like the preceding.

Composition, dried at 212° F.—

Silicic acid,	53.36	Containing oxygen,		27.70
Alumina,	17.26	"	8.07	
Lime,	9.74	"	2.67	
Magnesia,	8.09	"	3.24	
Protoxide of iron,	6.35	"	1.41	
Protoxide of manganese,	.89	"	.20	
Potash,	4.09	"	.69	
Soda,	1.02	"	.26	
	100.80		16.54 :	27.70

The oxygen in the bases is to that in the silicic acid, as 1 : 1.67

In both of these slags there is a considerable amount of oxide of iron, which is so much loss; this might probably be prevented by the use of a purer limestone for the flux. There is a large proportion of *magnesia*, both in the slags and in the limestone employed.

No. 493—Carbonate of Iron. *Labeled "Ironstone, from Button-mould Knob, Bullitt county, Ky." (Sub-carboniferous Sandstone Formation.*

A fine-grained, compact, carbonate of iron; interior grey, shading into rust-brown on the exterior; powder dull cinnamon color.

Specific gravity,		3.445
Composition, dried at 212° F.—		
Carbonate of iron,	53.64	= 31.30 per cent. of *Iron*.
Oxide of iron,	7.71	
Carbonate of lime,	6.08	
Carbonate of magnesia,	13.99	
Carbonate of manganese,	1.94	
Alumina,	.55	
Phosphoric acid,	.10	
Sulphuric acid,	1.37	= .55 per cent. of *Sulphur*.
Potash,	.69	
Soda,	.20	
Silica and insoluble silicates,	11.48	
Water and loss,	2.25	
	100.00	

The air-dried ore lost .50 per cent. of *moisture*, at 212° F.

An ore sufficiently rich for profitable smelting, which could be worked without much additional fluxing materials.

No. 494—LIMESTONE. *Labeled "Magnesian Limestone, on the road from Shepherdsville to Mount Washington, Bullitt county, Kentucky."* (*Lower Silurian Formation.*)

A fine granular rock, of a grey-buff color, rather difficult of fracture; sparkling in spots, with buff-colored calcarious spar; powder of a light grey-buff color.

Specific gravity,	2.799
Composition, dried at 212°—	
Carbonate of lime,	63.45
Carbonate of magnesia,	29.64
Alumina and oxide of iron,	3.15
Sulphuric acid,	.27
Potash,	.20
Soda,	.21
Silex and insoluble silicates,	2.18
Loss,	.90
	100.00

The air-dried rock lost 0.20 per cent. of *moisture*, at 212° F.

No. 495—LIMESTONE. *Labeled "Upper Silurian Limestone, Bullitt county, Kentucky, road to Mount Washington."*

A buff-grey, fine granular limestone; not adhering to the tongue.

Specific gravity,	2.765
Composition, dried at 212° F—	
Carbonate of lime,	50.25
Carbonate of magnesia,	31 05
Alumina and oxides of iron and manganese,	5.37
Sulphuric acid,	1.46
Phosphoric acid, a trace.	
Potash,	.59
Soda,	.20
Silica and insoluble silicates,	10.32
Loss,	.76
	100.00

The air-dried rock lost .20 per cent. of *moisture*, at 212° F.

No 496—SANDSTONE. *Labeled "Building Stone, Knob at Bullitt's Lick, Bullitt county, Kentucky."* (*Sub-carboniferous Formation.*)

A rather soft, fine-grained, buff-grey sandstone; adhering slightly to the tongue; exhibiting, under the lens, minute scales of mica; composed of fine-grained sand, united by an argillaceous cement.

Specific gravity,	2.427
Composition, dried at 212° F—	
Sand and insoluble silicates,	93 68
Alumina and oxides of iron and manganese,	3.95
Carbonate of magnesia,	.84
Carbonate of lime, a trace.	
Potash,	.21
Soda,	.59
Sulphuric acid and loss,	.73
	100.00

The air-dried rock lost .30 per cent. of *moisture*, at 212° F.

No. 497—SANDSTONE. *Labeled "Building Stone, quarry on the top of Button-mould Knob, Bullitt county, Kentucky."* (*Sub-carboniferous Sandstone Formation.*

A moderately hard, fine-grained sandstone, of grey-buff color; adhering slightly to the tongue; composed of fine grained sand, united by an argillaceous cement.

Specific gravity,	2.415
Composition, dried at 212° F.—	
Sand and insoluble silicates,	94.78
Alumina and oxides of iron and manganese,	2.85
Carbonate of magnesia,	2.29
Carbonate of lime,	.18
Potash,	.27
Soda,	.14
Sulphuric acid, a trace.	
	100.51

The air-dried rock lost 0.50 per cent. of *moisture*, at 212° F.

No. 498—SANDSTONE. *Labeled "Building Stone, seventy feet above the ——— Shale, Bellemont Furnace, Bullitt county, Ky.."* (*Sub-carboniferous Sandstone Formation.*)

A dirty buff-colored, fine-grained sandstone; adhering slightly to the tongue; resembling the preceding in structure.

Specific gravity,	2.453
Composition, dried at 212° F.—	
Sand and insoluble silicates,	94.75
Alumina, and oxides of iron and manganese,	3.48
Lime,	.16
Magnesia,	.70
Potash,	.96
Soda,	.10
Sulphuric acid, traces.	
	100.15

The air-dried rock lost 0.30 per cent. of *moisture*, at 212° F.

These three specimens of freestone resemble each other very nearly in composition and structure. They appear to be of uniform texture, sufficiently soft to be easily worked, and yet not so absorbent of water as to be very liable to *scale* under the action of frost. The specimens examined did not contain *pyrites*, (sulphuret of iron,) in any notable quantity; the presence of which, in a sandstone, causes a constant disintegration of the surface, in consequence of the gradual oxidation of the sulphur and iron, and the efflorescence of the sulphate of iron thus produced.

No. 499. *Labeled "Black Devonian Slate, cut of the railroad, Bullitt county, Kentucky."*

A dull slate-colored rock, of an imperfect slatey structure; easily broken into irregular fragments across the layers; some microscopical appearance of pyrites; scarcely adhering to the tongue; powder dark-grey.

Specific gravity,	2.474
Composition, dried at 212° F.—	
Alumina, and oxides of iron and manganese,	16.35
Carbonate of lime,	2.27
Carbonate of magnesia,	3.28
Phosphoric acid,	.06
Potash,	2.49
Soda,	.18
Bituminous matters,	8.80
Silica and insoluble silicates,	65.27
Loss,	1.30
	100.00

The air-dried rock lost 1. per cent. of *moisture*, at 212° F.

This shale contains a remarkable proportion of *potash*, nearly two and a half per cent. of the dried rock, which may render it useful, in some localities, for the improvement of land which has been exhausted of this alkali by the culture of tobacco, potatoes, &c.

BUTLER COUNTY.

No. 409—CARBONATE OF IRON. *Labeled "Carbonate of Iron in the shales of the millstone grit, Woodbury, below the mouth of Barren river, Butler county, Ky."*

A compact, dark-grey, or mouse-colored ore; weathered surfaces and fissures dark reddish-brown; some infiltrations of calcarious matter in the fissures; powder of a dirty buff color.

Specific gravity,		3.026
Composition, dried at 212° F.—		
Carbonate of iron,	70.20	= 39.45 per cent. of *Iron*.
Oxide of iron,	9.99	
Carbonate of lime,	2.55	
Carbonate of magnesia,	7.04	
Carbonate of manganese,	1.60	
Alumina,	1.51	

Phosphoric acid, - - -	.64
Sulphur, a trace.	
Potash, - - - - -	.42
Soda, - - - - -	.01
Silica and insoluble silicates, -	7.65
	101.54

The air-dried ore lost 0.40 per cent. of *moisture*, at 212° F.

A good iron ore.

CARTER COUNTY.

No. 473—LIMONITE. *Labeled "Iron Ore, resting on the sub-carboniferous limestone, Carter county, Ky."*

A dark brown limonite, irregularly cellular; small portions ochreous; powder dirty yellowish-brown.

Composition, dried at 212° F.—

Oxide of iron, - - -	78.42	= 54.93 per cent. of *Iron*.
Alumina, - - - -	1.48	
Brown oxide of manganese, -	3.17	
Magnesia, - - - -	.30	
Lime, a trace.		
Phosphoric acid, - - -	.73	
Potash, - - - - -	.21	
Soda, - - - - -	.18	
Combined water, - - -	11.94	
Silica and insoluble silicates, -	3.77	
	100.20	

The air-dried ore lost 1.20 per cent. of *moisture*, at 212°.

A good iron ore; as rich as it is profitable to smelt in the high furnace; containing more than the usual proportion of oxide of manganese.

CHRISTIAN COUNTY.

No. 216—SUB-SOIL. *Labeled "Sub-soil from the southern part of Christian county, between Dr. Quarles' and Oak Grove, Ky."*

Color of the dried soil light-brownish, with a tinge of dirty orange. Carefully washed with water one thousand grains of this sand left two hundred and ninety-three grains of fine sand, of which only six grains was as coarse as ordinary bar-sand; which was composed generally of small rounded particles of quartz, with a few larger rounded and ar-

gular fragments of hyaline and milky quartz, and of a red silicious mineral like carnelian.

One thousand grains of the air-dried soil, digested for one month, in a close bottle, in water charged with carbonic acid, under pressure, gave up nearly a grain of *solid extract*, which, dried at 212°, had the following composition, viz:

	Grain.
Organic and volatile matters,	0.044
Alumina and oxide of iron,	.097
Oxide of manganese,	.157
Lime,	.134
Magnesia,	.033
Phosphoric acid,	.011
Sulphuric acid,	.020
Potash,	.131
Soda,	.015
Silica,	.254
Carbonic acid and loss,	.064
	0.960

The air-dried soil lost 2.24 per cent. of *moisture*, at 300° F.; and thus dried was found to have the following *composition*, viz:

Organic and volatile matters,	2.96
Oxide of iron,	2.36
Alumina,	2.39
Phosphoric acid,	.27
Sulphuric acid, not estimated.	
Carbonate of lime,	.13
Carbonate of magnesia,	.79
Brown oxide of manganese,	.27
Potash,	.19
Soda,	.04
Sand and insoluble silicates,	90.26
Loss,	.34
	100.00

The analysis of the surface-soil, (No. 20,) from this locality was given in the preceding report, on pages 272–3, and 379; on reference to which it will be seen, that while the alumina and oxide of iron do not differ much in the soil and sub-soil, there is more *organic matter* in the soil, and a larger proportion of sand and silica in the sub-soil, which also exhibits a somewhat larger amount of phosphoric acid and

potash. The quantity of soluble matter, extracted by digestion in water containing carbonic acid, was four times greater from the soil than from the sub-soil.

No. 462—Coal. *Labeled "Woolrich's coal, the most southerly coal in Christian county, Ky."*

A very pure looking glossy, pitch-black coal; not very hard; with no appearance of pyrites or other impurities; breaks in thin layers; having but little fibrous coal between the layers; heated over the spirit-lamp, it does not decrepitate; swells up a good deal, and the fragments agglutinate into a shining, inflated coke. It appears to be a good coking coal.

Specific gravity, - - - - - - - - -	1.280		
Proximate analysis.			
Moisture, - - - -	4 60	Total volatile matters,	39.50
Volatile combustible matters, -	34.90		
Carbon in the coke, - -	58 36	Moderately dense coke,	60.50
Ashes, (dull red,) - - -	2.14		
	100.00		100.00

The per centage of *sulphur* was found to be 1.37.

The dull red ashes are composed of about three-fourths alumina and oxide of iron, to about one third of silica, with traces of lime and magnesia.

Ultimate analysis of this coal gave the following results, dried at 212°, viz:

Carbon, - - - - - - - - - - - -	76 636
Hydrogen, - - - - - - - - - - -	4 533
Sulphur, - - - - - - - - - - -	1 440
Ashes, - - - - - - - - - - -	2 200
Oxygen, nitrogen, and loss, - - - - - - - -	15.191
	100.000

This coal was not examined as to its yield of oils and gas by destructive distillation, at a low red heat; but its moderate proportion of *hydrogen* to its carbon is unfavorable to the formation of oily products.

CLARKE COUNTY.

No. 500—SOIL. *Sent by Dr. S. D. Martin, labeled "Soil from a garden planted in peach-trees, about three years ago; about a foot of the surface-soil well mixed; this ground has been cleared about sixty or seventy years; used as a meadow, and hay cut off of it for many years; then eighteen consecutive crops of hemp were raised on it; in* 1836 *it was sown in grass and small crops of hay cut off; but finally it was taken by the blue grass, and has been used as pasture until three years ago, when it was broken up again and planted with young peach trees, and cultivated ever since as a vegetable garden," Clarke county, Ky.*

Color of the dried soil, dark brownish-grey. Carefully washed with water it left nearly 53. per cent. of very fine sand, containing nearly 7. per cent. of coarser sand, which would not pass through fine bolting cloth; which, examined with the lens, appeared to be, principally, small rounded particles of iron ore, with some milky hyaline, and red and yellow quartz particles, mostly rounded but some angular.

One thousand grains of the air-dried soil, digested for one month in water containing carbonic acid, as above described, gave up more than two grains of light brown *solid extract*, dried at 212°; the composition of which is as follows, viz:

Organic and volatile matters,	0.420
Alumina and oxide of iron and phosphates,	.107
Brown oxide of manganese,	.137
Lime,	.509
Magnesia,	.183
Sulphuric acid,	.030
Potash,	.100
Soda,	.011
Silica,	.178
Carbonic acid and loss,	.418
	2.093

The air-dried soil lost 4.16 per cent. of *moisture*, at 380° F; and, when thus dried was found to have the following composition, viz:

Organic and volatile matters,	6.10
Oxide of iron,	4.92
Alumina,	3 94
Phosphoric acid,	.48
Carbonate of lime,	.47
Magnesia,	.62
Brown oxide of manganese,	.40
Potash,	.32
Soda,	.08
Sand and insoluble silicates,	82 65
Sulphuric acid not estimated, and loss,	.02
	100.00

Although this soil has been so long in cultivation, it is yet very rich in all the essential elements of vegetable food. It is not stated, on the label accompanying it, whether or not the ground had been manured; from the large proportion of potash and phosphoric acid contained, it is probable that it has been enriched by manure since it has been cultivated as a garden.

No. 501—Sub-soil. From Dr. S. D. Martin, Clarke County, Ky. *Labeled "Sub-soil, eighteen inches below the surface, from the same place as the preceding."*

Color of the dried sub-soil lighter and more yellowish than that of the soil.

Washed with water it yielded nearly 49. per cent. of fine brownish sand, which contained about 7.5 per cent. of coarser sand, composed of rounded particles of a dark color, principally iron ore, but containing some quartzy particles, like the preceding.

One thousand grains of the air-dried sub-soil, digested in the carbonated water, yielded less than a grain and a half of *solid extract*, of a light grey color, containing the following ingredients, viz:

	Grains.
Organic and volatile matters,	0.080
Alumina and oxides of iron and manganese,	.095
Lime,	.428
Magnesia,	.035
Phosphoric acid,	.030
Potash,	.059
Soda,	.034
Silica,	.267
Carbonic acid, sulphuric acid, and loss,	.342
	1.370

One thousand grains of the air-dried sub-soil lost 2.96 per cent. of *moisture*, when dried at 370° F.

Its composition, when thus dried, is as follows, viz:

Organic and volatile matters,	4.01
Oxide of iron,	7.06
Alumina,	7.71
Phosphoric acid,	.38
Carbonate of lime,	.99
Magnesia,	1.04
Brown oxide of manganese,	.29
Potash,	.36
Soda,	.03
Sand and insoluble silicates,	78.03
Sulphuric acid not estimated, and loss,	.10
	100.00

Whilst the sub-soil contains less *organic matter* than the soil above it, and has a smaller proportion of fine sand, the alumina, oxide of iron, lime, and magnesia are found in it in larger proportions.

CLAY COUNTY.

No. 460—Coal. *Labeled "Col. Garrard's coal, Goose Creek Salt Works, Clay county, Ky."*

A pitch-black, shining, and apparently very pure coal, having some fibrous coal between the layers, but showing no pyrites or other impurities.

Heated over the spirit-lamp it did not decrepitate, but swells up and agglutinates into a very light cellular coke burning with a very smokey reddish-yellow flame. It appears to be a good coking coal.

Specific gravity, 1.259

Proximate Analysis.

Moisture,	2.70	Total volatile matters,	37.60
Volatile combustible matters,	34.90		
Carbon in the coke,	61.10	Coke, light and shining,	62.40
Ashes, (dirty buff,)	1.30		
	100.00		100.00

Composition of the ashes—

Silica,	0.49
Alumina and oxide of iron,	.69
Lime,	.05
Magnesia,	.07
	1.30

Submitted to *ultimate analysis*, this coal was found to consist of the following ingredients, dried at 212°:

Carbon,	80.619
Hydrogen,	5.444
Sulphur,	.575
Nitrogen,	1.457
Oxygen and loss,	10.305
Ashes,	1.600
	100.000

A remarkably pure coal, which would no doubt yield abundance of good gas, and is very fine for coking, containing but a small per centage of ashes.

CLINTON COUNTY.

No. 222—Soil. *Labeled "Soil, Mr. Andrews', Caney Gap, Clinton county, Ky.; large timber—red oak, white oak, chestnut, hickory, beech, and poplar. Red Ferruginous Sub-soil."* (*Sub-carboniferous Limestone Formation.*)

Color of the dried soil of a warm grey.

Washed with water it gave more than 51. per cent. of fine *sand*, of a dirty buff color, containing about 12. per cent. of coarser sand, like common bar sand.

One thousand grains of the air-dried soil, digested in the carbonated water, gave up less than a grain and a half of solid extract of a brownish color, dried at 212°, which contained—

	Grains.
Organic and volatile matters,	0.830
Alumina, oxide of iron, and trace of phosphates,	.168
Lime,	.073
Magnesia,	.016
Potash,	.042
Soda,	.038
Silica,	.070
Carbonic acid, sulphuric acid, and loss,	.244
	1.431

The air-dried soil lost 1.96 per cent. of *moisture* at 400° F.; dried at which temperature its composition was as follows:

Organic and volatile matters,	3.970
Alumina,	1.776
Oxide of iron,	2.466
Brown oxide of manganese,	.076
Carbonate of lime,	.076
Magnesia,	.131
Phosphoric acid,	.090
Potash,	.085
Soda,	.099
Sand and insoluble silicates,	90.720
Sulphuric acid, (not estimated,) and loss,	.521
	100.000

No. 412—LIMONITE. *Labeled "Iron Ore, ridge between Wolf river and Spring creek, five miles west of Albany, Clinton county, Ky."*

A dense, dark colored limonite; structure compact and compact fibrous; layers incrusted with yellow ochreous ore; powder dark yellowish-brown.

Specific gravity,		3.503
Composition, dried at 212° F.—		
Oxide of iron,	74.30	= 52.03 per cent. of *Iron*.
Alumina,	1.48	
Brown oxide of manganese,	1.68	
Phosphoric acid,	.18	
Sulphur, a trace.		
Magnesia,	.35	
Alkalies, not estimated.		
Silica and insoluble silicates,	9.95	
Combined water,	12.24	
	100.18	

The air-dried ore lost 1.20 per cent. of *moisture* at 212°, F.

A very good iron ore.

CRITTENDEN COUNTY.

No. 25—(*See former report*)—COAL. *From Sneed's mines, on Tradewater river, Crittenden county, Ky.*

This coal, of which the proximate analysis is given on pages 275 and 276 of the former report, has recently been submitted to ultimate analysis, with the following results, viz:

Composition, dried at 212° F.—

Carbon,	78.500
Hydrogen,	5.333
Sulphur,	1.040
Ashes,	3.800
Nitrogen,	1.344
Oxygen and loss,	9.983
	100.000

CUMBERLAND COUNTY.

No. 232—Soil. *Labeled "Soil, bottom land, between the forks of Sulphur creek, Jacob Speers' land, Cumberland county, Ky." (Sub-carboniferous sandstone, or Knob Formation, immediately above, overlying the Devonian Black Slate.)*

Color of the dried soil very dark grey, nearly slate colored; it contained some fragments of ferruginous sandstone, some of which were rounded at the angles. On careful washing with water, this soil left a considerable proportion of fine sand, and about 10. per cent. of coarser sand, which would not pass through fine bolting cloth, which consisted of rounded particles of quartz and ferruginous sandstone.

One thousand grains, digested in carbonated water, as previously described, gave up more than five grains of *solid extract*, of the following composition, viz:

	Grains.
Organic and volatile matters,	1.530
Alumina, oxides of iron and manganese, and trace of phosphates,	1.333
Carbonate of lime,	1.538
Carbonate of magnesia,	.303
Sulphuric acid,	.065
Potash,	.228
Soda,	.045
Silica,	.080
	5.122

The air-dried soil lost 2.40 per cent. of *moisture* at 375° F.; and and was found to contain the following ingredients, viz:

Organic and volatile matters,	5.770
Alumina,	1.230
Oxide of iron,	3.140
Carbonate of lime,	.336
Magnesia,	.438
Brown oxide of manganese,	.076
Phosphoric acid,	.127
Sulphuric acid,	.734
Chlorine,	.006
Potash,	.220
Soda,	.029
Sand and insoluble silicates,	87.110
Loss,	.784
	100.000

This soil is remarkable in the large proportion of soluble matter which it yields to water containing carbonic acid. It is of more than the average fertility.

DAVIESS COUNTY.

No. 230—Soil. *Labeled "Soil, Daviess county, Ky.; large growth of tobacco; native growth white oak, poplar, hickory, &c.; on the Owensboro' and Henderson road, 1½ miles from Green river."* (*Coal measures, but the soil mostly from the overlying quaternary.*)

Color of the dried soil, brownish-grey. By carefully washing it with water this soil left about 74. per cent. of *fine sand*, of a dirty buff color, of which 24. per cent. was as coarse as bar sand, composed of rounded quartz grains, clear, yellow, and reddish.

One thousand grains of the air-dried soil gave up, when digested in carbonated water for a month, about three and a half grains of brown *solid extract*, dried at 212°, which has the following composition, viz:

	Grains.
Organic and volatile matters,	2.100
Alumina, oxide of iron and phosphates,	.480
Lime, with some oxide of manganese,	.616
Magnesia,	.056
Sulphuric acid,	.041
Potash,	.057
Soda,	.058
Silica,	.184
	3.592

The air-dried soil lost only 1.62 per cent. of *moisture* at 365° F.; and dried at this temperature gave, by analysis, the following ingredients, viz:

Organic and volatile matters,	3.350
Alumina,	2.026
Oxide of iron,	2.146
Brown oxide of manganese,	.126
Carbonate of lime,	.176
Magnesia,	.258
Phosphoric acid,	.088
Sulphuric acid, not estimated.	
Potash,	.096
Soda,	.053
Silica,	91.920
	100.239

This soil, which contains so large a proportion of *silicious matter*, and but a moderate quantity of *organic matters*, *potash* and *phosphoric acid*, supported a very luxuriant growth of tobacco, probably because so much of its nutritious ingredients are in the *soluble condition;* as is proved by the large relative proportion of *solid extract* given by it on digestion in the water containing carbonic acid. This circumstance, however, while it increases its present fertility, will hasten the process of exhaustion, under the drain of large herbaceous crops carried off the ground, without any return being made to it in the form of manures.

The rapidity with which the tobacco plant robs the soil of its richness is explained by the fact, that about one-fourth of the weight of the dried plant is composed of the mineral matters essential to vegetable growth, especially potash, lime, magnesia, soda, sulphuric acid, phosphoric acid, &c., as may be seen by reference to table 8, at the end of this report.

No. 189—Coal. *Labeled "Wolf Hill coal, Daviess county, Ky."*

A remarkably pure looking coal; deep black and glossy; with some fibrous coal between the layers, but no appearance of pyrites or other impurities, except some incrustation of sulphate of lime in the joints. Heated over the spirit lamp it swelled up somewhat, but did not agglutinate. Specific gravity 1.275.

This coal, the *proximate* analysis of which was given by Dr. Owen in his first report, page 44, was submitted to *ultimate* organic analysis,

and an examination for its proportion of sulphur; the summary of the analysis is as follows:

Carbon,	77.891
Hydrogen,	5.422
Sulphur,	.300
Nitrogen,	1.821
Oxygen and loss,	12.566
Ashes, buff grey,	2.000
	100.000

This coal has not yet been tried as to its relative yield of illuminating gas, or bituminous oils and paraffine, but its ultimate composition is unfavorable to the production of rich gas, or much oily matter. Coals having less oxygen and nitrogen in their composition are better for illuminating gas; and a larger proportion of hydrogen than that exhibited in this coal is found in those kinds which yield much oil on distillation.

No. 502—Coal. *Labeled "Twenty-four inch coal, on the Triplett place, four miles south-east of Owensboro', Daviess county, Ky."*

A glossy, pitch-black coal, pretty firm, and seemingly pretty free from pyrites; a little sulphate of lime in the joints; not much fibrous coal between the layers. Over the spirit-lamp it softens, swells up, and agglutinates; burns with a smoky flame, and leaves a bright cellular coke. Probably a coking coal.

Specific gravity, 1.328

Proximate Analysis.

Moisture,	6.70	Total volatile matters,	42.70
Volatile combustible matters,	36.00		
Carbon in the coke,	51.30	Moderately light coke,	57.30
Ashes, (purple-grey,)	6.00		
	100.00		100.00

The composition of the ashes is as follows:

Silica,	2.00
Alumina and oxide of iron,	3.18
Lime,	.27
Magnesia,	.25
Loss,	.30
	6.00

Ultimate Analysis, (dried at 212°.)

Carbon,	71.019
Hydrogen,	5.022
Sulphur,	2.090
Oxygen, nitrogen, and loss,	15.069
Ashes,	6.800
	100.000

EDMONSON COUNTY.

No. 414—LIMONITE. *Labeled "Iron Ore, from the Nolin Ore Bank, Edmonson county, Ky."*

Composed of hard, dark brown, layers enclosing softer, yellow, and brownish-yellow ore. Powder of a yellow color.

Composition, dried at 212° F.—

Oxide of iron,	60 90	= 42.64 per cent. of *Iron*.
Alumina,	.65	
Brown oxide of manganese,	.75	
Lime, a trace.		
Magnesia,	1.15	
Phosphoric acid,	.57	
Potash,	.36	
Soda,	.32	
Silica and insoluble silicates,	23.68	
Combined water,	11.15	
Loss,	.47	
	100.00	

The air-dried ore lost 1.50 per cent. of *moisture* at 212° F.

A very good silicious limonite.

No. 415—LIMONITE. *Labeled "Iron Ore, in the shales above the coal, Nolin Iron Works, Edmonson county, Ky."*

A dense, dark brown ore, of an irregular cellular structure; powder light yellowish-brown.

Composition, dried at 212° F.—

Oxide of iron,	74.70	= 52.31 per cent. of *Iron*.
Alumina,	.45	
Brown oxide of manganese,	.35	
Phosphoric acid,	.55	
Magnesia,	.15	
Lime, a trace.		
Silica and insoluble silicates,	12.65	
Alkalies, not estimated.		
Combined water,	11.19	
	100.04	

The air-dried ore lost 0.80 per cent. of *moisture* at 212° F.

Very nearly resembling the preceding, but containing a larger per centage of oxide of iron, and less silica.

No. 416—Carbonate of Iron. *Labeled "Carbonate of Iron, in the shale above the sandstone, Nolin Iron Works, Edmonson county, Kentucky."*

A dense, very fine-grained, dark grey ore; weathered surfaces reddish-brown; powder of a grey color.

Specific gravity, 3.507

Composition, dried at 212° F.—

Carbonate of iron,	65.13	= 37.04 per cent. of *Iron*.
Oxide of iron,	7.98	
Carbonate of lime,	1.95	
Carbonate of magnesia,	8.45	
Carbonate of manganese,	1.83	
Alumina,	.95	
Phosphoric acid,	.36	
Sulphuric acid,	.67	= .10 *Sulphur*.
Potash,	.57	
Soda,	.05	
Silex and insoluble silicates,	9.17	
Organic matter, moisture & loss,	2.89	
	100.00	

The air-dried ore lost 0.50 per cent. of *moisture* at 212°.

No. 419—Limonite. *Labeled "Iron Ore, Mr. W. B. Morris' stock farm, Edmonson county, Ky. (Above his coal.")*

A dull yellowish-brown earthy looking ore; portions of it ochreous, yellow; friable; adhering somewhat to the tongue; powder light yellowish-brown, becoming black when calcined in a covered crucible.

Composition, dried at 212° F.—

Oxide of iron,	62.12 = 43.50 per cent. of *Iron.*
Alumina,	2.45
Brown oxide of manganese,	.05
Lime, a trace.	
Magnesia,	.29
Phosphoric acid,	.43
Sulphuric acid,	.06
Potash,	.38
Soda,	.42
Silex and insoluble silicates,	20.55
Organic matter, water, and loss,	13.25
	100.00

The air-dried ore lost 2.70 per cent. of *moisture* at 212°.

This ore contains *organic matter*, somewhat similar to that which exists in soils, which causes it to become black when it is heated in a closed vessel. This organic matter can be dissolved out of the ore by alkaline solutions, but was found not to contain either *Crenic* or *Apocrenic* acids. The ore is a good rich mineral of a *silicious* character.

No. 472—Bitumen. (*Mineral pitch.*) *Labeled "From the Tar Spring, near the Nolin Iron Works, Edmonson county, Ky."*

A dull brownish black bitumen of the consistence of pitch, containing involved sand, and portions of vegetable remains; not elastic.

When heated it melts, gives off combustible vapors, and leaves a cellular coke, burning with a smoky yellowish flame. It is soluble in ether, oil of turpentine, naptha, &c., but insoluble in water and alcohol. Acted on by strong nitric acid, sulphuric acid, and caustic potash solution.

Proximate Analysis.

Moisture,	1.80	Total volatile matters,	53.00
Volatile combustible matters,	51.20		
Carbon in the coke,	13.70	Fixed residium,	47.00
Ashes and sand,	33.30		
	100.00		100.00

Doubtless containing the ordinary ingredients of petroleum.

ESTILL COUNTY.

No. 503—Copper Ore. *Brought from near Irvine, Estill county, Ky., by O. C. Winburn.*

Exterior of the lumps ochreous, brownish-yellow; interior partly of the same character, and partly of a reddish-brown color, with diffused portions of yellow pyrites, and a light greenish substance, (carbonate of copper;) easily broken under the hammer; powder of a dirty olive color.

Composition, dried at 212° F.—

Copper,	21.13
Sulphur,	9.28
Peroxide of iron,	36.55
Alumina,	.38
Carbonate of lime,	14 05
Magnesia,	1.68
Silicious residue,	19 57
	101.64

The locality of this mineral has not yet been visited by Dr. Owen. Should it be found in sufficient abundance, to warrant the erection of proper furnaces to smelt the ore, it is rich enough to prove a profitable ore.

This is believed to be the first instance of the discovery of copper ore in Kentucky.

FAYETTE COUNTY.

No. 504—Soil. *Labeled "Virgin soil from a Beech ridge, on Robert Wickliffe's farm, two and a half miles from Lexington, on the Richmond turnpike; much less productive than the neighboring blue limestone soil; Fayette county, Ky."*

Color of the dried soil grey-buff. It contains irregular lumps of soft iron ore, varying in color from nearly black to dark yellow.

One thousand grains carefully washed with water left 489. grains of *pure sand*, of which 113. grains would not pass through fine bolting-cloth, and, examined with the lens, was found to consist of rounded particles of ferruginous mineral, varying from yellowish-brown, to almost black, mostly easily crushed in the fingers; with a few grains of milky quartz.

One thousand grains of the air-dried soil, digested for two months in water containing carbonic acid, gave up more than two and a half grains of dark *brown extract*, of which more than one half was carbonate of lime. Its *composition*, dried at 212°, was as follows:

	Grains.
Organic and volatile matters,	0.680
Alumina, oxide of iron, and phosphates,	.498
Carbonate of lime,	1.518
Magnesia,	.056
Sulphuric acid,	.036
Potash,	.072
Soda,	.012
Silica,	.199
Oxide of manganese and loss,	.449
	3.520

The air-dried soil lost 4.12 per cent. of *moisture* at 400° F.

Its *composition*, thus dried, is as follows:

Organic and volatile matters,	4.881
Alumina, and oxides of iron and manganese,	10.306
Carbonate of lime,	.276
Magnesia,	.133
Phosphoric acid,	.254
Sulphuric acid,	.109
Potash,	.139
Soda,	.047
Sand and insoluble silicates,	83.834
Loss,	.021
	100.000

A comparison between this and the richer *blue limestone* soil of Fayette county can be made by turning to pages 276 and 379 of the preceding report; and its inferiority to that will be seen to depend on its larger proportion of sand and silicious matters, and its smaller proportions of *phosphoric* acid and the *alkalies*, as well as of lime and magnesia, alumina and oxide of iron.

This soil, which in this rich region of country is called a poor soil, by comparison, would be considered quite a good soil in some parts of Kentucky.*

*Compare this with the analysis of Jefferson county soil, O'Bannon's station.

No. 505—SILICIOUS ROCK. *Labeled "Buff silicious rock, underlying the beech ridge soil, Robert Wickliffe's farm, two and a half miles from Lexington, cut of Lexington and Big Sandy railroad, near the Richmond turnpike, Fayette county, Ky."*

A dull, fine-granular rock, of a dirty buff color; adhering slightly to the tongue; quite friable; powder grey-buff.

Composition, dried at 212° F—

Silica and fine sand,	87.83
Alumina, oxides of iron and manganese,	8.65
Carbonate of lime, only a trace.	
Carbonate of magnesia,	1 40
Phosphoric acid,	.25
Sulphuric acid,	.22
Potash,	.27
Soda,	.14
Water and loss,	1 24
	100.00

This rock, ground-up, might make pretty good *fire-bricks*.

No. 506—SILICIOUS SHALE, *alternating with the preceding buff-colored rock, in the cut of the Lexington and Big Sandy railroad, through the beech ridge on Mr. Robt. Wickliffe's farm, (same locality as the two preceding,) Fayette county, Ky.*

A soft grey-buff clay shale, showing darker discolorations with oxides of iron and manganese; adheres strongly to the tongue; easily disintegrates into clay on exposure to the air; powder grey-buff color.

Composition, dried at 212°—

Sand and insoluble silicates,	*83.45
Alumina and oxide of iron and manganese,	10.25
Carbonate of lime,	1.79
Carbonate of magnesia,	2.30
Phosphoric acid,	.50
Sulphuric acid,	.92
Potash,	.41
Soda,	.01
Water and loss,	.37
	100.00

*The 83.45 grains of *sand and insoluble silicates* were found, on analysis, to consist of 70 grains of *silica*, and the remainder principally [illegible], with traces of oxide of iron, lime, and magnesia.

These rocks, which form the sub-strata of this remarkable beech ridge, in this limestone region, are very different in composition from the prevailing rock stratum in Fayette county.

The two varieties of the blue limestone, next to be described, are such as are generally found in this vicinity underlying the soil.

No. 507—LIMESTONE. *Labeled "Upper shelly layer, from Van Akin's quarry, just below Lexington, on the Elkhorn branch, Fayette county, Ky." (Blue limestone, of Lower Silurian Formation.)*

A bluish-grey, coarse granular limestone, glimmering with small confused crystals of calcarious spar, and containing many fossil remains, as of small *Encrinal* stems, Atrypa, Modiola, Leptæna, Orthis, Pleurotomaria, &c., &c. Weathered surfaces of a dirty-buff color; powder very light yellowish-grey.

Specific gravity,		2.660
Composition, dried at 212° F.—		
Carbonate of lime,	92.73 = 52.03 *Lime.*	
Carbonate of magnesia,	.63	
Alumina, and oxides of iron and manganese,	2.42	
Phosphoric acid,	.86	
Sulphuric acid,	.34	
Chlorine,	.05	
Potash,	.23	
Soda,	.28	
Silica and insoluble silicates,	2.18	
Loss,	.28	
	100.00	

The air-dried rock lost 0.30 per cent. of *moisture* at 212° F.

No. 508—LIMESTONE. *Labeled "Limestone used for curb-stones, &c., &c., Van Akin's quarry, Fayette county, Ky."*

Underlying the preceding; in thicker layers, and of a darker color and finer grained than that; glimmering with calcarious spar, and containing the usual fossils of the *Trenton limestone*, or blue limestone of the Lower Silurian Formation.

Specific gravity,		2.711
Composition, dried at 212° F.—		
Carbonate of lime,	77.63 = 43.56 *Lime.*	
Carbonate of magnesia,	10.00	
Alumina, and oxides of iron and manganese,	3.23	
Phosphoric acid,	.70	
Sulphuric acid,	3.12	
Chlorine, not estimated.		
Potash,	.32	
Soda,	.15	
Silica and insoluble silicates,	4.98	
	100.13	

The air-dried rock lost 0.20 per cent. of *moisture*, at 212° F.

No. 509—Sub-soil. *Labeled "Red clay, under the sub-soil, eastern part of Fayette county, Ky."*

Dried earth of a dirty reddish brown color.

One thousand grains, washed carefully with water, left 664 grains of *reddish-brown sand*, of which 75 grains was too coarse to pass through the finest bolting cloth, and was composed of rounded particles of soft iron ore, with a few rounded quartzose grains.

One thousand grains of the air-dried soil, digested for two months in water containing carbonic acid, gave up more than four grains of *nearly white extract*, dried at 212°, having the following composition:

	Grains.
Organic and volatile matters,	0.350
Alumina, oxides of iron and manganese, and phosphates,	.018
Carbonate of lime,	3.497
Magnesia,	.253
Sulphuric acid,	.055
Potash,	.038
Soda, not estimated.	
Silica,	.139
	4.350

The air-dried sub-soil lost 7.30 per cent. of *moisture*, at 400°, dried at which temperature its *composition* was:

Organic and volatile matters,	5 242
Alumina, and oxides of iron and manganese,	19 206
Carbonate of lime,	1.196
Magnesia,	.426
Phosphoric acid,	.434
Sulphuric acid,	.054
Potash,	.308
Soda,	.086
Sand and insoluble silicates,	72 994
Loss,	.054
	100.000

No. 510—Sub-soil. *Labeled "Ferruginous clay, under the sub-soil, at Megowan's quarry, terminus of the Big Sandy railroad at Lexington, Fayette county, Ky."*

Dried sub-soil of a greyish-reddish-brown, containing irregular nodules of chert, partly decomposed and porous.

Washed with water one thousand grains left 514 grains or *reddish sand*, of which 160 grains would not go through the finest bolting-cloth, and consisted mainly of rounded particles of soft dark colored iron ore, which could be crushed in the fingers; with a quartzose grains.

One thousand grains of the air-dried sub-soil, digested for two months in water containing carbonic acid, gave up only a little more than one grain of *olive-grey extract*, dried at 212°; the composition of which was as follows:

	Grains.
Organic and volatile matters,	0.280
Alumina, oxides of iron and manganese, and phosphates,	.249
Carbonate of lime,	.278
Magnesia,	.046
Sulphuric acid,	.102
Potash,	.052
Soda,	.026
Silica,	.079
	1.112

The air-dried sub-soil lost 6.38 per cent. of *moisture* at 420° F.; dried at which temperature its *composition* is as follows:

	Grains.
Organic and volatile matters,	4.913
Alumina and oxides of iron and manganese,	20.300
Carbonate of lime,	.116
Magnesia,	.034
Phosphoric acid,	.383
Sulphuric acid,	.082
Potash,	.309
Soda,	.159
Sand and insoluble silicates,	73.874
	100.170

In these two specimens of the red clay, which extensively underlies the upper sub-soil in the *blue grass region*, we find considerable similarity of composition, especially in the proportions of phosphoric acid and alkalies, which are comparatively large. The alumina and oxide of iron, nearly in like quantity in these two Fayette county specimens, is much greater in that brought from Woodford county, near Versailles, (which see;) and in them all the proportion of carbonate of lime is variable. In all of them, a portion of what is stated as *organic and volatile matters*—representing the loss of weight observed on the complete calcination at a red heat, of the well dried soil—must be considered only *combined water*.

Although containing as much as twenty per cent. of *alumina and oxide of iron*, this *red clay* of Fayette county allows water freely to pass through it, so that it does not prevent the drainage of the soil; which is favored by the cavernous nature of the limestone beneath. Whether or not the red clay of Woodford county, which contains more than thirty-three per cent. of these ingredients, causes the surface water to stagnate, the writer is not advised; but it is probable, from its appearance, that it does not act injuriously in this respect.

No. 511—Limestone. *Labeled "Magnesian Limestone, upper layer five inches to a foot thick; not used for building purposes; a bed in the Bird's Eye Limestone of the Lower Silurian Formation, Grimes' Quarry, Horse Shoe Point, Grimes' mill, about one and a quarter miles from the Richmond turnpike near Kentucky river, Fayette county, Kentucky."*

A greyish-buff, fine granular rock, pretty uniform in structure, except for some small cavities lined with light colored ochreous matter; no fossils or pyrites; adhering very slightly to the tongue.

Specific gravity,	2.716
Composition, dried at 212° F—	
Carbonate of lime,	51.57
Carbonate of magnesia,	29.33
Alumina, and oxides of iron and manganese,	3.57
Phosphoric acid,	.37
Sulphuric acid,	.34
Potash,	.71
Soda,	.82
Silex and insoluble silicates,	11 58
Loss,	1.71
	100.00

The air-dried rock lost 0.10 per cent. of *moisture*, at 212° F.

No. 512—Limestone. *Labeled "Building Stone, from Grimes' Quarry, Fayette county, Ky."*

Some of the layer immediately under the above described, about five feet thick; much used for building purposes.

A light yellowish-grey, fine granular limestone, quite homogeneous in its structure, with no appearance of fossils or pyritous matter. Under the lens appears to be made up of pure crystalline grains, aggregated together without cement; powder nearly white.

Specific gravity,		2.703
Composition, dried at 212° F.—		
Carbonate of lime,	55 54 = 31.16 *Lime.*	
Carbonate of magnesia,	40.80 = 19.68 *Magnesia.*	
Alumina, oxide of iron, &c.,	.96	
Sulphuric acid,	.02	
Potash,	.36	
Soda,	.22	
Silex and insoluble silicates,	2.79	
	100 69	

The air-dried rock lost 0.30 per cent of *moisture*, at 212° F.

No. 513—LIMESTONE. *Labeled "Portion of one of the boundary stones of the city of Lexington; originally from Grimes' quarry; locality as above; appearance much the same as that of the preceding; adheres slightly to the tongue."*

Specific gravity,	2.615
Composition, dried at 212° F.—	
Carbonate of lime,	55.99
Carbonate of magnesia,	37.33
Alumina, oxides of iron, &c.,	.72
Phosphoric acid,	.25
Sulphuric acid,	.33
Potash,	2.35
Soda,	.25
Silex and insoluble silicates,	3.38
	100.60

The air-dried rock lost 0.10 per cent. of *moisture*, at 212° F.

The proportion of *potash* in the above specimen is remarkable. The portion analyzed had been broken from the old boundary stone, just at the *surface of the soil*, in order to exhibit the power of this stone to resist the decomposing atmospheric influences, under the most unfavorable circumstances; whether the prolonged contact of the rock with the soil had made any change in its proportion of potash, by interpenetration, or whether there was an error in the determination, would be a subject for further investigation.

This building stone, which has recently been selected by the building committee of the Kentucky Clay Monument Association, for the material of their proposed monument, commends itself, in many respects, as one of the best materials which could be chosen for their purposes.

Its homogeneous structure and purity of composition; its considerable proportion of magnesia, with the absence of fossils, pyrites, or flinty matter; are all favorable to great durability and facility of shaping it with the chissel; and its light warm-grey color is more pleasant to the eyes of most persons than the pure white of statuary marble.

In the city of Lexington the door-steps of some of the oldest houses, made of this rock, exhibit very little sign of disintegration; and, according to the experience of architects in general, a pure hom-

ogeneous, magnesian limestone may be classed amongst the most durable of building rocks.

It was of this rock that the block was selected which was sent by the state of Kentucky to the Washington monument, at the capital of the United States.

It will be seen by comparison that the composition of this stone is remarkably similar to that of the Dolomitic limestones of this and other countries.

No. 556—Mineral Water. *Water from the bored well at the Lunatic Asylum, Lexington, Ky.*

The water of the large spring, formerly used at this extensive establishment, having become contaminated by the leakage of some of the large sewers, an attempt was made to procure a supply of water by boring; and, after penetrating one hundred and six feet, of which eighty-six feet were through the solid blue limestone rock, abundance of water was obtained. It was found to be a weak saline sulphur water, containing *sulphuretted hydrogen* and *carbonic acid gases*, and left, on evaporation to dryness at the temperature of 212°, about one grain and six-tenths of a grain from the one thousand grains of water, or more than eleven grains of saline matter to the pint.

This saline matter was found to consist of

Carbonate of lime;

Carbonate of magnesia;

Carbonate of iron, a trace;

Chloride of sodium, (common salt,) considerable proportion;

Sulphate of lime;

Sulphate of magnesia;

Silica and *probably* sulphates of soda and potash, with traces of iodine and bromine—one or both.

A full *quantitative* analysis not having been made, as yet, the presence of these minuter ingredients cannot be positively asserted.

This fine well has proved a great boon to this public establishment. It is employed for all the domestic purposes—for washing, drinking, cooking, &c., and since its use the medical superintendent, Prof. W. C. Chipley, thinks the general health of the inmates has been improved: in particular, *endemic diarrhea*, which was formerly a very frequent scourge, has been almost entirely removed. The first influence on the

bowels, resulting from its free use, was somewhat constringent, followed by some relaxation, after which their action became natural; it is observed to habitually increase the action of the kidneys.

FRANKLIN COUNTY.

No. 514—LIMESTONE. *Labeled "Hydraulic? limestone, main Benson, near Bright's mill, Franklin county, Ky."*

A pretty dense, grey, fine granular rock; generally dull, but glimmering in spots with particles of calcarious spar; powder light bluish-grey.

Specific gravity,	2.699	
Composition, dried at 212° F.—		
Lime,		50.19
Magnesia,		.66
Alumina and oxide of iron,		1 24
Carbonic acid,		40.15
Phosphoric acid,		.44
Sulphuric acid,		.68
Potash,		.23
Soda,		.29
Silex and insoluble silicates,		6 94
		100.82

The air-dried rock lost 0.30 per cent. of *moisture*, at 212° F.

This limestone does not contain enough silica, alumina, &c., to constitute it a good water-lime.

No. 515—LIMESTONE. *Labeled "Near Bridgeport, Franklin county, Ky."*

A fine grained dark bluish-grey rock. Weathered surfaces brownish-buff; no fossils, except what might be the cast of a small *fucoid* body, and certain other similar appearances of small stems traversing the rock, and of a dirty-buff color, very apparent on the generally dark-grey surface; powder light grey.

Specific gravity,	2.700	
Composition, dried at 212° F.—		
Carbonate of lime,		76.75
Carbonate of magnesia,		.19
Alumina, oxides of iron, &c.,		2.25
Phosphoric acid,		.09
Sulphuric acid,		.85

Potash,	.48
Soda,	.44
Silex and insoluble silicates,	18.86
Loss,	.09
	100.00

The air-dried rock lost 0.20 per cent. of *moisture*, at 212° F.

The proportion of silex in this limestone is sufficient to constitute it a water-lime, provided it is in such a state of aggregation as to unite readily with the lime, which can be ascertained by a practical trial.

No. 516—LIMESTONE. *Labeled "Encrinital limestone from near Bridgeport, Franklin county, Ky."*

On the recent fracture this rock appears to be made up of coarse confused crystalline grains of calcarious spar, colored dark grey and brownish by ferruginous admixture; but on the weathered surfaces, which are of a dirty buff color, innumerable joints and portions of *small* encrinal stems appear.

Composition, dried at 212° F.—

Carbonate of lime,	92.65 = 51.99 per cent. of *Lime.*	
Carbonate of magnesia,	1.54	
Alumina, oxide of iron, &c.,	1.19	
Phosphoric acid,	.09	
Sulphuric acid,	1.27	
Potash,	.30	
Soda,	.13	
Silica and insoluble silicates,	3.68	
	100.85	

The air-dried rock lost 0.20 per cent. of *moisture*, at 212° F.

No. 517—SOIL. *Labeled "Virgin upland soil, from the waters of Benson creek, near Hardinsville, Franklin county, Ky., farm of John J. Julian."*

Color of the dried soil dark, dirty buff-grey.

One thousand grains washed with water left 677 grains of *fine sand*, of which about 90. grains was too coarse to pass through the finest bolting cloth; this consisted mainly of rounded particles of soft iron ore, with a few quartzose grains.

This soil was found to be mixed with fragments of charcoal, which increased its apparent amount of *organic and volatile matters.*

One thousand grains of the air-dried soil, digested for two months in water containing carbonic acid, gave up more than three grains and a half of *dark brown extract*, dried at 212°, which was composed of

	Grains.
Organic and volatile matters,	1.430
Alumina, oxides of iron and manganese, and phosphates,	.758
Carbonate of lime,	.917
Magnesia,	.056
Sulphuric acid,	.037
Potash,	.096
Soda,	.047
Silica,	.339
	3.680

Dried at 400° the air-dried soil lost 5.18 per cent. of moisture; dried at which temperature its *composition* was found to be as follows:

Organic and volatile matters,	9.133
Alumina, and oxide of iron and manganese,	8.100
Carbonate of lime,	.316
Carbonate of magnesia,	.517
Phosphoric acid,	.243
Sulphuric acid,	.068
Potash,	.173
Soda,	.049
Sand and insoluble silicates,	80.754
Loss,	.647
	100.000

No. 518—Soil. *Labeled "Same kind of soil and growth as the preceding; has been twelve years in cultivation, in corn and oats chiefly. Waters of Benson creek, near Hardinsville, farm of John J. Julian, Franklin county, Ky."*

Dried soil a little lighter colored than the preceding.

One thousand grains washed with water left 705 grains of fine greyish sand of which only about 30 grains was too coarse to pass through fine bolting cloth; consisting mainly of rounded and angular fragments of ferruginous and quartzose minerals.

One thousand grains of the air-dried soil, digested for two months in water containing carbonic acid, gave up more than two grains and a half of *yellowish-brown extract*, dried at 212°, of the following composition:

	Grains.
Organic and volatile matters,	0.570
Alumina, oxide of iron, and phosphates,	.277
Brown oxide of manganese,	.338
Carbonate of lime,	.857
Magnesia,	.100
Sulphuric acid,	.295
Potash,	.050
Soda,	.031
Silica,	.119
	2.637

Dried at 370° this soil lost 1.98 per cent. of *moisture*, and its composition was found to be as follows:

Organic and volatile matters,	3.790
Alumina and oxides of iron and manganese,	4.589
Carbonate of lime,	.196
Magnesia,	.066
Phosphoric acid,	.151
Sulphuric acid,	.054
Potash,	.135
Soda,	.026
Sand and insoluble silicates,	90.734
Loss,	.259
	100.000

The proportions of all the *essential* elements of this soil are smaller than in the preceding virgin soil of the same locality.

No. 518 (*A*)—Soil. *Same kind of soil and growth as the preceding; from a field that has been from forty to fifty years in cultivation; waters of Benson, Franklin county, near Hardinsville, farm of Mr. John J. Julian.*

Dried soil of a grey-buff color.

One thousand grains of the air-dried soil, washed carefully with water, left 720 grains of *fine sand*, of which 21.70 grains would not pass through fine bolting-cloth. This latter portion consisted, principally, of small rounded ferruginous particles.

One thousand grains of the air-dried soil, digested in the usual manner, for a month, in water containing carbonic acid, gave up more than two and a third grains of brownish extract, dried at 212° which exhibited the following composition, viz:

	Grains.
Organic and volatile matters,	0.470
Alumina, oxides of iron and manganese, and phosphates,	.287
Carbonate of lime,	.913
Magnesia,	.091
Sulphuric acid,	.081
Potash,	.086
Soda,	.017
Silica,	.200
Loss,	.222
	2.366

Dried at the temperature of 400° the air-dried soil lost 2.525 per cent. of moisture. Its *composition*, thus dried, is as follows:

Organic and volatile matters,	4 206
Alumina,	2.120
Oxide of iron,	2 915
Carbonate of lime,	.173
Magnesia,	.233
Brown oxide of manganese,	.004
Sulphuric acid,	.043
Phosphoric acid,	.128
Potash,	.130
Soda,	.051
Sand and insoluble silicates,	90.170
	1.173

By comparison with the preceding soil, it will be seen that the soil of this field, which has been from forty to fifty years in cultivation, contains a smaller relative proportion of phosphoric and sulphuric acids, of potash, and of carbonate of lime, than the virgin soil, or the soil from the field which has been but twelve years in cultivation; and that it yielded a smaller quantity of nutritious extract to the carbonated water than those soils.

No. 518 (*B*)—Soil. *Labeled "Sub-soil from a field on John J. Julian's farm, waters of Benson, Franklin county, Ky."*

Dried soil of a dark grey-buff color.

One thousand grains of this sub-soil gave, on washing with water, 630.7 grains of fine sand, of which all but 18 grains passed through fine bolting-cloth. This latter portion consisted of round particles, of a ferruginous mineral, with a few quartzose grains.

One thousand grains of the air-dried soil, digested for a month in the carbonated water, gave up less than a grain of nearly white extract, dried at 212°, composed as follows, viz:

	Grain.
Organic and volatile matters,	0.217
Alumina, oxides of iron and manganese, and phosphates,	.063
Carbonate of lime,	.181
Magnesia,	.030
Sulphuric acid,	.034
Potash,	.046
Soda,	.038
Silica,	.200
Loss,	.006
	0.830

The air-dried soil lost 3.30 per cent. of *moisture* at 400°. Its composition is as follows:

Organic and volatile matters,	3.179
Alumina,	4 470
Oxide of iron,	4.825
Carbonate of lime,	.082
Magnesia,	.312
Brown oxide of manganese,	.005
Sulphuric acid,	.033
Phosphoric acid,	.148
Potash,	.282
Soda,	.002
Sand and insoluble silicates,	86.380
Loss,	.282
	100.000

GREENUP COUNTY.

No. 307—LIMONITE. "*Hydrated oxide of iron, in the form of pot ore, associated with the limestone ore, Bellefonte Furnace, Greenup county, Kentucky.*"

A concretionary mass of limonite, with a large irregular cavity lined with an almost black layer; exterior surface, and between the layers, soft and brown; powder brownish-yellow; when calcined, of a handsome spanish-brown color.

Composition, dried at 212° F.—

Oxide of iron, - - -	80.30 = 56.23 per cent. of *Iron*.
Alumina, not estimated.	
Brown oxide of manganese, -	.35
Magnesia, - - - -	.40
Potash, - - - -	.34
Soda, - - - - -	.01
Phosphoric acid, - - -	.60
Silica and insoluble silicates, -	6.55
Combined water, - - -	12.12
	100.67

The air-dried ore lost 1.00 per cent. of *moisture* at 212° F.

A pure *limonite*, containing only traces of *lime* and *alumina*, and not sufficient silicious matter to form *cinder* enough in the furnace to protect the reduced iron from the action of the oxygen of the blast. It can be smelted successfully by admixture with poorer ores and limestone.

No. 481—LIMESTONE. *Labeled "Limestone used as a flux at the Buffalo Furnace; lies near the level of the Clay creek branch of Little Sandy river, Greenup county, Ky."*

A compact, fine granular, greenish-grey limestone; uniform in texture and appearance.

Specific gravity, - - - - - - -	2.691	
Composition, dried at 212° F.—		
Carbonate of lime, - - - - - - - -		73 90
Carbonate of magnesia, - - - - - - -		2.08
Alumina and oxide of iron, - - - - - - -		1.19
Phosphoric acid, - - - - - - - - -		.46
Potash, - - - - - - - - - -		.27
Soda, - - - - - - - - - -		.05
Silex and insoluble silicates, - - - - - -		21 67
Loss, - - - - - - - - - - -		.38
		100.00

The air-dried rock lost 0.20 per cent. of *moisture* at 212° F.

No. 482—CARBONATE OF IRON. *Labeled "Centre part of the Kidney Ore, which lies over the main block ore, tops of hills, with impure (bastard) limestone under it, Buffalo Furnace, Greenup county, Kentucky."*

Portion of a nodular mass; dull, fine-grained; of which the exterior portion is of a dark brown color, separating in concentric layers; the central part is of a dark grey color, passing, on its exterior, into the yellowish and brown layers, which make up the outside of the mass. (The analysis of the *exterior* portion was given in the previous report.) Powder of the interior grey part of a yellowish-grey color.

Composition, dried at 212° F.—

Carbonate of iron,	70.27	= 40.70 per cent. of *Iron*.
Oxide of iron,	10.16	
Alumina,	.15	
Phosphoric acid,	.73	
Carbonate of lime,	2.45	
Carbonate of magnesia,	5.52	
Carbonate of manganese,	1.46	
Potash,	.40	
Soda,	.09	
Silex and insoluble silicates,	8.15	
Loss,	.62	
	100.00	

The air-dried ore lost 0.50 per cent. of *moisture*, at 212°.

No. 474—Limonite. *Labeled "Clay Iron Stone, Giger's Hill, Catlettsburg, Greenup county, Ky."*

Portion of a concretionary mass, irregular in form, with a cavity in the interior, and some concentric layers around it; compact; adhering slightly to the tongue; of a dirty reddish-brown color; powder brownish-ochreous.

Composition, dried at 212° F.—

Oxide of iron,	68.30	= 47.83 per cent. of *Iron*.
Alumina,	3.65	
Carbonate of lime,	.28	
Magnesia,	2.64	
Potash,	.27	
Soda,	.22	
Silex and insoluble silicates,	12.28	
Combined water,	12.09	
Phosphoric acid and loss,	.27	
	100.00	

The air-dried ore lost 1.60 per cent. of *moisture*, at 212°.

No. 475—Impure Carbonate of Iron. *Labeled "Ferruginous limestone under the limestone ore, Greenup county, Ky. (How much iron and lime)"*

A fine granular rock, of a dull aspect; containing small spangles of mica; not adhering to the tongue. Interior of a dark olive-grey color; exterior, to the depth of more than half an inch, dull reddish-brown, shading into dirty yellowish-brown on the outside surface; powder (of an average portion,) of a grey-buff color.

Specific gravity, - - - - - - - -		3.155
Composition, dried at 212° F.—		
Carbonate of iron, - - -	28.01	= 23.62 per cent. of *Iron*.
Oxide of iron, - - -	14 42	
Carbonate of lime, - -	29.37	
Carbonate of magnesia, - -	5.57	
Carbonate of manganese, -	.18	
Alumina, - - - -	1.38	
Phosphoric acid, - - -	.29	
Potash, - - - - -	.42	
Soda, - - - - -	.33	
Silex and insoluble silicates, -	19.98	
Organic matters and loss, -	.05	
	100.00	

The air-dried rock lost 0.60 per cent. of *moisture* at 212° F.

Although this mineral contains rather too small a proportion of iron to be considered a good *ore* of that metal, it yet will answer a profitable purpose when it is mixed, in proper proportion, with some of those limonites of Greenup county which are refractory in the furnace, in consequence of their very large per centage of oxide of iron. The considerable proportion of lime and magnesia, contained in this rock, renders it an appropriate fluxing material for those very rich iron ores which are of a silicious character.

No. 476—Limonite. *Labeled "Limestone ore, over the limestone, Pennsylvania Furnace, Greenup county, Ky."*

Exterior of the ore of a dirty yellowish-grey color. On one edge the fracture presented a compact layer of dark brown limonite, which gradually passes into a granular mass, composed of small brownish-red grains, cemented by a whitish and yellowish matter, of which mixture

the ore is principally composed, giving it a fine oolitic appearance; powder light brownish-red.

Composition, dried at 212° F.—

Oxide of iron,	72.80	= 50.98 per cent. of *Iron*.
Alumina,	2.17	
Brown oxide of manganese,	.45	
Carbonate of lime,	.18	
Magnesia,	1.19	
Potash,	.48	
Soda,	.02	
Silex and insoluble silicates,	10.57	
Combined water,	11.20	
Loss,	.94	
	100.00	

The air-dried ore lost 2.70 per cent. of *moisture* at 212° F.

No. 316—LIMONITE. *Labeled "Kidney ore, above the block ore and under the main limestone, Pennsylvania Furnace, Greenup county, Ky."*

A dark, purplish-brown, limonite; compact; adhering slightly to the tongue; containing minute spangles of mica; some of the fissures coated with glimmering dark colored, minute crystals; powder of a spanish-brown color.

Composition, dried at 212° F.—

Oxide of iron,	76 90	= 53.85 per cent. of *Iron*.
Alumina,	1.21	
Brown oxide of manganese,	.25	
Phosphoric acid,	.64	
Magnesia,	.28	
Potash,	.23	
Soda,	.16	
Silex and insoluble silicates,	11.77	
Combined water,	9.09	
	100.53	

The air-dried ore lost 0.50 per cent. of *moisture* at 212° F.

No. 317—LIMONITE. *Labeled "Block ore, below the hearth-stone, average seven to eight inches, Pennsylvania Furnace, Greenup county, Ky."*

A dense. compact, limonite of a dark purple-brown color; presenting some cavities lined with ochreous ore; adhering slightly to the tongue; powder of a brownish-red color.

Specific gravity,		3 292
Composition, dried at 212° F.—		
Oxide of iron,	68.20	= 47.76 per cent. of *Iron*.
Alumina,	2.98	
Brown oxide of manganese,	.25	
Phosphoric acid,	.99	
Lime, a trace.		
Magnesia,	1.02	
Silex and insoluble silicates,	17.17	
Combined water,	8.57	
Alkalies, not estimated, & loss,	.82	
	100.00	

The air-dried ore lost 2.20 per cent. of *moisture*, at 212° F.

No. 318—LIMONITE. *Labeled "Limestone ore, incrusted with ochreous oxide of iron, Pennsylvania Furnace, Greenup county, Ky."*

A friable and porous ore, composed of irregular portions of dark brown hæmatite, imbedded in yellowish, (ochreous) soft matter, of different shades of color; powder brownish-yellow.

Composition, dried at 212° F.—		
Oxide of iron,	61.10	= 42.78 per cent of *Iron*.
Alumina,	.85	
Carbonate of lime,	.45	
Magnesia,	1.09	
Brown oxide of manganese,	.95	
Phosphoric acid, a trace.		
Potash,	.38	
Soda,	.10	
Silica and insoluble silicates,	23 85	
Combined water,	11.67	
	100.44	

The air-dried ore lost 1.50 per cent. of *moisture*, at 212° F.

No. 477—LIMESTONE. *Labeled "Limestone, under the limestone ore, used as a flux, Pennsylvania Furnace, Greenup county, Ky."*

A dark grey, fine grained, compact limestone.

Composition, dried at 212° F.—

Carbonate of lime,	91 47
Carbonate of magnesia,	2.75
Oxide of iron,	1.82
Brown oxide of manganese,	.05
Alumina,	.48
Potash,	.13
Soda,	.10
Silex and insoluble silicates,	3.38
	100.18

The air-dried rock lost 0.50 per cent. of *moisture*, at 212° F.

No. 478—LIMONITE. *Labeled "Lower kidney ore, over the one foot sandstone, Raccoon ore banks, Greenup county, Ky."*

A dense dark-colored ore; reddish and purplish brown; with irregular cavities, and portions of soft yellowish and red ochreous mineral.

Specific gravity,		3.083
Composition, dried at 212° F.—		
Oxide of iron,	58.30	= 40.82 per cent. of *Iron*.
Alumina,	1.05	
Brown oxide of manganese,	.65	
Phosphoric acid,	1.25	
Carbonate of lime,	.15	
Magnesia,	.77	
Potash,	.40	
Soda,	.08	
Silex and insoluble silicates,	29.77	
Combined water,	8.31	
	100.73	

The air-dried ore lost 1.30 per cent. of *moisture*, at 212 F.

No. 289—LIMONITE. *Labeled "Lower six inch black ore, Raccoon Furnace, Greenup county, Ky."*

A dull looking mineral, in irregular hard layers of a dark brown color, coated and separated by soft dirty ochreous ore; powder dull yellow ochre color.

Composition, dried at 212° F.—

Oxide of iron,	24.70	= 17.29 per cent. of *Iron*.
Alumina,	3.75	
Brown oxide of manganese	.05	
Phosphoric acid, a trace.		
Magnesia,	.67	
Potash,	.32	
Soda,	.01	
Silex and insoluble silicates,	64.42	
Combined water,	5.66	
Loss,	.42	
	100.00	

The air-dried mineral lost 1.20 per cent. of *moisture*, at 212° F.

Rather too poor in iron to be valuable, except for mixture with very rich calcarious ores, to produce cinder.

No. 309—LIMONITE. *Labeled "Main Kidney Ore, above the limestone ore, Greenup Furnace, Greenup county, Ky."*

A dull looking ore; dirty ochreous on the exterior; dull reddish and yellowish-brown in the interior; apparently a portion of a nodular mass; scarcely adhering to the tongue; powder dirty ochreous.

Specific gravity, 2.770

Composition, dried at 212° F.—

Oxide of iron,	41.40	= 28.99 per cent. of *Iron*.
Alumina,	3.36	
Brown oxide of manganese,	.75	
Phosphoric acid,	.54	
Carbonate of lime,	1.15	
Magnesia,	1.50	
Potash,	.23	
Soda,	.01	
Silica and insoluble silicates,	41.47	
Combined water,	10.54	
	100.95	

The air-dried ore lost 2.30 per cent. of *moisture*, at 212°.

Rather a poor ore, containing a large proportion of silex, which may be made profitable in judicious mixture with other ores.

No. 479—CARBONATE OF IRON. *Labeled "Carbonate of Iron, lowest bed, middle part, Greenup Furnace, Greenup county, Ky."*

Exterior olive-yellow; friable; soiling the fingers; interior dull dark grey, of fine granular, dense structure; powder light grey.

Specific gravity,		3.497
Composition, dried at 212° F.—		
Carbonate of iron,	67.84	37.46 per cent. of *Iron*.
Oxide of iron,	5.89	
Carbonate of lime,	3.25	
Carbonate of magnesia,	4.88	
Carbonate of manganese,	1.97	
Alumina,	1.45	
Phosphoric acid,	.60	
Potash,	.50	
Soda,	.09	
Silex and insoluble silicates,	13.78	
	100.25	

The air-dried ore lost 0.50 per cent. of *moisture* at 212° F.

A valuable ore, which contains within itself nearly enough, or perhaps quite enough, fluxing materials to form its own cinder.

No. 312—CARBONATE OF IRON. *Labelcd "Carbonate of Iron, lowest ore obtained at Greenup ore banks, Greenup county, Ky."*

A dull, dark brown, fine granular mineral, with a few minute scales of mica; exterior dirty ochreous; powder dirty orange-brown.

Composition, dried at 212° F.—		
Carbonate of iron,	56.92	37.10 *Iron*.
Oxide of iron,	14.14	
Carbonate of lime,	1.25	
Carbonate of magnesia,	5.28	
Carbonate of manganese,	2.04	
Alumina,	1.05	
Phosphoric acid,	.99	
Potash,	.61	
Soda,	.01	
Organic matters,	.80	
Silex and insoluble silicates,	16.15	
Water and loss,	.76	
	100.00	

The air-dried ore lost 0.50 per cent. of *moisture* at 212° F.

This ore nearly resembles the preceding in composition.

No. 311—Carbonate of Iron. *Labeled "Carbonate of Iron, lowest bed of ore, lower part of the bed, Greenup Furnace, Greenup county, Ky."*

A dark-grey, fine granular ore; powder yellowish-grey.

Composition, dried at 212° F.—

Carbonate of iron,	60.49	32.57 per cent. of *Iron.*
Oxide of iron,	5.25	
Carbonate of lime,	3.15	
Carbonate of magnesia,	6.52	
Carbonate of manganese,	.83	
Alumina,	.41	
Phosphoric acid, a trace.		
Potash,	.34	
Soda,	.29	
Silex and insoluble silicates,	21.82	
Water and loss,	.90	
	100.00	

The air-dried ore lost 0.40 per cent. of *moisture*, at 212°.

Rather less rich than the two preceding ores, but yet a valuable ore of the same general character.

No. 330—Iron Furnace Slag. *Labeled "Pea-green cinder, Buena Vista Furnace, Greenup county, Ky."*

A greyish-green, blebby cinder, containing small nodules of cast iron, with iron rust on the weathered surfaces. Before the blow-pipe it melts, without intumescence, into a clear light bottle-green glass.

Composition—

Silica,	58.00	Containing of oxygen,	28.884	
Alumina,	20.50	"	9.582	
Lime,	12.06	"	3.554	
Magnesia,	2.19	"	.876	
Protoxide of iron,	3.51	"	.778	
Protoxide of manganese,	1.21	"	.272	
Potash,	2.12	"	.349	
Soda,	.55	"	.140	
	100.14		15.551	: 28.884

The oxygen in the bases to that in the silica is as - - 1 : 1.78

Contains a little more silica, and a little less lime and magnesia, than slag No. 47, from the same furnace, (see former report, page 290.) This contains, also, more protoxide of iron and manganese. From the involved little nodules of iron it is inferred that this was of rath-

er more pasty consistence than that. In this, as well as in No. 47, the bases, especially the alumina, are a little in excess of the proportion to produce the most fusible cinder.

No. 293—LIMONITE. *Labeled "Kidney ore, with sulphate of lime, Birk ore bank, overlaid by sandstone, Laurel Furnace, Greenup county, Ky."*

A dense, dark colored limonite, with many fissures coated with sulphate of lime; powder of a dull spanish-brown color.

Specific gravity,		3.026
Composition, dried at 212° F.—		
Oxide of iron,	77.50	= 54.25 per cent. of *Iron*.
Alumina,	1.23	
Brown oxide of manganese,	1.03	
Phosphoric acid,	.40	
Lime,	.76	
Magnesia,	.79	
Sulphuric acid,	1.56	= .63 *Sulphur*.
Potash,	.20	
Soda,	.14	
Silica and insoluble silicates,	7.77	
Combined water,	9.62	
	101.00	

The air-dried ore lost 3 40 per cent. of *moisture*, at 212°.

The gypsum and sulphate of lime contained in the fissures of this ore is very likely to contaminate the product with sulphur, to a greater or less degree.

No. 433—LIMESTONE. *Labeled "Limestone used as a flux at Laurel Furnace, from Tygert's creek, Greenup county, Ky."*

A compact, light grey limestone; sparkling with small crystals of calcarious spar.

Specific gravity,		2.699
Composition, dried at 212° F.—		
Carbonate of lime,	97.90	= 54.93 per cent. of *Lime*.
Carbonate of magnesia,	.74	
Alumina, oxide of iron, and phosphates,	.53	
Potash,	.28	
Soda,	.08	
Silex and insoluble silicates,	1.27	
	100.80	

The air dried rock lost 0.30 per cent. of *moisture*, at 212° F.

No. 432—Ferruginous Lime-stone. *Labeled "Ferruginous Limestone, under the limestone ore, near the tops of the hills, waters of Old town creek, Laurel Furnace, Greenup county, Ky."*

A dark grey, fine granular rock; portions dull brownish and greenish; exterior surface ochreous; not adhering to the tongue; powder of a light grey color.

Specific gravity,		2.731
Composition, dried at 212° F.—		
Carbonate of iron,	22.19	= 11.82 per cent. of *Iron*.
Oxide of iron,	1.49	
Carbonate of lime,	50 33	
Carbonate of magnesia,	1.83	
Carbonate of manganese,	.47	
Alumina,	.77	
Phosphoric acid,	.77	
Sulphur,	.26	
Potash,	.38	
Soda,	.20	
Silex and insoluble silicates,	21 43	
	100.12	

The air-dried rock lost 0 30 per cent. of *moisture*, at 212°.

If it were not for the phosphoric acid and the sulphur present in this limestone, it might advantageously replace the preceding limestone as a flux in the high furnace. It is more fusible and contains a considerable per centage of iron.

No. 294—Mixed Carbonate and Oxide of Iron. *Labeled "Baker Bank Kidney Ore, near top of hills, Old-town creek, Laurel Furnace, Greenup county, Ky."*

Nodule in the interior of the mass dark grey carbonate of iron; scarcely adhering to the tongue; exterior irregular layers yellowish-brown and dark reddish-brown; adhering to the tongue; powder of the mixed specimen, dirty brownish-yellow.

Composition of the mixed mass, dried at 212° F—

Carbonate of iron,	54.42	= 47.51 per cent. of *Iron*.
Oxide of iron,	30.24	
Carbonate of lime,	.45	
Carbonate of magnesia,	.83	
Carbonate of manganese,	1.29	
Alumina,	1.86	
Phosphoric acid,	.43	
Sulphur,	.35	
Potash,	.38	
Soda,	.20	
Silex and insoluble silicates,	6.97	
Bituminous matter, water, and loss,	2 58	
	100.00	

The air-dried ore lost 0.60 per cent. of *moisture* at 212°.

This ore is as rich as is desirable for profitable smelting, requiring the addition of lime, and probably of some more silicious ore, to produce a proper amount of cinder.

No. 431—LIMONITE. *Labeled "Ore, partly roasted, from Laurel Furnace ore banks, Greenup county, Ky." (What is the white mineral?)*

A dark reddish-brown mineral, incrusted on the exterior and in the fissures with a whitish substance, which appears to be principally carbonate of lime; adhering strongly to the tongue; powder of chocolate-brown color; contains no protoxide of iron.

Composition, dried at 212° F.—

Oxide of iron,	74.50	= 52.17 per cent. of *Iron*.
Alumina,	1.00	
Brown oxide of manganese,	2.43	
Carbonate of lime,	.77	
Magnesia,	1.81	
Phosphoric acid,	.33	
Sulphur,	.57	
Potash,	.15	
Soda,	.13	
Combined water,	3.88	
Silex and insoluble silicates,	14 93	
	100.00	

The air-dried ore lost 1.70 per cent. of *moisture* at 212°.

No. 430—LIMONITE. *Labeled "Lower bed of ore used at Laurel Furnace, Greenup county, Ky."*

A concretionary limonite, with irregular cavities, varying, in layers, from dark-brown and compact to yellow and reddish soft mineral; powder of a dirty yellowish ochre color.

Composition, dried at 212° F.—

Oxide of iron,	38.38	= 26.87 per cent. of *Iron*.
Alumina,	3.54	
Brown oxide of manganese,	1.23	
Phosphoric acid,	1.01	
Sulphur,	.05	
Lime, a trace.		
Magnesia,	.60	
Potash,	.28	
Soda,	.18	
Silex and insoluble silicates,	46.83	
Combined water,	8.12	
	100.22	

The air-dried ore lost 1.50 per cent. of *moisture* at 212°.

The only drawback to the use of this highly silicious ore is in the considerable amount of phosphoric acid which it contains—rather more than one per cent.—which, if it passed mainly into the iron in smelting, as it generally does, unless an excess of lime is used in the flux, would contaminate it with nearly 1.76 per cent. of phosphorus, an ingredient which is always injurious to the strength of the iron, even in as small proportion as the half of one per cent.

Were it not for the phosphoric acid contained in it, this highly silicious ore might be very advantageously used in mixture with the richer ores of Laurel Furnace; but when pure and very tough iron is required such ores as this must be avoided, although the metal which they yield is yet applicable to many common uses.

No. 290—LIMONITE. (*Roasted.*) *Labeled "Kidney ore, showing a prismatic structure only after thorough roasting, Laurel Furnace, Greenup county, Ky."*

Powder dull brownish-red color; structure somewhat like that of starch; in irregular curved prisms; color chocolate-brown; adhering strongly to the tongue.

Composition, dried at 212° F.—

Oxide of iron,	80.03	= 56.02 per cent. of *Iron*.
Alumina,	1.44	
Brown oxide of manganese,	2.03	
Phosphoric acid,	.66	
Lime,	.64	
Magnesia,	2.87	
Potash,	.25	
Soda.	.16	
Silex and insoluble silicates,	9.93	
Combined water,	2.01	
	100.02	

The air-dried ore lost 0.80 per cent. of *moisture* at 212° F.

No sulphur was present in this specimen of roasted ore.

No. 291—LIMONITE. "*Labeled "Main Block Ore, near tops of hills, Old-town creek, Laurel Furnace, Greenup county, Ky.*"

A dark, reddish-brown ore, nearly black in parts; adheres slightly to the tongue; powder brownish-red.

Specific gravity, - - - - - - - - 3.018

Composition, dried at 212° F.—

Oxide of iron,	73.90	= 51.75 per cent. of *Iron*.
Alumina,	1.71	
Brown oxide of manganese,	1.13	
Phosphoric acid,	.62	
Sulphur,	.09	
Lime, a trace.		
Magnesia,	.39	
Potash,	.19	
Soda,	.05	
Silex and insoluble silicates,	10.43	
Combined water,	11.51	
	100.02	

The air-dried ore lost 1.90 per cent. of *moisture* at 212°.

No. 292—*Labeled "Kidney Ore, over the Ferruginous Limestone in the hills, Old-town creek, Laurel Furnace, Greenup county, Ky.*"

Color yellowish, reddish, and reddish-brown; containing nodules, irregular cavities, and layers of different degrees of hardness; adhering to the tongue; powder of a dull red color, or spanish-brown color.

Specific gravity,		3.406
Composition, dried at 212° F.—		
Oxide of iron,	81.40	= 57. per cent. of *Iron*.
Alumina,	.77	
Brown oxide of manganese,	1.63	
Phosphoric acid,	.24	
Sulphur,	.07	
Lime, a trace.		
Magnesia,	.35	
Potash,	.26	
Soda,	.22	
Silex and insoluble silicates,	8.33	
Combined water,	6.72	
Loss,	.01	
	100.00	

The air-dried ore lost 1.90 per cent. of *moisture* at 212°.

This appears to be the *purest* ore used at Laurel Furnace. It contains rather too small a proportion of the materials for the formation of cinder to be profitably smelted with lime alone. The addition of the ferruginous limestone, No. 432, would exactly supply this desideratum; but would, also, render the iron less pure, in consequence of the phosphorus and sulphur which it contains. The use of as large an excess of lime as can be worked, without making the cinder too pastey, is the best means of obviating this disadvantage.

No. 435—PIG-IRON. *Labeled "Medium textured Pig-iron, produced frequently at Laurel Furnace when pumice-form slag is formed, Greenup county, Ky. (Does it contain much sulphur?")*

A moderately fine-grained, grey, pig-iron, with brilliant grains; it flattens somewhat under the hammer, but soon crushes to powder; yields easily to the file.

Specific gravity,		7.009
Composition—		
Iron,	90.00	
Graphite,	1.77	Total carbon, 2.67 per cent.
Combined carbon,	.90	
Silicon,	4.28	
Slag,	1.15	
Aluminium,	.13	
Calcium,	.14	
Magnesium,	.21	

Potassium,	.17
Sodium,	.14
Phosphorus,	.61
Sulphur,	.12
Manganese,	.33
Loss,	.05
	100.00

No. 434—PIG-IRON. *Labeled "Soft, but not very strong tough pig-iron, produced at Laurel Furnace when making chiefly dark purple slag, Greenup county, Ky." (Does it contain much sulphur?)*

Somewhat coarser-grained, and a little lighter colored, than the preceding (No. 435;) breaks and crushes to powder quite easily under the hammer; yields readily to the file.

Specific gravity,	6.886	
Composition—		
Iron,	89.54	
Graphite,	1.87	Total carbon, 2.03 per cent.
Combined carbon,	.16	
Silicon,	5.57	
Slag,	1.25	
Aluminum,	.13	
Calcium,	.19	
Magnesium,	.20	
Potassium,	.17	
Sodium,	.11	
Phosphorus,	.46	
Sulphur,	.10	
Manganese,	.54	
	100.29	

These specimens of iron do not contain enough sulphur to cause any serious injury to the quality of the metal; the phosphorus, it is true, rather exceeds that proportion, but the principal cause of the want of strength observed in this product is in the large quantity of *silicon* which is found in it, especially in pig-iron No. 434, which appears to have been produced at a higher temperature in the furnace than No. 435. Whether this contamination, which results from the silicious nature of the ores used at Laurel Furnace, or from a too high temperature in the melting, may be prevented by the use of more limestone in the flux, cannot be positively stated, as none of the cinder produced at the furnace was sent to the laboratory for analysis. But

it is probable that more limestone could be advantageously added. The admixture of some *aluminous* ores, also, would doubtless improve the quality of the iron.

Difference of opinion has existed amongst writers on iron as to the influence exerted upon it by silicon. Whilst Berzelius and Stromeyer did not find it materially to injure the qualities of the iron, in their experiments, other observers, as Boussingault, Mushet, and Karsten, are positive in the assertion that its presence in considerable proportion—less than that in the above specimens from Laurel Furnace—makes the iron cold-short, or, in other words, diminishes its toughness at the ordinary temperature, whilst it also diminishes its specific gravity. Below the proportion of 0.40 per cent. it is believed to increase the firmness of the iron in the same manner as carbon, but above that proportion it acts on the qualities of this metal in the manner of phosphorus. Indeed, Mushet, who was a practical iron man, who experimented extensively on this metal, believes that the *cold-short* property of iron is generally owing to the presence of an excess of *silicon*.

No. 440—CARBONATE OF IRON. *Labeled "Grey ore, above the red ore, and next to the top-hill ore, Mount Savage Furnace, Greenup county, Ky."*

A light-grey, granular ore; on the exterior changed to yellowish and reddish brown; powder (of mixed portions of the interior and exterior,) of a light cinnamon color.

Composition, dried at 212° F.—

Carbonate of iron,	43.90	= 35.02 per cent. of *Iron*.
Oxide of iron,	23.06	
Carbonate of lime,	3.87	
Carbonate of magnesia,	3.28	
Carbonate of manganese,	.65	
Alumina,	.33	
Phosphoric acid,	.23	
Sulphur,	.18	
Potash,	.23	
Soda,	.23	
Silex and insoluble silicates,	22.15	
Combined water,	2.60	
	100.71	

The air-dried ore lost 0.70 per cent. of *moisture*, at 212° F.

No. 441—LIMONITE. *Labeled "Silicious? ore, Mount Savage Furnace, Greenup county, Ky."*

A dull, granular limonite; generally of a dark, brownish-red color; portions ochreous; containing a few minute scales of mica; adheres to the tongue; powder dull brownish-red.

Composition, dried at 212° F.—

Oxide of iron,	51.10	= 35.78 per cent. of *Iron*.
Alumina,	1.07	
Brown oxide of manganese,	1.83	
Phosphoric acid,	.76	
Sulphur,	.32	
Lime, a trace.		
Magnesia,	.68	
Potash,	.38	
Soda,	.10	
Silex and insoluble silicates,	35.93	
Combined water,	8.13	
	100.30	

The air-dried ore lost 1.60 per cent. of *moisture*, at 212° F.

No. 442—LIMONITE. *Labeled "Limestone ore, Mount Savage Furnace, Greenup county, Ky."*

A very dark-brown ore; made up of dense irregular layers, inclosing irregular cavities of various sizes; sometimes coated with ochreous; scarcely adhering to the tongue; powder yellowish-brown.

Composition, dried at 212° F.—

Oxide of iron,	83.83	= 58.70 per cent. of *Iron*.
Alumina,	.43	
Brown oxide of manganese,	1.73	
Phosphoric acid,	.94	
Sulphur,	.21	
Lime, only a trace.		
Magnesia,	.32	
Potash,	.30	
Soda,	.11	
Silex and insoluble silicates,	.83	
Combined water,	11.30	
	100.00	

The air-dried ore lost 0.70 per cent of *moisture*, at 212° F.

A remarkably pure limonite, containing scarcely anything but hydrated per-oxide of iron, although called limestone ore at the Furnace. As it contains scarcely any of the materials for the formation of cinder, it must be smelted together with other ores containing a larger proportion of earthy matters.

No. 443—CARBONATE OF IRON. *Labeled "Blue Block Ore, Mount Savage Furnace, Greenup county, Ky. (Lies lowest in the hills."*)

A dull dark-grey, fine granular rock, with a few specks of calcareous spar; scarcely adhering to the tongue; powder light-grey.

Specific gravity,	3.360	
Composition, dried at 212° F.—		
Carbonate of iron,	67.50	— 33.12 per cent. of *Iron*.
Oxide of iron,	1.28	
Carbonate of lime,	2.15	
Carbonate of magnesia,	4.57	
Carbonate of manganese,	1.18	
Alumina,	.35	
Phosphoric acid,	.36	
Sulphur,	.17	
Potash,	.29	
Soda,	.09	
Silica and insoluble silicates,	21.46	
Loss,	.61	
	100.00	

No. 444—MIXED LIMONITE. *Labeled "Kidney ore, top of the rough block ore, Mount Savage Furnace, Greenup county, Ky."*

A dull-grey, friable nucleus, enclosed in hard layers of blackish-brown limonite. Powder of the mixture of a yellowish-brown, or scotch-snuff color.

Composition, dried at 212° F.—		
Oxide of iron,	53.44	— 49.39 per cent. of *Iron*.
Carbonate of iron,	24.79	
Carbonate of lime,	.87	
Carbonate of magnesia,	.62	
Carbonate of manganese,	1.44	
Alumina,	.09	
Phosphoric acid,	1.26	
Sulphuric acid,	.11	
Potash,	.34	

Soda,	.08
Silex and insoluble silicates,	9.93
Combined water,	6.89
Loss,	.14
	100.00

The air-dried ore lost 1.00 per cent. of *moisture*, at 212° F.

Contains rather a larger proportion of phosphoric acid than is desirable, but otherwise, a very good ore.

No. 445—IMPURE CARBONATE OF IRON. *Labeled "Blue Limestone ore, deep in the bed, (with sulphur?,) Mount Savage Furnace, Greenup county, Ky."*

A dull, granular mineral; general color brownish-grey, with a greenish tint in portions, and in others presenting the appearance of pyrites; powder dark-greenish-grey.

Specific gravity,		3.567
Composition, dried at 212° F.—		
Carbonate of iron,	47.84	= 41.63 per cent. of *Iron*.
Sulphuret of iron,	31.60	= 11.51 per cent. of *Sulphur*.
Carbonate of lime,	3.25	
Carbonate of magnesia,	3.65	
Carbonate of manganese,	6.00	
Alumina,	.55	
Phosphoric acid, only a trace.		
Potash,	.34	
Soda,	.08	
Silica and insoluble silicates,	4.75	
Organic matter, water, and loss,	1.94	
	100.00	

The air-dried ore lost 0.30 per cent. of *moisture* at 212° F.

This ore contains entirely too much sulphur. A considerable proportion of it may, however, be removed by thorough roasting.

No. 446. LIMONITE. *Labeled "Best quality of 'rough block ore,' under the 'Kidney ore,' Mount Savage Furnace, Greenup county, Kentucky."*

A dense, very dark-brown limonite; not adhering to the tongue; exhibiting small cavities and minute spangles of mica; the curved

layers are covered with brownish-ochreous, soft, mineral; powder brownish-yellow.

Composition, dried at 212° F.—

Oxide of iron,	66.76 = 46.75 per cent. of *Iron*.
Alumina,	1.00
Brown oxide of manganese,	1.23
Phosphoric acid,	1.41
Sulphur, a trace.	
Lime, a trace.	
Magnesia,	.26
Potash,	.34
Soda, a trace.	
Silex and insoluble silicates,	17.87
Combined water,	11.59
	100.46

The air-dried ore lost 1.60 per cent. of *moisture*, at 212°.

Its proportion of phosphoric acid is considerable.

No. 422—LIMONITE. *Labeled "Roasted Kidney ore, rather sandy, Caroline Furnace, Greenup county, Ky."*

Composed of dark reddish-brown layers, enclosing a friable light reddish colored nucleus; adhering to the tongue; powder handsome spanish-brown color.

Composition, dried at 212° F.

Oxide of iron,	66.03 = 46.24 per cent of *Iron*.
Alumina,	4.15
Brown oxide of manganese,	.55
Lime, a trace.	
Magnesia,	.76
Phosphoric acid,	.67
Sulphur,	.06
Potash,	.46
Soda,	.11
Silex and insoluble silicates,	27.15
Combined water,	.71
	100.65

The air-dried ore lost 0.70 per cent. of *moisture* at 212°.

No. 423—IRON FURNACE SLAG. *Labeled "What is the heavy bluish granular material in this slag, from Caroline Furnace, Greenup county, Ky?"*

The granular, nearly opake portion is of steel bluish-grey and pinkish colors, contained in the purple glassy slag. Before the blow-pipe both kinds readily melt into a blebby white glass.

Composition—

	Granular.	*Oxygen.*	
Silica,	48.80		25.338
Lime,	33.27	9.461	
Alumina,	12.50	4.843	
Magnesia,	1.24	.495	
Protoxide of iron,	1.19	.265	
Protoxide of manganese,	.51	.115	
Potash,	1.62	.275	
Soda,	.18	.046	
	99.13	15.499 :	25.338
Oxygen in the bases to that in the silica as		1 :	1.63

Composition—

	Glassy.	*Oxygen.*	
Silica,	48.86		25.369
Lime,	33.05	9.398	
Alumina,	12.86	5.011	
Magnesia,	2.74	1.095	
Protoxide of iron,	1.13	.251	
Protoxide of manganese,	.51	.115	
Potash,	1.54	.262	
Soda,	.15	.038	
	100.85	16.169 :	25.369
Oxygen in the bases to that in the silica as		1 :	1.57

No marked difference of composition can be perceived by the analyses of these two varieties of cinder. The granular appearance and change of color were occasioned probably by some irregularity in the cooling of the slag. This cinder contains a larger proportion of lime than is necessary to form a bi-silicate—at least one-third more than is usually present in the Greenup Furnace slags. This *excess* of lime may exert a purifying influence on the iron produced from ores containing much sulphur, but does not increase the fusibility of the cinder.

No. 424—LIMONITE. *Labeled "Limestone Kidney ore, also associated with the four-feet Limestone, Caroline Furnace, Greenup county, Kentucky."*

Composed of dark brown curved layers, incrusted with dirty yellowish and whitish friable matter; powder of a brownish-buff color.

Composition, dried at 212° F.—

Oxide of iron,	63.60	= 44.54 per cent of *Iron*.
Alumina,	.25	
Brown oxide of manganese,	.55	
Phosphoric acid,	.70	
Sulphur,	.06	
Lime, a trace.		
Magnesia,	.99	
Potash,	.25	
Soda,	.05	
Silica and insoluble silicates,	23 23	
Combined water, and loss,	10.77	
	100.45	

The air-dried ore lost 1.30 per cent. of *moisture*, at 212° F.

No. 425—LIMONITE. *Labeled "Hydrated variety of Limestone ore, over the four-feet Limestone, Caroline Furnace, Greenup county, Kentucky."*

A dark-brown limonite, in dense layers, irregularly disposed, involving some small irregular cavities, and covered, in some parts, with a yellow-ochreous soft mineral; powder of a yellowish umber color; when calcined of a purplish-brown color.

Composition, dried at 212° F.—

Oxide of iron,	85.91	= 60.16 per cent. of *Iron*.
Alumina,	1.25	
Brown oxide of manganese,	2.17	
Phosphoric acid,	.09	
Carbonate of lime,	.17	
Magnesia,	.85	
Potash,	.23	
Soda,	.18	
Silex and insoluble silicates,	1.25	
Combined water,	7.90	
	100.00	

The air-dried ore lost 1.60 per cent of *moisture* at 212°.

A very pure iron ore, containing more than the usual proportion of oxide of manganese, and which must be mixed with poorer ores in order to be profitably fluxed in the furnace.

No. 426—FERRUGINOUS LIMESTONE. *Labeled "Bottom portion of Limestone Ore; not considered as good as the red; Caroline Furnace, Greenup county, Ky."*

Irregular portions of compact tawny-brown ferruginous limestone, showing some glimmering crystals of calcareous spar, with friable yellowish and whitish incrusting and included ochreous matter; powder of a grey-buff color; when calcined of a light umber color.

Composition, dried at 212° F.—

Oxide of iron,	25 80	= 18.06 per cent. of *Iron*.
Carbonate of lime,	65.13	= 36.55 per cent. of *Lime*.
Magnesia,	1.41	
Brown oxide of manganese,	.17	
Alumina,	.13	
Phosphoric acid,	.17	
Potash,	.11	
Soda,	.06	
Silex and insoluble silicates,	1.27	
Carbonic acid & combined water,	5.75	
	100.00	

The air-dried rock lost .60 per cent. of *moisture* at 212°.

This mineral may be profitably mixed with the richer silicious ores of this locality, for smelting, instead of the limestone generally used as a flux.

No. 427—FERRUGINOUS LIMESTONE. *Labeled "Four feet Limestone, under the Limestone Ore, Caroline Furnace, Greenup county, Kentucky."*

A fine grained limestone, glimmering with small plates of calcareous spar, and containing fossil remains; grey, with a portion of a light-grey buff color; powder light yellowish-grey.

Specific gravity,	2.729

Composition, dried at 212° F.—

Carbonate of lime,	84.47
Sulphate of lime,	.71
Carbonate of magnesia,	3.47
Carbonate of manganese,	.26
Carbonate of iron,	7.73
Oxide of iron,	1.77
Alumina,	.25
Phosphoric acid,	.62
Potash,	.32
Soda,	.14
Silex and insoluble silicates,	.55
	100.29

The air-dried rock lost 0.30 per cent. of *moisture* at 212° F.

No. 428—LIMONITE. *Labeled "Roasted Limestone Ore, Caroline Furnace, Greenup county, Ky."*

Interior of a purplish-brown color; exterior (incrustation) of a dirty light-red, including to pink; friable; adhering firmly to the tongue; powder of a handsome maroon color.

Composition, dried at 212° F.—

Oxide of iron,	84.45	= 59.14 per cent. of *Iron*.
Alumina,	1.20	
Brown oxide of manganese,	.09	
Phosphoric acid,	.38	
Sulphur,	.06	
Magnesia,	1.43	
Potash,	.44	
Soda,	.10	
Silica and insoluble silicates,	9.05	
Combined water and loss,	2.80	
	100.00	

The ore lost .90 per cent. of *moisture*, at 212°.

This specimen contains no appreciable quantity of lime.

No. 429—LIMONITE. *Labeled "Top-hill Kidney Ore, Caroline Furnace, Greenup county, Ky."*

Formed of irregular curved layers, inclosing cavities; interior of the layers dense and dark reddish-brown; exterior coating friable and yellow (ochreous;) powder of a rich brownish-yellow color; when calcined of a spanish-brown color.

Composition, dried at 212° F.—

Oxide of iron,	69.60	= 48.74 per cent. of *Iron*.
Alumina,	.55	
Brown oxide of manganese,	.75	
Phosphoric acid,	.42	
Sulphur,	.07	
Lime, a trace.		
Magnesia,	.35	
Potash,	.42	
Soda,	.01	
Silex and insoluble silicates,	15.65	
Combined water and loss,	12.18	
	100.00	

The air-dried ore lost 0.50 per cent. of *moisture*, at 212°.

A very good ore, requiring no other flux than limestone.

No. 299—LIMONITE. *Labeled "Good red-brown 'Limestone Ore,' under the four feet Limestone, Caroline Furnace, Greenup county, Kentucky."*

A dark, reddish-brown, dull, fine granular ore; glimmering with minute facets of spar; adhering to the tongue; powder of a light spanish-brown color; when calcined of a dark snuff color.

Composition, dried at 212° F.—

Oxide of iron,	53.46	= 37.44 per cent. of *Iron*.
Alumina, a trace.		
Brown oxide of manganese,	.85	
Phosphoric acid,	.87	
Sulphur,	.02	
Carbonate of lime,	33.85	= 19. per cent. of *Lime*.
Magnesia,	3.15	
Potash,	.23	
Soda,	.07	
Silex and insoluble silicates,	1.05	
Combined water and loss,	6.45	
	100.00	

The air-dried ore lost .80 per cent. of *moisture* at 212°.

This ore, which is rich enough in iron for profitable smelting, contains, like No. 426, an excess of lime and a deficiency of silica; this, however, contains twice as much iron as that. This ore could, no doubt, be advantageously used in mixture with the "Limestone Kidney Ore," No. 424, which is rich in *silica*, and contains no appreciable quantity of lime.

No. 300—Carbonate of Iron. *Labeled "Blue Limestone Ore" Caroline Furnace, Greenup county, Ky.*

A dark-grey, fine granular mineral; not adhering to the tongue; portions and fissures dirty yellowish and brownish; under the lens exhibits minute crystalline scales and specks of mica; some little white incrustation in the fissures; powder brownish-cinnamon color.

Specific gravity,		3.566
Composition, dried at 212° F.—		
Carbonate of iron,	60.40	= 43.82 per cent. of *Iron*.
Oxide of iron,	21.38	
Carbonate of lime,	3.17	
Carbonate of magnesia,	3.46	
Carbonate of manganese,	1.52	
Alumina,	.65	
Phosphoric acid,	.63	
Sulphur, a trace.		
Potash,	.40	
Soda,	.13	
Silex and insoluble silicates,	6.03	
Combined water and loss,	2.23	
	100.00	

The air-dried ore lost 1.00 per cent. of *moisture*, at 212°.

No. 436—Limonite. *Labeled "Red ore of Iron, divide between Tygerts and Kinch creeks, Kenton Furnace, Greenup county, Ky."*

A dull, friable, fine granular limonite, of a dark-purple-brown color, (like that of crocus martis); adhering to the tongue; powder of the same color; when calcined nearly black.

Composition, dried at 212° F.—		
Oxide of iron,	88.51	= 61.98 per cent. of *Iron*.
Alumina,	.15	
Brown oxide of manganese,	1.95	
Phosphoric acid,	.19	
Sulphur,	.03	
Lime, a trace.		
Magnesia,	.78	
Potash,	.09	
Soda,	.17	
Silex and insoluble silicates,	2.23	
Combined water,	6.00	
	109.10	

The air-dried ore lost 1.80 per cent. of *moisture*, at 212 F.

A pretty pure hydrated oxide of iron, requiring for smelting an admixture of the materials for the production of cinder.

No. 437—LIMONITE. *Labeled "Limestone Ore, near the head of Grassy creek, Kenton Furnace, Greenup county, Ky."*

A dull, dark-brown mineral, mixed with ochreous matter in the cavities and between the layers; powder of a light-clove-brown color.

Composition, dried at 212° F.—

Oxide of iron,	80.20	= 56.14 per cent. of *Iron*.
Alumina,	.47	
Brown oxide of manganese,	.05	
Phosphoric acid,	.86	
Magnesia,	.51	
Potash,	.48	
Soda,	.02	
Silex and insoluble silicates,	6.45	
Combined water, and loss,	11.31	
	100.35	

The air-dried ore lost 1. per cent. of *moisture* at 212° F.

Nearly as rich in iron as the preceding, and like that, containing in itself too small a proportion of earthy materials for the formation of a sufficient quantity of slag in the furnace.

No. 438—LIMONITE. *Labeled "Earthy variety of 'Block Ore,' Kenton Furnace, Greenup county, Ky."*

A dull, dark-brown ore, in curved layers, inclosing friable, brownish-yellow ochreous matter; powder dirty light-yellowish-brown.

Composition, dried at 212° F.—

Oxide of iron,	49.90	= 35.06 per cent. of *Iron*.
Alumina,	7.00	
Brown oxide of manganese	.27	
Phosphoric acid,	1.45	
Carbonate of lime,	8.05	
Magnesia,	4.19	
Potash,	.41	
Silex and insoluble silicates,	19.15	
Combined water,	9.61	
	100.03	

The air-dried ore lost 1.20 per cent of *moisture*, at 212° F.

This ore, with the only drawback of the considerable proportion of phosphoric acid which it contains, could be profitably smelted with the addition of a very little more lime, or could be employed to great advantage in mixture with the other richer ores of Kenton Furnace, to furnish the ingredients for the formation of cinder, in which they are deficient.

No. 439—LIMONITE. *Labeled "Black Limestone Ore; resting on the limestone, Kenton Furnace, Greenup county, Ky."*

Dull; almost black, with a slight reddish tint; showing a few minute glimmerings of spar; having a somewhat prismatic structure; adhering slightly to the tongue; powder dark brown, nearly black; calcined powder nearly black.

Composition, dried at 212° F.—

Oxide of iron,	73.34	= 51.36 per cent. of *Iron*.
Brown oxide of manganese,	9.41	
Alumina,	.27	
Phosphoric acid,	.36	
Carbonate of lime,	1.27	
Magnesia,	.83	
Potash,	.40	
Soda,	.03	
Silex and insoluble silicates,	4.55	
Combined water and loss,	9.54	
	100.00	

The air-dried ore lost 2.00 per cent. of *moisture* at 212° F.

This mineral owes its dark color, and its property of becoming darker on calcination, to the presence of a large proportion of oxide of manganese. This ingredient in the ore is generally supposed to cause the production of iron which is the best adapted to the manufacture of steel. The alloy of manganese with iron is believed to give it greater firmness and hardness; and the celebrated Swedish chemist, Berzelius, states that the best varieties of steel owe their good qualities partly to the manganese contained in them. It has been found, however, by the careful experiments of Karsten and others, that although the ores containing manganese are the best for the production of iron for making steel, yet some of the best specimens of cast-steel obtained from ores containing oxide of manganese, are destitute of this metal in any notable quantity.

In the smelting of manganesic iron ores there is a great tendency to the production of hard, brittle, *white* iron; not so much because the metal manganese, by its combination with the iron, communicates to it these qualities, but because the oxide of manganese, forming a very fusible slag with the silica in the high furnace, facilitates the reduction and fusion of the iron at a comparatively low temperature, and thus, incidentally prevents the separation of carbon in the form of graphite, which is necessary to the formation of soft grey iron. It thus favors the production of a *pure* hard metal, fitted for the manufacture of steel. Grey soft iron can, however, be produced from manganesic iron ores, either by increasing the heat in the furnace, or by the addition of earthy materials, to counteract the too great fluxing influence of the oxide of manganese, and make the cinder less fusible.

No. 101. (*See former report.*) *Main Ashland coal, above the Clay parting, Greenup county, Ky.*"

This coal, the proximate analysis of which is given on page 318 of the previous report, has been submitted to ultimate analysis. The result of four several operations is as follows, viz:

Composition, dried at 212° F.—

Carbon,	79.091
Hydrogen,	5.111
Sulphur,	.734
Ashes,	4.000
Oxygen, nitrogen, and loss,	11 064
	100.000

GRAYSON COUNTY.

No. 408—LIMONITE. *Labeled "Iron ore, ascending the table land between Cancy and Little Clifty creeks, Grayson county, Ky."*

A dull friable mineral; adhering to the tongue; presenting various shades of dull red and yellow, in irregular concentric layers; powder light yellowish-brown.

Composition, dried at 212° F.—

Oxide of iron,	63.60 = 44.54 per cent. of *Iron*.
Alumina,	2.36
Brown oxide of manganese,	.87
Phosphoric acid,	.89
Carbonate of lime,	.27
Magnesia,	1.22

Potash,	.25
Silica and insoluble silicates,	19.15
Combined water,	12.02
	100.63

The air-dried ore lost 1.00 per cent. of *moisture*, at 212° F.

No. 456—MAGNESIAN LIMESTONE. *Labeled "Hydraulic Limestone, two miles west of Grayson Springs. (Used for grave stones.")*

A dull, fine granular, light-grey limestone, with a slight tint of greenish; exhibiting a few minute spangles of mica; adhering slightly to the tongue.

Specific gravity,	2.651
Composition, dried at 212° F.—	
Carbonate of lime,	46.83 = 26.28 *Lime.*
Carbonate of magnesia,	26.84 = 12.96 *Magnesia.*
Carbonate of iron,	3.44
Brown oxide of manganese, a trace.	
Alumina,	.38
Phosphoric acid,	.12
Sulphuric acid,	.33
Potash,	.50
Soda,	.37
Silica and insoluble silicates,	20.78
Loss,	.41
	100.00

The air-dried rock lost 0.50 per cent. of *moisture* at 212°.

The hydraulic properties of this limestone were not tried at the laboratory.

HANCOCK COUNTY.

No. 468—COAL. *Labeled "First bed above the Hawesville main coal, under fossiliferous shale, Hancock county, Ky."*

A jet-black coal; specimen tarnished on the surface as though it had been exposed to the weather; seperates in thin layers, which show some fibrous coal on their surfaces, but no pyrites.

Specific gravity,	1.282

Heated over the spirit-lamp it did not decrepitate; softened and swelled somewhat, but the fragments did not agglutinate; burnt with a smokey flame, leaving a somewhat cellular coke; a splint coal.

Proximate Analysis.

Moisture,	6.50	Total volatile matters,	41.40
Volatile combustible matters,	34.90		
Carbon in the coke,	53.20	Dense coke,	58.60
Ashes, (grey-purple,)	5 40		
	100.00		100.00

The per centage of *sulphur* in the undried coal is 0 47.

The composition of the ashes is as follows:

Silica,	1.38
Alumina, oxide of iron, &c.,	2.78
Lime,	.38
Magnesia,	.17
Loss,	.69
	5.40

The *ultimate* composition of this coal, dried at 212°, was found to be as follows:

Carbon,	73.255
Hydrogen,	5.155
Sulphur,	.520
Ashes,	5 600
Oxygen, nitrogen, and loss,	15 470
	100.000

Like the splint-coals in general, or the so-called *dry* coals, this contains a considerable proportion of oxygen in its composition. The proportion of the nitrogen was not ascertained, but it rarely exceeds two per cent. in coals.

No. 519—Coal. *Labeled "Thirty-three inch coal, fifteen feet below the surface, in Judge Mayhall's shaft, Hancock county, Ky."*

A compact coal, having somewhat the appearance of jet; breaking with a conchoidal fracture in the direction of the layers; not soiling the fingers; some appearance of pyrites, but no fibrous coal. Heated over the spirit-lamp it softened, swelled up, and agglutinated somewhat, and left a spongey coke.

Specific gravity, 1.392

Proximate Analysis.

Moisture,	3 00	Total volatile matters,	42.10
Volatile combustible matters,	39.10		

Carbon in the coke, - -	45 40	Bright, inflated coke, -	57.90
Ashes, (purple-grey,) - -	12 50		
	100.00		100.00

The ashes were found to consist of

Silica, - - - - - - - - - - - -	2.99
Alumina, oxide of iron, &c., - - - - - - - -	9 23
Magnesia, - - - - - - - - - -	.24
Trace of lime and loss, - - - - - - - - -	.04
	12.50

As the ashes contain but a very small proportion of magnesia, and only a trace of lime, they will require quite a high temperature to fuse them into clinker.

Submitted to *ultimate analysis* this coal gave the following results, dried at 212° F., viz:

Carbon, - - - - - - - - - - - -	63 436
Hydrogen, - - - - - - - - - - - -	4 622
Sulphur, - - - - - - - - - - - -	5 866
Ashes, - - - - - - - - - - - -	13.600
Oxygen, nitrogen, and loss, - - - - - - - - -	12 476
	100.000

The large proportion of sulphur and of earthy matter in this coal are serious drawbacks on its value. It is probable, however, that the coal may vary as to both these ingredients in other parts of the bed.

No. 520—Coal. *Labeled "Out-crop of coal on Mr. Pate's land, one and a half miles north-west of the house, on the Hardinsburg road, Hancock county, Ky."*

A dull looking, very friable coal, presenting the appearance of having been much weathered; surfaces and seams covered with ochreous incrustation; some fibrous coal between the layers, but no appearance of pyrites. Over the spirit-lamp it swelled up somewhat, burnt with a smokey flame, but the fragments did not agglutinate; probably not a coking coal.

Specific gravity, - - - - - - - -	1.266		
Proximate Analysis.			
Moisture, - - - -	6 30	Total volatile matters,	46.10
Volatile combustible matters, -	39.80		

Carbon in the coke, - -	51.40	Dense coke, - -	53.90
Ashes, (red-brown,) - -	2.50		
	100.00		100.00

The analysis of the ashes is as follows:

Silica, - - - - - - - - - - - -	0.49
Alumina, oxide of iron, &c., - - - - - - - -	1.70
Lime, - - - - - - - - - - - -	.30
Magnesia, - - - - - - - - - - -	.10
	2.59

The ultimate composition of this coal was found to be as follows, dried at 212° F:

Carbon, - - - - - - - - - - -	75 328
Hydrogen, - - - - - - - - - - -	5.600
Sulphur, - - - - - - - - - - -	.890
Ashes, - - - - - - - - - - - -	2.300
Oxygen, nitrogen, and loss, - - - - - - - -	15.882
	100.000

No. 213—Coal. *Labeled "Breckinridge Cannel Coal, Hancock county, Ky."*

This interesting coal, of which the results of some proximate analyses by Dr. Owen, are given on page 177 of his former report, has been submitted to new examinations in this laboratory. Dull black, with a satiny lustre on the cross fracture; very tough, breaking with great difficulty; cleaving into thin layers; does not soil the fingers; considerable appearance of fine particles of pyrites, but no fibrous coal between the layers. Over the spirit-lamp burns with a yellow smoky flame; the fragments soften a little, but do not swell, alter their form much, nor agglutinate; powder brownish black.

Specific gravity, - - - - - - - - -	1.318

On repeating the proximate analysis of this coal the following results were obtained, viz:

Moisture, - - - -	1.30	Total volatile matter,	55.70
Volatile combustible matters, -	54 40		
Carbon in the coke, - -	32.00	Scarcely coherent coke,	44.30
Ashes, (umber colored,) -	12.30		
	100.00		100.00

On examining different portions of the mass, a large piece about five inches thick, which had been sent for analysis, a considerable difference as to the proportion of ashes, &c., was found to exist—for example: the proportion of *total volatile matters* was found to vary from 55.70 to as high as 71.70 per cent.; of *coke* from 28.30 to 44.30; and of *ashes* from 7. to 12.30 per cent, in the undried coal.

The per centage of sulphur ascertained on one specimen was 2.443 in the air-dried coal.

The composition of the ashes is as follows:

Silica,	3.49
Alumina and oxide of iron,	7 78
Lime,	.55
Magnesia,	.39
	12.21

By *ultimate* analysis this coal was found to contain

Carbon,	68.128
Hydrogen,	6.489
Sulphur,	2 476
Nitrogen,	2.274
Oxygen and loss,	5.833
Ashes,	14 800
	100.000

It will be seen, on making the comparison, that this coal contains a larger proportion of hydrogen and less oxygen than any other of the Kentucky coals hitherto examined. The only other coal which approaches it in this respect is the cannel coal from Haddock's mine, Owsley county, (which see,) which resembles it also in yielding, by destructive distillation, a notable quantity of oils and wax-like matter. There are few coals in the world, so far as yet reported in the journals and works of science, which equal these coals in these characteristics. One of the most noted of these is the Bogbead Cannel Coal of Scotland, used extensively for the production of Benzole, illuminating and lubricating oils, and *Paraffine;* of which, for the sake of comparison, we append the *ultimate* composition, as quoted in Liebig and Kopps *Jahresbericht* for 1851, S. 733, from Russell's analysis:

Ultimate Composition of the Boghead Coal, of Scotland.

Carbon,	65 34
Hydrogen,	9.12
Sulphur,	0.15
Nitrogen,	0 71
Oxygen,	5 46
Ashes,	18 68
	99 46

While the Boghead coal contains a larger proportion of ashes than the Breckinridge coal, the latter contains a much larger quantity of both *sulphur* and *nitrogen*. The Boghead coal also excels this greatly in its proportion of hydrogen to the carbon, approaching thus more nearly than that to the nature of the bitumens. Indeed, the question has been mooted in Europe whether this and similar minerals are stone coals or real *bitumens;* and Geuther* has decided, from the nature of the products of distillation, and of the ashes of the Boghead coal, as well as by its microscopic analysis, that it is simply a bituminous shale or slate.

Abstracting the ashes and sulphur, the composition of the Breckinridge and Boghead coals compare as follows:

	Breckinridge Coal.	*Boghead Coal.*
Carbon,	82 355	80.487
Hydrogen,	7.844	11 235
Nitrogen,	2 749	.874
Oxygen,	7.051	6 726

By means of the tables which will be appended to the end of this report, a comparison of the composition of the Kentucky coals can be made.

Eight different trials were made of the distillation of the Breckinridge coal for the production of oils, &c. The operation was generally performed in an iron retort, gradually heated to a moderate red-heat; the products were collected by means of a series of receivers and a graduated bell glass over water to measure the gas obtained. The first receiver was usually kept at a temperature of from 260° to 285° F., by means of a chloride of calcium bath; the second receiver was kept in boiling water; the third was simply exposed to the ordinary temperature of the room, and the last was enveloped with ice, or a mix-

*Liebig and Kopp's Jahrenberieht for 1855. S. 896.

ture of ice and salt; the gas, before it was collected, was generally passed through potash, or wash bottles containing Hydrochloric acid, solution of Arsenious acid, and basic acetate of lead, severally. Under these circumstances it was found that a slow gradual application of the heat favored the production of the oily products, and diminished the relative amount of gas.

The first receiver contained a dark-brown tarry product, which became a soft solid on cooling; the second and third receivers contained thinner oils of a light brown color, floating on a strong ammoniacal water, which contained much sulphuret of ammonium, and some little sulphocyanide of ammonium; whilst the last receiver, which was cooled with ice, condensed a clear light-yellow volatile oil—principally Benzole—and besides ammoniacal water, contained limped crystals of bi-carbonate of ammonia. The arsenical and lead solutions showed the presence of abundance of sulphuretted hydrogen, and considerable carbonic acid; and the gas collected had pretty high illuminating powers.

Examined by Dr. Ellett's process—by the action of Bromine vapor—some of the gas was found to contain as much as 9. per cent. of olefiant gas and hydrocarbon vapors.

The products which were separated by this process of *fractional distillation* were not so pure as to induce us to recommend it to the manufacturer on a large scale, for the reason, probably, that some of the more fixed oils were carried forward into the latter receivers in the series, by the mechanical action of the gas, which was continually passing through them; yet the use of a series of receivers may facilitate the subsequent processes for purification. The clear, bright-yellowish, thin, oily matter which passed into the fourth receiver, became gradually brownish after exposure for a few days to the light, after the manner of imperfectly purified Benzole. These products have not as yet been analyzed to ascertain the relative proportions of *Paraffine, Eupione, Benzole, &c., &c.;* they are, indeed, of a very complex nature, containing, besides several neutral hydrocarbons, a number of organic bases and acids. When collected together in one cooled receiver they appear as a fluid dark-colored *"crude oil."*

This "crude oil," which is produced at the Breckinridge coal and oil company's works, near Cloverport, in the quantity of about 6,000 gallons per week, is manufactured by distillation and purification into

various commercial products: as, the *Benzole*, which, from its volatility and combustibility, is employed, mixed with alcohol, as a burning fluid, or used in the form of vapor as a substitute for common illuminating gas; *Naptha* employed as a solvent for Caoutchouc, Gutta Percha, &c.; *illuminating and lubricating oils* as good for these purposes as spermaceti oil; *Paraffin*, a substance resembling sperm ceti, obtained from the coal in the proportion of only about one per cent., used for burning in the form of candles, and for giving a finish to some kind of leather; and a residuary black substance used as asphaltum.

This new manufacture, in view of the increasing scarcity of spermaceti oil, is of very great value to the whole country, and will probably be expanded to a great extent.

It has generally been believed that no other than the Breckinridge Cannel Coal could be profitably used, in this country, for this purpose; but, doubtless, amongst the Cannel Coals and Bituminous Schists of our state, some may be found which may exceed the Haddock's Cannel Coal, and equal the Breckinridge coal in this particular.

To ascertain whether the proportion of the oily products might be increased by the use of sur-heated steam, instead of simple dry-heat applied to the coal, an apparatus for the purpose was constructed. The coal, introduced in a semi-cylindrical tray, into a tubular iron retort, was subjected to the action of steam, which had passed through tubes kept heated in the fire—receivers being attached, as above described. The results obtained did not, however, show any great advantage of this over the simple application of heat to the retort containing this coal. It was, indeed, somewhat difficult to regulate the heat of the tubes, and thus it is probable the steam was used at too high a temperature in the experiments. The results of the eight operations, as far as noted, are as follows, calculated to 1,000 grains of the undried coal:

Experiments.	Crude oil	Ammoniacal water	Coke.	Gas.	Weight of gas, and loss.
1st, - - -	314.10	66.10	468.7	465. cubic inches,	131.1 grains.
2nd, coal dried at 600°,	290.00	43.50	470.	425. cubic inches,	196.5
3rd, - - - - -	400.		460.	—	140.
4th, - - - - -	—	—	450.	—	—
5th, very slow, - -	348.80	37.50	471.	—	142.7
6th, - - -	300.	61.90	417.	—	201.2
7th, with steam, - -	427.5		412.	—	160.5
8th, - - - - -	—	—	464.	—	—
Average, - -	318.2	52.10	455.	445.	161.8

This average yield of crude oil corresponds nearly with that given by Dr. Owen in his former report, as the result of his experiments, and verifies the extraordinary fact that this singular coal, when submitted to slow distillation below a bright-red heat, will give almost one-third of its weight of *oily matters*, besides yielding more than 45. per cent. of *coke*, and good illuminating gas in the proportion of nearly two cubic feet to the avoirdupois pound. It will be sufficiently near the results obtained to sum up the per centage of the products of the Breckinridge coal as follows:

Crude oil, - -	32.	per cent.
Ammoniacal water, -	5.5	per cent.
Coke, - - -	45.5	
Gas and loss, -	17.	equal to 2227. cubic inches to the pound avoirdupois.
	100.0	

In consequence of the large proportion of nitrogen in this coal the ammoniacal liquor is unusually strong, and might be used to yield ammonia and its salts; it also contains much sulphur, of which the coal has a very large amount. The gas which is produced, therefore, has a large admixture of sulphuretted hydrogen, and, if used for illuminating purposes, must be purified with more than the usual care from this injurious and offensive ingredient. But when the object of the manufacturer is simply to obtain the oily products and the *paraffine*, the gas produced in the operation might be economically used under the retorts, or in the processes of re-distillation and purification of these products.

As stated above, the only Kentucky coal hitherto examined, which resembles the Breckinridge in its composition, (particularly in its pro-

portion of hydrogen,) and its yield of oily products on distillation, is the cannel coal from Haddock's mine, Kentucky river.

The other coals which were submitted to distillation did not yield enough of fluid matter to make them at all valuable for this purpose.

Under this head, for convenience of reference, I will give the comparative results obtained from the several coals examined, including a good specimen of Pennsylvania coal, (Youghiogheny coal,) used by the Lexington gas company as the best adapted to their purposes.

Coals.	Crude oils	Ammoniacal water.	Coke.	Gas, (cubic inches)
Breckinridge cannel, - - -	31·20	52.10	455.	445 good.
Haddock's cannel, - - -	248.50	51 50	589	370. very good.
Union Company's coal, bottom part,	148.	38.	750.	465. very good.
Mulford's five-foot, or Main coal, -	136 50	64 75	684.	567. very good.
Robert's, or Muddy river coal, -	102.10	119.80	659.50	570. good.
Ice house coal, - - -	108.	7.1.	714.	465. very good.
Youghiogheny coal, - - -	136.	52.	710.	545. very good.

These results are calculated to 1,000 grains of each of the coals in the air-dried condition.

The low temperature at which the distillation was carried on is unfavorable to the production of much gas, as is proved by the fact, that in the ordinary course of the manufacture of illuminating gas, from the Youghiogheny coal, fully twice as much is obtained from it as was procured in our slower process. But as all these coals were submitted, as nearly as possible, to the same temperature, in the above described experiments, it is believed that the relative proportions and quality of the gas obtained from them would hold good also under conditions of heat more favorable for the formation of gaseous products. If this be true, the Mulford's main coal, and the Ice-house coal, and Union Company's coal, will prove to be as good, or nearly as good, for gas and coke as the best Pennsylvania bituminous coal; but with the drawback that they contain a larger proportion of sulphur. For the composition of these several coals we refer to their descriptions under their appropriate counties.

HOPKINS COUNTY.

No. 463—Coal. *Labeled "Hull's coal, Clear creek, Hopkins county, Kentucky."*

A shining pitch-black coal; not very hard; dividing into thin layers separated by fibrous coal, on which there were some microscopical

appearance of pyrites. Over the spirit-lamp it softened and swelled up a good deal, and the fragments became agglutinated into a light cellular coke. Probably a coking coal.

Specific gravity, - - - - - - - - -	1.277		
Proximate Analysis.			
Moisture, - - - - -	3.20	Total volatile matters, -	38.60
Volatile combustible matters, -	35.40		
Carbon in the coke, - -	57.80	Inflated coke, - -	61.40
Ashes, (reddish-grey,) - -	3.60		
	100.00		100.00

The composition of the ashes is as follows:

Silica, - - - - - - - - - - - - -	1.59
Alumina and oxide of iron, - - - - - - - -	1.58
Lime, a trace.	
Magnesia, - - - - - - - - - - - -	.10
Loss, - - - - - - - - - - - - -	.33
	3.60

The coal, on *ultimate analysis*, dried at 212°, was found to contain

Carbon, - - - - - - - - - - - -	75.491
Hydrogen, - - - - - - - - - - - -	5.088
Sulphur, - - - - - - - - - - - -	1.520
Oxygen, nitrogen, and loss, - - - - - - - -	14.101
Ashes, - - - - - - - - - - - -	3.800
	100.000

This appears to be quite a good coal, with a small proportion of ashes, containing, however, a rather more than an average quantity of sulphur.

No. 465—Coal. *Labeled "Mr. Samuel's coal, two and a half feet thick, Hopkins county, Ky."*

A dull looking coal, with the appearance of having been weathered; separating easily into thin layers; oxide of iron, as from decomposed pyrites, on the surfaces of the seams. Over the spirit-lamp it decrepitates, and burns with a smokey flame; some of the fragments soften and swell a little, but most of them retain their original form; coke easily burnt to ashes; a splint coal.

Specific gravity, - - - - - - - - -	1.422		
Proximate Analysis.			
Moisture, - - - - -	5.00	Total volatile matters, -	33.40
Volatile combustible matters, -	28.40		

Carbon in the coke,	53.50	Coke, (not adherent,)	66.60
Ashes, (reddish-grey,)	13.10		
	100.00		100.00

The ashes were found to be composed of

Silica,	7.19
Alumina and oxide of iron,	5.68
Lime,	.05
Magnesia,	.06
Loss,	.12
	13.10

The *ultimate composition* of this coal, dried at 212°, is as follows:

Carbon,	66.000
Hydrogen,	4.244
Sulphur,	.820
Oxygen, nitrogen, and loss,	13.436
Ashes,	15.500
	100 000

The large proportion of earthy matter in this coal considerably diminishes its value; but, as the ashes contain but very small quantities of lime and magnesia, they will not be likely to fuse into clinker, except at an exceedingly high temperature. The specimen examined appeared to have been taken from the *out-crop* of the coal; it is possible that the interior portion may be more pure, although it is likely to contain rather more sulphur.

No. 135—Coal. *Labeled "Wright's Mountain Coal, Townes and Kirkwell, Hopkins county, Ky."*

This coal, of which the description and proximate analysis are given on page 339 of the former report, has been submitted to *ultimate analysis* with the following results, viz:

Carbon,	77.400
Hydrogen,	4.999
Sulphur,	*1 060
Nitrogen,	1.620
Oxygen and loss,	12.521
Ashes,	2.400
	100.000

*Erroneously printed in the former report 0.106.

JEFFERSON COUNTY.

No. 521—Hydraulic Limestone (Unburnt.) *"From the Falls of the Ohio river at Louisville, Jefferson county, Ky."*

A greenish-grey, dull, fine granular limestone; adheres slightly to the tongue; powder light-grey.

Composition, dried at 212° F.—

Carbonate of lime,		50.43 = 28.29 *Lime.*	
Carbonate of magnesia,		18.67 = 8.89 *Magnesia.*	
Alumina, and oxides of iron and manganese,		2.93	
Phosphoric acid,		.06	
Sulphuric acid,		1.58	
Potash,		.32	
Soda,		.13	
Silica and insoluble silicates,		25.78	Silica, 22.53; Alumina colored with oxide of iron, 2.88; Lime, magnesia & loss, .32 = 25.78
Loss,		.10	
		100.00	

The air-dried rock lost .70 per cent. of *moisture*, at 212° F.

The analysis of this well-known water-lime will serve for comparison with that of other limestones supposed to possess *hydraulic* qualities.

No. 522—Soil. *Labeled "Virgin Soil, from E. B. O'Bannon's farm, O'Bannon's station, overlying cellular magnesian limestone, of the Upper Silurian Formation, twelve miles from Louisville, Jefferson county, Ky."*

Dried soil of a grey-brown color; some small rounded particles of iron ore noticed in it. As this and the following soils were received just before this report was made up there was not time for digestion in water containing carbonic acid, to ascertain the relative amount of matters soluble in that menstruum; they were therefore submitted to ordinary analysis, dried at 370 F.

The composition of this soil is as follows:

Organic and volatile matters,	7.996
Alumina, and oxides of iron and manganese,	7.480
Carbonate of lime,	.394
Magnesia,	.240
Phosphoric acid,	.205
Sulphuric acid,	.082
Potash,	.200
Soda,	.043
Sand and insoluble silicates,	83.134
Loss,	.226
	100.000

The air-dried soil lost 4.42 per cent. of *moisture* at 370°.

No. 523—Soil. *Labeled "Soil from an old field, over cellular magnesian limestone of the Upper Silurian Formation, which lies from six to twelve feet beneath the surface. Has been from twenty-five to thirty years in cultivation; E. B. O'Bannon's farm. (Would it be a good soil for the cultivation of the grape?)"*

Color of the dried soil light greyish-brown; lighter than the preceding.

Composition, dried at 400° F.—

Organic and volatile matters,	4.506
Alumina, and oxides of iron and manganese,	6.240
Carbonate of lime,	.316
Magnesia,	.200
Phosphoric acid,	.191
Sulphuric acid,	.067
Potash,	.158
Soda,	.070
Sand and insoluble silicates,	88.313
	100.000

The air-dried soil lost 2.80 per cent. of *moisture*, at 400° F.

By comparison of the two preceding analyses it will be seen what the soil, which has been in cultivation for twenty-five to thirty years, has lost of its original value: *First.* It has lost *organic and volatile matters*, which is evinced also in its lighter color, and in the smaller quantity of *moisture* which it is capable of holding at the ordinary temperature, but which was driven off at the heat of 400°. These organic matters absorb and retain moisture with great power. Besides the nourishment which organic matters in the soil give directly to veg-

etables, by their gradual decomposition and change, these substances also greatly increase the solubility of the earthy and saline ingredients in the soil, which are necessary to vegetable growth. *Second.* It has lost *some of every mineral ingredient of the soil which enters into the vegetable composition:* as lime, magnesia, oxide of iron, phosphoric acid, sulphur, and the alkalies. The only apparent exception to this is in the greater proportion of soda in the old soil than in the virgin soil. This increase may have been occasioned by the ordinary free use of salt on the farm, and its transfer to the cultivated field by the animals feeding on it. It will be seen, in the *third* place, that the proportion of *alumina and oxide of iron* to the *sand and silicates* is smaller in the soil of the old field than in the virgin soil, cultivation having, perhaps, favored the washing down into the sub-soil those ingredients which are the most readily transported by water. To renovate this field to its original state would require the application of ordinary barn-yard manure, which contains all the ingredients which have been removed from it except the *alumina, and oxides of iron and manganese.* To supply these, if it be deemed desirable, the *red sub-soil found on the washed slopes* of the old field, presently to be described, would answer very well, applied as a top dressing; but the immediate sub-soil, next to be described, does not, by its analysis, promise to be of any service in this or in any other respect.

Would this be a good soil for the cultivation of the grape? If it has sufficient drainage to prevent the habitual lodgement of water in the sub-soil, there is nothing in the composition of the soil to forbid its use for this purpose. The soil which will produce good indian corn will generally produce the grape. The vine requires for its growth, and the production of its fruit, precisely the same mineral ingredients which are necessary to every other crop which may be produced on the soil, differing in this respect from them only in the proportion of these several ingredients. The juice of the grape contains a considerable proportion of *potash*, much of which is deposited in the wine-cask, after fermentation, in the form of tartar, (acid tartrate of potash,) and which must be supplied to the growing vine from the soil to enable it to produce the grape. It has hence been generally believed that vineyard culture tends speedily to exhaust the soil of its alkalies, unless they are habitually re-applied in manures. This is true in regard to every *green* crop which is carried off the ground: as hay, turnips, potatoes,

and especially tobacco, and the fruits of the orchard; whilst the indian corn and other grains carry off less of the alkalies they also require and remove them in considerable proportion; and Boussingault, of France, has arrived at the conclusion, from his experiments on his vineyard of 170 acres, in Alsace, that the grape does not remove any more of the valuable mineral substances from the soil, annually, than the ordinary grain and root crops.

The following tabular view of his results, from an equal surface of ground to each crop, is given in Liebig and Kopp's *Jahresbericht fur* 1850.

Removed by—		Potash.	Soda.	Lime.	Magnesia	Phospho-ric acid	Sulphuric acid.
The vine.	Wine,	11 53	0.13	17.48	3 91	6.66	1 02
	Husks,	12.07	0.13	3.50	0.72	3.50	1.77
	Small wood,	4 64	–	0.51	0 95	2.27	0 53
Total,		28.24	0.26	21.49	5.58	12 43	3.32
Potatoes,		107 1		–	–	23.8	–
Beets,		153 0		–	–	20 4	–
Wheat with straw,		45.9		–	–	323.0	–

The leaves of the vine were not taken into the estimation, because they fall and decay on the soil.

The quantity of grape-juice produced, per acre, is greater in this county than that obtained in the vineyards of France, but in the above figures, if they are to be taken as correct data, there is a wide margin for increase. The great reputation of Boussingault as an accurate analyst and observer must be the guarantee of their correctness. In corroboration of those facts are the more recent analyses, by Berthier, of the fruit and wine, stems, and leaves of the vine, showing that the great demand made upon the soil for alkali is not so much for the *grapes*, but for growth of the *wood* and the *leaves*, so that, if these are not removed, the crop does not prove inordinately exhaustive.

To return to the two comparative soil analyses. The difference between the proportions, of the valuable ingredients of the two above stated, may seem quite unimportant on a superficial examination, but when we apply these differences to the more than *three millions of pounds of soil* which are contained in an acre of ground, calculated only to the depth of one foot, we may see their significance. Thus the

the *potash* in the virgin soil is in proportion of 0.200 per cent., and in the soil of the *old field* in that of 0.158. This proportion gives *six thousand pounds* of pota-h to the acre of earth, one foot deep, in the *new soil*, and *four thousand seven hundred and forty pounds* only into the *old*, showing. that if the old soil was originally like the neighboring virgin soil, it has lost, amongst other ingredients, as much as one thousand two hundred and sixty pounds of pota-h from the acre, within one foot of the surface only. To restore to it this amount of alkali alone would require the application of a large amount of ordinary manure.

No. 524—SUB-SOIL. *Labeled "Sub-soil, seven to twelve inches under the surface, old field twenty-five to thirty years in cultivation, over cellular magnesian limestone of the Lower Silurian Formation, E. B. O'Bannon's farm, Jefferson county, Ky."*

Color of the dried soil light greyish-brown.

Composition, dried at 400° F.—

Organic and volatile matters,	2 844
Alumina, and oxides of iron and manganese,	6 335
Carbonate of lime,	.256
Magnesia,	.226
Phosphoric acid,	.099
Sulphuric acid,	.082
Potash,	.181
Soda,	.023
Sand and insoluble silicates,	89 900
Loss,	.049
	100.000

The air-dried sub-soil lost 2.98 per cent of *moisture* at 400° F.

By the examination of this upper sub-soil it does not appear that any of the valuable ingredients of the surface-soil have lodged in it. It contains, it is true, more *potash*, and has less organic matter, but in other respects does not materially differ from the upper soil. A greater difference may be seen in the *deeper* sub-soil, the analysis of which will next be given.

No. 525—SUB-SOIL. *Labeled "Red sub-soil, on the washed slopes of an old field, found almost universally a few feet under the surface, E. B. O'Bannon's farm, Jefferson county, Ky."*

Color of the dried soil light brick-red; it contains some small nodules of iron ore.

Composition, dried at 400° F.—

Organic and volatile matters,	3.112
Alumina, and oxides of iron and manganese,	17.020
Carbonate of lime,	.194
Magnesia,	.366
Phosphoric acid,	.497
Sulphuric acid,	.088
Potash,	.297
Soda,	.111
Sand and insoluble silicates,	77.434
Loss,	.881
	100.000

The air-dried *sub-soil* lost 3.60 per cent. of *moisture*, at 400° F.

No. 526—Soil. *Labeled "Soil from a poor point of old field, where gravel iron ore prevails, E. B. O'Bannon's farm, Jefferson county, Ky."*

Color of the dried soil rather lighter than that of the preceding; soft pebbles of iron ore, very dark in appearance when broken.

Composition, dried at 380° F.—

Organic and volatile matters,	4.390
Alumina, and oxides of iron and manganese,	11.840
Carbonate of lime,	.236
Magnesia,	.216
Phosphoric acid,	.126
Sulphuric acid,	.109
Potash,	.239
Soda,	.043
Sand and insoluble silicates,	82.694
Loss,	.458
	100.000

The air-dried soil lost 3.94 per cent. of *moisture* at 380° F.

The cause of the unproductiveness of this soil lies more in the *state of aggregation* than the composition, as shown by the chemical analysis. The valuable ingredients necessary to vegetable growth are contained in it in at least as large proportions as in the earth from the other portions of the field; but in this there is doubtless a *larger quantity of them locked up in the pebbles of so-called iron ore*, which the fibres

of the vegetable roots cannot penetrate. If, by any means, these were to be disintegrated or pulverised, the soil would doubtless be rendered more fertile. Doubtless if these several soils had been digested in the carbonated water this one would have given up much less of *soluble extract* to that menstruum than the others. The iron gravel, diffused through this soil, has been also submitted to analysis.

No. 527—FERRUGINOUS GRAVEL. *Labeled "Gravel of Iron Ore, disseminated in the sub-soil over cellular magnesian limestone, E. B. O'Bannon's farm, Jefferson county, Ky."*

Irregular tuberculated lumps, from the size of a large hickory nut down to that of a mustard seed; easily broken; fracture showing a general dark appearance, like that of peroxide of manganese; some of the lumps presented some included lighter earthy matter like clay; powder of a snuff-brown color. It dissolved in hydrochloric acid with the escape of chlorine. It contained no protoxide of iron, but much oxide of manganese.

Composition, dried at 212° F.—

Oxide of iron and alumina,	33 90
Brown oxide of manganese,	4.28
Carbonate of lime,	.58
Carbonate of magnesia,	1.22
Alkalies and acids not estimated.	
Silex and insoluble silicates,	58.18
Combined water,	8 20
Loss,	1.64
	100.00

Dried at 212° it lost 2.80 per cent of *moisture*.

No. 528—LIMESTONE. *Labeled "Cellular (Magnesian?) Limestone, found about six to ten feet under the surface of the ground, where the preceding soils were collected, O'Bannon's farm, Jefferson county, Ky. Upper Silurian Formation."*

A light-grey, friable cellular rock, layers and cavities covered with minute crystals.

Composition, dried at 212° F.—

Carbonate of lime, - - -	50.76	= 28.49 *Lime.*
Carbonate of magnesia, - -	45.00	
Alumina, oxides of iron and manganese, and phosphates,	1.78	
Sulphuric acid, - - -	.04	
Potash, - - - - -	.21	
Soda, - - - - -	.35	
Silex and insoluble silicates, -	2.48	
	100.62	

The air-dried rock lost 0.20 per cent. of *moisture* at 212°.

No. 529—Soil. *Labeled "Virgin soil, over compact magnesian building stone of the Upper Silurian Formation, White Oak ridge, at Pleasant Grove meeting house, Wm. Galey's farm, Jefferson county, Ky. (This soil is considered not more than one half as productive as that over the cellular magnesian limestone.")*

Dried soil of a dirty grey-buff color.

Composition, dried at 400° F.—

Organic and volatile matters, - - - - - -	3.761
Alumina and oxides of iron and manganese, - - -	6.952
Carbonate of lime, - - - - - - - -	.156
Magnesia, - - - - - - - - - -	.240
Phosphoric acid, - - - - - - - - -	.088
Sulphuric acid, - - - - - - - - -	.310
Potash, - - - - - - - - - -	.177
Soda, - - - - - - - - - -	.031
Silex and insoluble silicates, - - - - - -	88.294
	100.039

The air-dried soil lost 3.22 per cent. of *moisture* at 400°.

Contains less organic matters, phosphoric acid, and alkalies, and a larger proportion of sand and silicates, than the soil over the cellular magnesian limestone.

No. 530—Limestone. *Labeled "Magnesian Building Stone, found under the preceding soil, Upper Silurian Formation, same locality as the last, Jefferson county, Ky."*

A fine grained, light-grey limestone; weathered surfaces having a buff discoloration, with peroxide of iron; under the lens appears to be made up of a mass of pure crystalline grains.

Composition, dried at 212° F.—

Carbonate of lime,	56.36	= 31.62 of *Lime*.
Carbonate of magnesia,	37.07	
Alumina, oxides of iron and manganese, and phosphates,	1.28	
Sulphuric acid, a trace.		
Potash,	.33	
Soda,	.35	
Silex and insoluble silicates,	5.68	
	101.07	

The air-dried rock lost 0.10 per cent. of *moisture* at 212°.

This is probably a very durable stone; and, in consequence of its very slow disintegration, can communicate very little soluble material to the soil above it. It resembles a good deal, in composition, the magnesian building stone from Grimes' quarry, in Fayette county, which is remarkable for its great durability amongst the rocks of that region.

LAUREL COUNTY.

No. 406—IMPURE CARBONATE OF IRON. *Labeled "Iron Ore, White Oak, Laurel county, Ky., from General Jackson. (Examine for other metals.")*

A dark-grey, fine granular mineral, showing minute spangles of mica, and some incrustation, in parts, with sulphate of lime; weathered surface of yellowish and reddish-brown color.

Specific gravity,		3.126

Composition, dried at 212° F.—

Carbonate of iron,	32.29	= 19.10 per cent. of *Iron*.
Oxide of iron,	5.01	
Carbonate of lime,	2.95	
Carbonate of magnesia,	3.60	
Carbonate of manganese,	.64	
Alumina,	1.55	
Phosphoric acid,	1.00	
Potash,	.42	
Soda,	.01	
Silex and insoluble silicates,	51.55	
Organic matter and loss,	.98	
	100.00	

The air-dried mineral lost 0.30 per cent. of *moisture*, at 212°.

Contains too small a proportion of *iron* to be profitable smelted alone.

No. 410—CARBONATE OF IRON. *Labeled "Iron Ore, Craig's creek, Laurel county, Ky. (Examine for other metals.")*

A dense, dark-grey, fine granular rock; exhibiting some minute spangles of mica; weathered surface dark-reddish and yellowish-brown; powder grey.

Specific gravity,		3.395
Composition, dried at 212° F.—		
Carbonate of iron,	68.46	— 35.45 per cent. of *Iron.*
Oxide of iron,	3.41	
Carbonate of lime,	.75	
Carbonate of magnesia,	3.73	
Carbonate of manganese,	1.31	
Alumina,	1.43	
Phosphoric acid,	.52	
Potash,	.34	
Soda,	.07	
Organic matter,	.79	
Silex and insoluble silicates,	19 65	
	100.46	

The air-dried ore lost 0.40 per cent. of *moisture* at 212°.

A very good iron ore, which could be readily smelted, after roasting, by the aid of the ordinary flux of limestone.

No. 411—CARBONATE OF IRON. *Labeled "Iron Ore, two and a half miles from Mr. Hargal's, Robinson creek, Laurel county, Ky. (Examine for other metals.")*

A dark-grey, dull, fine granular ore, with a shining mineral resembling zinc blend or brown spar, filling some of the small fissures; not adhering to the tongue; powder yellowish-grey.

Specific gravity,		3.352
Composition, dried at 212° F.—		
Carbonate of iron,	66 01	— 33.05 per cent. of *Iron.*
Oxide of iron,	2.67	
Carbonate of lime,	5.85	
Carbonate of magnesia,	9.19	
Carbonate of manganese,	.86	
Alumina,	.35	
Phosphoric acid,	.63	

Potash,	.34
Soda,	.33
Silex and insoluble silicates,	12.68
Traces of sulphur, zinc, & loss,	1.09
	100.00

The air-dried ore lost 0.40 per cent. of *moisture* at 212°.

Resembling the preceding, but containing rather less silica and more carbonates of lime and magnesia. This ore would require little or no limestone to flux it; and would most probably yield its iron with facility, without any addition.

No. 224—Soil. *Labeled "Soil of Laurel county, Kentucky, derived from the argillaceous shale and soft sandstone, near the base of the Coal Measures, above the Conglomerate and near the base of the Muriatiferous groupe."*

Color of the dried soil dark-grey; sifted through a seive, having one hundred and sixty-nine apertures to the inch, it left about one-eighth of its weight of fragments of soft reddish and dark-brown ferruginous sandstone. The finer portion, carefully washed with water, left about 42. per cent. of *sand*, of which all but about 5.5 per cent. was fine enough to pass through the finest bolting-cloth. The coarser portion was found, by the lens, to consist principally of rounded and flat fragments of ferruginous sandstone. One thousand grains of the air-dried soil, digested for a month in water containing carbonic acid, gave up nearly two and a half grains of *soluble extract*, of the following composition, dried at 212°:

	Grains.
Organic and volatile matters,	0.710
Alumina, oxide of iron, and phosphates,	.287
Lime,	.937
Magnesia,	.066
Brown oxide of manganese,	.029
Sulphuric acid,	.171
Potash,	.067
Soda,	.007
Silica,	.130
	2.404

The air-dried soil lost 3.60 per cent. of *moisture* at 400° F.

Dried at which temperature its *composition* is as follows:

Organic and volatile matters,	6 190
Alumina and oxide of iron,	8.926
Oxide of manganese,	.078
Carbonate of lime,	.116
Magnesia,	.280
Phosphoric acid,	.139
Sulphuric acid,	.355
Potash,	.239
Soda,	.021
Chlorine,	.009
Sand and insoluble silicates,	83.696
Loss,	.021
	100.000

LAWRENCE COUNTY.

No. 466—Coal. *Labeled "McHenry's big seven feet coal, branch of Three Mile creek, over sandstone, between Tug and Louisa forks of Big Sandy river, Lawrence county, Ky."*

A moderately soft, glossy-black coal, with some fibrous coal between the layers, and occasionally some pyritous matter, and a little ochreous incrustation resulting from its decomposition. Heated over the spirit-lamp it decrepitated, softened, and swelled up considerably into an inflated coke, burning with a smokey yellow flame. A coking coal.

Specific gravity, 1.326

Proximate Analysis.

Misture,	3.60	Total volatile matters,	39.50
Volatile combustible matters,	35 90		
Carbon in the coke,	53 50	Coke, cellular,	61.50
Ashes, (lilac colored,)	7 00		
	100.00		100.00

The composition of the *ash* is as follows:

Silica,	2.18
Alumina, and oxide of iron,	4.23
Lime,	.08
Magnesia,	.28
Loss,	.23
	7.00

Submitted to ultimate analysis it gave the following results:

Carbon,	72.655
Hydrogen,	5 111
Sulphur,	1.750
Oxygen, nitrogen, and loss,	13 084
Ashes,	7.400
	100 000

No. 469—Coal. *Labeled "Keener's coal, three to four feet thick, three miles above Terman's Ferry, Big Sandy river, Lawrence county, Ky."*

A shining pitch-black coal; not very hard; breaking into thin layers; fibrous coal, with pyritous matter, evident by the lens, between the layers, and some efflorescence of sulphate of iron. Over the spirit-lamp it softens, and the fragments agglutinate and swell into a moderately dense cellular coke; it does not decrepitate much.

Specific gravity, - - - - - - - - 1.358

Proximate Analysis.

Moisture,	4.10	Total volatile matters,	37.80
Volatile combustible matters,	33.70		
Carbon in coke,	53 00	Dense coke,	62.20
Ashes, (light grey,)	9.20		
	100.00		100.00

The *composition* of the ash of this coal was found to be—

	Grains.
Silica,	3.39
Alumina and oxide of iron,	4.48
Magnesia,	.18
Lime, a trace, and loss,	.35
	8.40

On *ultimate analysis* this coal gave

Carbon,	70.200
Hydrogen,	4.777
Sulphur,	1 470
Oxygen, nitrogen, and loss,	13.953
Ashes,	9.600
	100.000

Both very good coals, with a little more than the average proportion of ashes.

No. 325—FERRUGINOUS LIMESTONE. *Labeled "Segregations in the creek, seven miles below Millions', (How much Iron?) Big Sandy Railroad, Lawrence county, Ky."*

A dark-grey, fine granular ore, with a dirty-yellowish-brown weathered surface; resembles a dark colored limestone; powder of a light-grey color.

Composition, dried at 212° F.—

Carbonate of lime,	50.95
Carbonate of magnesia,	4.53
Carbonate of iron,	3.01
Oxide of iron,	4.62
Alumina,	1.91
Phosphoric acid,	.36
Potash,	.57
Soda,	.31
Organic matters,	2.00
Silex and insoluble silicates,	32.17
	100.43

The air-dried mineral lost 0.70 per cent. of *moisture* at 212°.

LINCOLN COUNTY.

No. 531—MINERAL WATER. *Labeled "From the Grove Spring, in the yard of the proprietor of the Crab Orchard Springs, Mr. Caldwell, Lincoln county, Ky."*

A chalybeate water, which had deposited a little of its oxide of iron in the bottle in which it was brought.

Evaporated to dryness, at 212°, this water left 0.384 of a grain of solid residuum to the 1,000 grains of the water.

The composition of this mineral water was found to be, in 1,000 grains of the water—

Carbonate of iron,	0.021	Held in solution in the water, by carbonic *acid*.
Carbonate of manganese,	.005	
Carbonate of lime,	.195	
Carbonate of magnesia,	.041	
Sulphate of magnesia,	.056	
Sulphate of potash,	.013	

Chloride of sodium, - -	.013
Silica, - - - - -	.040
Nitric acid, a trace.	
	0.384

It contained also free carbonic acid, which was not estimated.

No. 532—MINERAL WATER. *Labeled "From the 'Brown Spring,' half a mile from Crab Orchard, on the Lancaster Turnpike."*

A chalybeate water; it had been partly decomposed, and the oxide of iron separated in the bottle during carriage, but its composition was ascertained after mixing the sediment fully with the water. One thousand grains of the water left 0.442 grains of solid residuum, on evaporation to dryness, at 212°.

The composition of this water was found to be, in one thousand grains—

Carbonate of iron, - -	0.028	
Carbonate of manganese, -	.005	Held in solution in the water, by free carbonic acid.
Carbonate of lime, - -	.117	
Carbonate of magnesia, - -	.020	
Sulphate of magnesia, - -	.112	
Sulphate of lime, - - -	.015	
Sulphate of potash, - -	.028	
Chloride of sodium, - -	.018	
Silica, - - - - -	.046	
Moisture and loss, - - -	.053	
	0.442 grs.	

The free carbonic acid, also present, was not estimated.

No. 533—MINERAL WATER. *"From the 'Field Spring,' on the lot of the proprietor of the Crab Orchard Springs, Mr. John H. Caldwell, Lincoln county, Ky."*

A chalybeate water. A thousand grains of the water contain about 0.446 of a grain of solid matter, dried at 212°.

The *composition* of this mineral water may be thus stated, in one thousand grains of the water—

Carbonates of iron & manganese,	0.015	
Carbonate of lime, - - -	.139	Held in solution by carbonic acid.
Carbonate of magnesia, - -	.131	
Sulphate of magnesia, - -	.066	
Sulphate of soda, - - -	.024	
Sulphate of potash, - -	.022	
Chloride of sodium, - -	.008	
Silica, - - - - -	.041	
	0.446	

The free carbonic acid present was not estimated.

Whilst these three chalybeate waters each contain about the same amount of saline matters, they present some differences in the proportions of the several ingredients. The "Brown Spring" contains rather the largest quantity of carbonate of iron, and the "Field Spring" the least. The carbonate of magnesia is in larger amount in the Field spring. and the sulphate of magnesia in the Brown spring. The proportion of carbonate of lime is highest in the Field spring.

All these waters are good *saline chalybeates*, and applicable in all cases to which such remedies are appropriate. Whether experience in the use of the waters from these several wells has exhibited any difference in the effects on the system, attributable to the slight differences of composition, the writer is not informed.

By comparing these with the waters from the several chalybeate springs at Bryant's springs, near Crab Orchard, to be described further on, a considerable analogy of composition will also be observed.

No. 534—Mineral Water. *Labeled "From Howard's Sulphur Well, one and a half miles from Crab Orchard, on the Mt. Vernon road, Lincoln county, Ky."*

A *white sulphur* water: but all the sulphuretted hydrogen had been decomposed by carriage.

Specific gravity, - - - - - - - - - 1.00007

One thousand grains of the water contained 0.164 of a grain of solid matter, dried at 212°.

The *composition* of the water is as follows, in 1,000 grains:

Carbonate of magnesia,	0.065	Held in solution by *carbonic acid.*
Carbonate of lime,	.013	
Sulphate of magnesia,	.012	
Sulphate of potash,	.008	
Alumina, and trace of phosphate,	.002	
Chloride of sodium,	.017	
Silica,	.022	
Moisture and loss,	.025	
	0.164	

It contained also sulphuretted hydrogen and carbonic acid gases—amount of which was not estimated.

The medicinal virtues of the water would depend principally on the sulphuretted hydrogen, and on the depurative influence of the water taken in considerable quantities; whether the saline ingredients, which together amount only to a little more than a grain to the pound avoirdupois, are sufficient to exert much sensible action on the system, is somewhat questionable, especially as they are not of a very potent nature. This water is, nevertheless, a good weak sulphur water.

No. 535—Mineral Water. *Labeled "Water from 'Epsom Spring,' (No. 1) one mile from Crab Orchard, on the Lancaster Turnpike, Lincoln county, Ky."*

Specific gravity, - - - - - - - - - 1.0041

One thousand grains evaporated to dryness at 212° left 5.428 grains of solid saline matter. The water was found, also, to contain a considerable amount of free carbonic acid, which was not estimated.

Composition, in 1,000 grains of the water.

	Grains.	
Carbonate of lime,	0.673	Held in solution by carbonic acid.
Carbonate of magnesia,	.116	
Carbonate of iron, a trace.		
Sulphate of magnesia,	3.454	
Sulphate of lime,	.203	
Sulphate of potash,	.087	
Sulphate of soda,	.774	
Chloride of sodium,	.081	
Silica,	.080	
	5.428	

No. 536—Mineral Water. *Labeled "Water from the Epsom Spring at Foley's, half a mile from the centre of Crab Orchard, on the Fall Dick road."*

Specific gravity, - - - - - - - - 1.0068

One thousand grains of the water, evaporated to dryness at 212°, left 6.884 grains of solid saline matter.

The *composition* of this water may be stated as follows, in 1,000 grains of the water:

	Grains.	
Carbonate of lime, - - -	0.912	Held in solution by carbonic acid.
Carbonate of manganese, -	.131	
Carbonate of iron, a trace.		
Sulphate of magnesia, - -	3.520	
Sulphate of lime, - - -	.185	
Sulphate of potash, - -	.170	
Sulphate of soda, - - -	1.013	
Chloride of sodium, - -	·304	
Silica, - - - - -	.056	
Moisture and loss, - - -	.593	
	6 884	

The amount of free carbonic acid present was not estimated.

Although the sulphate of magnesia, (Epsom Salt,) is the principal saline ingredient of these "Epsom Springs" at and near Crab Orchard, the presence of the other saline ingredients, and of the carbonate of iron, modifies greatly the action of that well known salt, so that the medicinal effects, from the use of these waters, is considerably different from that of a pure solution of sulphate of magnesia, and they are applicable to a greater variety of cases.

The medicinal virtues of the saline matter of the Crab Orchard Springs have been so highly appreciated of late that a large quantity of "Crab Orchard Salts," obtained by evaporating the water to dryness in iron kettles, has been sold by our druggists, and it has become an *officinal* article. Some of this salts, as manufactured by Mr. B. H. Sowder, from the water of "Sowder's Spring," near Crab Orchard, presently to be described, was submitted to chemical examination.

No. 537—Crab Orchard Salts. *Brought by Mr. B. H. Sowder.*

A moist granular powder, with a slight tinge of brownish, like the whitest Havana sugar, in appearance.

Dried at 212° it lost more than twenty per cent. of *moisture.*

Composition, dried at 212° F.—

Sulphate of magnesia,	63.19
Sulphate of soda,	4.20
Sulphate of potash,	1.80
Sulphate of lime,	2.54
Chloride of sodium,	4.77
Carbonate of lime, magnesia, and iron, and silica,	.89
Bromine, a trace.	
Water of crystallation and loss,	22.61
	100.00

This salt had been obtained by the evaporation of the water of the spring next to be described. The water was boiled down in an iron kettle, to a certain density, and then, after allowing it to stand for some time in a wooden vessel, the clear liquid, drawn off from the mixed deposit of carbonates of lime and magnesia and oxide of iron, thrown down by boiling, was evaporated to full dryness.

By some of the manufacturers much attention is paid to this process of "purification" of the salt, so that it is entirely freed from oxide of iron and the precipitated carbonates, and is perfectly white; but whether the removal of these ingredients of the water is not injurious to the full medicinal virtue of the saline matter may well be questioned.

The Crab Orchard salts have been much employed by the physicians of Lexington. They find them less drastic, and more tonic, than pure unmixed Epsom Salts, and more likely to act on the liver, in the manner of calomel, when taken in small doses.

No. 538—Mineral Water. *"Sent by B. H. Sowder from "Sowder's Spring," about a mile and a half from Crab Orchard, on the north of the hill towards Dick's river, near its base, and some* 300 *yards from the river. Spring yields about two hundred gallons a day.*

Specific gravity, 1.006

One thousand grains of the water, evaporated to dryness at 212°, left 7.153 grains, of saline matter, in one thousand grains of the water.

Composition—

	Grains.	
Carbonate of lime, - -	0.506	Held in solution by carbonic acid.
Carbonate of magnesia, - -	.375	
Carbonate of iron, a trace.		
Sulphate of magnesia, - -	2.989	
Sulphate of lime, - - -	1.566	
Sulphate of potash, - -	.298	
Sulphate of soda, - - -	.398	
Chloride of sodium, - -	1.000	
Silica, - - - - -	.021	
Bromine, a trace.		
	7.153	

The amount of free carbonic acid present in this water was not estimated.

No. 539—MINERAL WATER. *From Bryant's Springs, near Crab Orchard. Labeled (No. 1) "Chalybeate Fountain in the valley," Lincoln county, Ky.*

The water had deposited a slight brownish sediment in the bottle, and the cork was somewhat blackened; it gave a little brownish-white deposit on boiling; reaction neutral.

It was found to have the following *composition*, in 1,000 *grains:*

Carbonate of lime, - - -	0.118	Held in solution by carbonic acid.
Carbonate of magnesia, - -	.024	
Carbonate of iron, with trace of manganese, - - -	.007	
Sulphate of magnesia, - -	.027	
Sulphate of potash, - -	.010	
Chloride of sodium, - -	.088	
Silica, - - - - -	.017	
	0.291 of a grain.	

Free carbonic acid not estimated.

No. 540—MINERAL WATER. *From Bryant's Springs, Lincoln county, Ky. Labeled "Chalybeate (No. 2) from the Pasture Spring."*

A very slight, dark sediment had formed in the bottle, and the cork was more blackened than by the above described water; tastes more chalybeate than that; gave a slight, brown precipitate on boiling; reaction neutral.

Composition, in 1,000 grains—

	Grain.	
Carbonate of lime, - - -	0.095	Held in solution by carbonic acid.
Carbonate of magnesia, - -	.037	
Carbonate of iron, - - -	.021	
Sulphate of lime, - - -	.010	
Sulphate of magnesia, - -	.070	
Sulphate of potash, - -	.026	
Chloride of sodium, - -	.015	
Silica, - - - - - -	.046	
	0.320	

Free carbonic, not estimated.

A somewhat stronger chalybeate than the "Valley Spring."

No. 541—MINERAL WATER. *From Bryant's springs, Lincoln county. Labeled "Sulphur Water (No. 3) Valley spring."*

No sediment in the bottle; no discoloration of the cork; a very faint taste and smell of sulphuretted hydrogen; gave no sediment on boiling.

Composition, in 1,000 grains—

	Grain.	
Carbonate of lime, - - -	0.093	Held in solution by carbonic acid.
Carbonate of magnesia, - -	.048	
Carbonate of iron, a trace.		
Sulphate of lime, a trace.		
Sulphate of magnesia, - -	.006	
Sulphate of potash, - -	.025	
Chloride of sodium, - -	.175	
Chloride of magnesium, - -	.042	
Silica, - - - - - -	.015	
	0.404	

The free *carbonic acid* and *sulphuretted hydrogen* present in the water were not estimated; a weak saline *sulphur water.*

No. 542—MINERAL WATER. *From Bryant's Springs, Lincoln county, Ky. Labeled "Sulphur Water (No. 4) from the Knob Spring."*

A little floculent black precipitate in the bottle; the cork was somewhat blackened; a more decided taste and smell of sulphur than in the last; a slight taste of common salt evident; no sediment formed on boiling.

Composition, in 1,000 grains.

	Grains.
Carbonate of iron, a trace.	
Chloride of sodium, - -	0.933
Sulphate of magnesia, - -	.069
Sulphate of lime, - - -	.104
Sulphate of soda, - - -	.205
Sulphate of potash, - -	.016
Silica, - - - - -	.015
	1.342

The examination of the saline residuum, obtained by the evaporation of some gallons of this water, would doubtless give evidence of the presence of traces of *iodine* and *bromine*. The free carbonic acid and sulphuretted hydrogen were not estimated. A stronger and more active saline sulphur water than the preceding.

No. 543—MINERAL WATER. *From Bryant's Springs, Lincoln county, Ky. Labeled "Mr. Stone's sulphur water."*

A very little black flocculent sediment in the bottle, and the cork had been somewhat blackened; the odor of sulphuretted hydrogen was scarcely perceptible, and the taste very faint. Gave a light colored sediment on boiling.

Composition, in 1,000 grains of the water—

Carbonate of lime, - -	0.058
Carbonate of magnesia, - -	.116
Carbonate of iron, - - -	.026
Sulphate of lime, - - -	.012
Sulphate of magnesia, - -	.023
Sulphate of potash, - -	.007
Chloride of sodium, a trace.	
Silica, - - - - -	.030
	0.272 of a grain.

The free *carbonic acid* and *sulphuretted hydrogen* were not estimated.

In this, and in the other sulphur waters described, the *sulphuretted hydrogen* had been decomposed during the transportation of the water to the laboratory; and the proportion of this gas, as well as of the carbonic acid, can only be correctly ascertained in water examined a:

the fountain, or introduced there with care into bottles containing the proper re-agents, to bring these gases to a fixed state.

No. 544—MINERAL WATER. *From Bryant's Springs, Lincoln county, Ky. Labeled "Well in front of Bryant's house."*

A little dark sediment in the bottle; no odor; a slight taste of Epsom salt; deposits a whitish sediment on boiling.

Composition, in 1,000 grains—

	Grains.	
Carbonate of lime,	0.480	Held in solution by carbonic acid
Carbonate of magnesia,	.013	
Carbonate of iron,	.019	
Sulphate of magnesia,	.904	
Sulphate of lime,	.966	
Sulphate of potash,	.066	
Sulphate of soda,	0.028	
Chloride of sodium,	.278	
Silica,	.090	
	2 844	

The amount of free carbonic acid in this water was not estimated.

This water resembles, in composition, the Epsom waters of the Crab Orchard springs, but, whilst it contains a smaller proportion of saline matters, it has a rather larger proportion of carbonate of iron and of sulphate of lime.

No. 545—MINERAL WATER. *Labeled "Stone Spring," from Bryant's Springs, Lincoln county, Ky.*

Presented nothing remarkable in taste and smell. There was a little flocculent precipitate of oxide of iron in the bottle, but the cork was not perceptibly blackened. One thousand grains of the water, evaporated to dryness, left but 0.05 of a grain of saline matter, which consisted of

Sulphate of magnesia;
Sulphate of lime;
Chloride of sodium;
Carbonate of iron;
Carbonate of lime; and
Carbonate of magnesia.

This is a remarkably *pure* water, and slightly chalybeate. Very few spring waters contain so small a proportion of saline matter as this, which has only about a third of a grain to the avoirdupois pound.

No. 407—Carbonate of Iron. *Labeled "'Flat Lick Iron Ore,' in burnt shale, near Stanford, on Thomas Holmes' land, Lincoln county, Ky."*

A dense, fine granular, greenish-grey carbonate of iron; powder of a dirty buff color.

Specific gravity, - - - - - - - -	3.339	
Composition, dried at 212° F.—		
Carbonate of iron, - - -	47.97	30.77 per cent. of *Iron*.
Oxide of iron, - - -	10 66	
Alumina, - - - -	2.99	
Phosphoric acid, - - -	.36	
Carbonate of lime, - - -	7.25	
Carbonate of magnesia, - -	12.13	
Carbonate of manganese, -	3 03	
Sulphur, - - - -	.21	
Potash, - - - -	.57	
Soda, - - - - -	.24	
Silex and insoluble silicates, -	13.95	
Water and loss, - - -	.64	
	100.00	

The air-dried ore lost 0.40 per cent. of *moisture*, at 212° F.

A very good iron ore, which would require very little addition of limestone to flux it.

LIVINGSTON COUNTY.

No. 240—Coal. *Labeled "Union Company's Coal, bottom part, Livingston county, Ky."*

A glossy pitch-black coal; firm, but not very hard; a little fibrous coal, and some pyritous matter between the layers. Over the spirit-lamp it does not decrepitate except in the pyritous portions; softens, swells a good deal, and agglutinates into a light cellular coke; burning with a smokey flame.

Specific gravity, - - - - - - - - 1.356

The *ultimate analysis* of this coal gave the following results:

Carbon,	78.000
Hydrogen,	4.977
Sulphur,	.630
Nitrogen,	.628
Oxygen and loss,	7.165
Ashes,	8.600
	100.000

Submitted to distillation, at a heat gradually increased to dull redness, one thousand grains of this coal gave

148.00 grains thick dark-colored "crude oil."
38.00 grains ammoniacal water.
750.00 grains light cellular coke; and
465 cubic inches of good gas.

Like the rest of the soft bituminous coals, this does not yield a large quantity of oily or waxy matters on distillation; but it gives a large proportion of good coke, and doubtless would answer well for the production of illuminating gas. Its proportion of sulphur is moderate.

LOGAN COUNTY.

No. 217—SUB-SOIL. *Labeled "Sub-soil, southern part of Logan county, ten miles from Franklin, on the road from Keysburg. (Sub-carboniferous Limestone Formation.)"*

Color of the dried sub-soil of a handsome dirty orange, or brownish-reddish-yellow color. Carefully washed with water this soil left 69½ per cent. of greyish red sand, of which all but about 6½ per cent. was *very fine;* this coarser portion consists of rounded particles of hyaline and milky quartz, with a little admixture of ferruginous mineral.

One thousand grains, dried at the ordinary temperature, were digested for a month in water containing carbonic acid, to which it gave up only about half a grain of solid extract, dried at 212°, the *composition* of which was as follows:

Organic and volatile matters,	0.260
Oxide of iron and alumina,	.036
Brown oxide of manganese,	.027
Phosphoric acid,	.011
Sulphuric acid, not estimated.	
Lime,	.037
Magnesia,	.033

Potash,	.054
Soda,	.017
Silica,	.110
	0.585 of a gr.

Dried at 400° F., this sub-soil lost 2.80 per cent. of *moisture*.

Its *composition*, thus dried, was found to be—

Organic and volatile matters,	3.14
Oxide of iron,	3.66
Alumina,	4.77
Phosphoric acid,	.14
Sulphuric acid, not estimated.	
Carbonate of lime,	.30
Magnesia,	.40
Brown oxide of manganese,	.18
Potash,	.12
Soda,	.03
Silex and insoluble silicates,	89.27
	102.01

The analysis of this *sub-soil* may be compared with that of its superincumbent surface-soil, No. 141, given on pages 342 and 379, of the preceding report. It will be seen, that whilst that gave a larger proportion of soluble matter to the water containing carbonic acid, and contains a trifle more of organic and volatile constituents, and less phosphoric acid, yet the composition of the two is strikingly alike—making allowance for an evident error in the estimation of the oxide of iron and alumina, in this latter analysis, which causes the apparent excess of about two per cent. in the sum.

MONROE COUNTY.

No. 418—LIMONITE. *Labeled "Iron Ore, Malone's farm, Cole's fork of Mill creek, Monroe county, Ky."*

A dense limonite, of a dark yellowish-brown color; with irregular cavities; and shining portions of a nearly black color; powder light yellowish-brown.

Composition, dried at 212° F.—

Oxide of iron,	76.90	= 53.85 per cent. of *Iron*.
Alumina,	.27	
Brown oxide of manganese,	.95	
Carbonate of lime,	.27	
Magnesia,	.73	
Phosphoric acid,	.30	
Potash,	.20	
Soda,	.08	
Silex and insoluble silicates,	9.35	
Combined water,	11.79	
	100.84	

The air-dried ore lost 1.40 per cent. of *moisture*, at 212° F.

Quite a pure hydrated oxide of iron, which, for successful smelting, must be mixed with poorer ores and limestone. As previously stated, experience has proved that iron ores containing more than fifty per cent. of iron cannot be so cheaply smelted in the high furnace as those which contain a larger proportion of earthy ingredients.

No. 228—Soil. *Labeled "Soil from the dividing ridge between Barren and Cumberland rivers, where the broom-sedge grass prevails, Monroe county, Ky. (Sub-carboniferous Sandstone or Knob Formation)"*

Color of the dried soil dark yellowish-grey. Sifted through a seive, with about 169 apertures to the inch, some cherty fragments were left. Carefully washed in water it gave about 52. per cent. of *sand*, of which all but about 14. per cent. would go through bolting cloth of 5,000 apertures to the inch; this coarser sand consisted of rounded particles of hyaline and milky quartz, and of yellow, red, and brown ferruginous quartz.

One thousand grains, dried at the ordinary temperature, and digested for a month in water containing carbonic acid. gave up nearly three grains of *soluble extract*, of which the *composition* was—

Organic and volatile matters,	0.920
Alumina, oxide of iron and phosphates,	.468
Brown oxide of manganese, not estimated.	
Carbonate of lime,	1.078
Magnesia,	.026
Sulphuric acid,	.119
Potash,	.040

Soda,	.040
Silica,	.110
Loss,	.052
	2.853

The air-dried soil lost 1.82 per cent of *moisture* at 365° F.; dried at which temperature its *composition* was found to be as follows:

Organic and volatile matters,	4.130
Alumina,	2.700
Oxide of iron,	2.120
Carbonate of lime,	.106
Magnesia,	.200
Brown oxide of manganese,	.116
Phosphoric acid,	.075
Sulphuric acid, not estimated.	
Potash,	.119
Soda,	.122
Silex and insoluble silicates,	89.393
Water and loss,	.913
	100.000

No. 454—Zinc Ore. *Labeled "Zinc and Lead Ore," from the rocks under the Devonian Black Slate, Sulphur Lick, Monroe county, Ky."*

A fine granular rock, containing carbonate of lime, with sulphurets of zinc and lead disseminated through it.

Composition—

Sulphuret of zinc,	77.33	= 51.77 per cent. of *Zinc.*
Silica, &c.,	17.48	
Carbonates of lime and magnesia, and sulphuret of lead disseminated,	5.19	
	100.00	

If found in sufficient abundance might be profitably employed in the manufacture of zinc white paint.

MUHLENBURG COUNTY.

No. 464—Coal. *Labeled "Walker's Coal, one and a half miles west of Turners, Muhlenburg county, Ky;"*

A dull looking coal, with the appearance of having been weathered; some signs of decomposed pyrites on its exposed surfaces; separates

easily into thin layers, between which are fibrous coal and impressions as of broad reed leaves. Over the spirit-lamp it does not decrepitate; burns with a smokey flame; softens and agglutinates somewhat, and swells into a moderately dense coke.

Specific gravity,		1.271	
Proximate Analysis.			
Moisture,	3.80	Total volatile matters,	45.30
Volatile combustible matters,	41.50		
Carbon in the coke,	53.60	Coke, (bright cellular,)	54.70
Ashes, (dirty buff,)	1.10		
	100.00		100.00

The composition of the ashes of this coal is as follows:

Silica,	0.29
Alumina and oxide of iron,	.58
Lime,	.10
Magnesia,	.13
	1.10

The considerable proportion of lime and magnesia in this ash will make it more than usually fusible in a strong fire.

By *ultimate analysis* this coal, dried at 212°, was found to be composed of

Carbon,	79.577
Hydrogen,	5.199
Sulphur,	.640
Nitrogen, oxygen, and loss,	13.384
Ashes,	1.200
	100.000

Quite a pure coal, but its large proportion of oxygen and nitrogen prevents it from being a very good coking coal.

No. 191—Coal. *Labeled "Robert's Main Muddy River Coal, Muhlenburg county, Ky."*

A very pure looking, dark, glossy coal, with scarcely any appearance of fibrous coal between the layers, and only microscopical appearances of pyrites in a few spots; not soiling the fingers; firm, but not very hard. Over the spirit-lamp it decrepitates a little; burns with a smokey flame; softens, swells up, and agglutinates into a moderately dense cellular coke, with botryoidal prominences.

Specific gravity, - - - - - - - - -	1.263		
Proximate Analysis.			
Moisture, - - - - -	5.80	Total volatile matters, -	38.30
Volatile combustible matters, -	32.50		
Carbon in the coke, - -	56.70	Bright coke, - -	61.70
Ashes, (light-grey,) - -	5.00		
	100.00		100.00

The proximate analysis of the lower portion of this coal was given by Dr. Owen in his first report, page 142.

The *composition* of the ashes was found to be—

Silica, - - - - - - - - - - - -	2.99
Alumina, with little oxide of iron, - - - - - -	1.68
Lime, - - - - - - - - - - - -	.27
Magnesia, - - - - - - - - - - - -	.05
Loss, - - - - - - - - - - - -	.01
	5.00

Submitted to *ultimate analysis* this coal, dried at 212° F, gave of

Carbon, - - - - - - - - - - - -	74.455
Hydrogen, - - - - - - - - - - - -	4.933
Sulphur, - - - - - - - - - - - -	.906
Nitrogen, - - - - - - - - - - - -	1.030
Oxygen and loss, - - - - - - - - - -	13.076
Ashes, - - - - - - - - - - - -	5.600
	100.000

By destructive distillation, at a moderate heat, one thousand grains of Roberts' coal gave

102.10 grains of thick black tarry matter;
119.80 grains of ammoniacal water of a dark purple color;
659.50 grains of bright coke;
Leaving 118.60 grains for loss and gas.

1000.00

The gas collected measured only 370 cubic inches, and was of moderately good quality.

This coal is not, therefore, very well suited to the manufacture of gas, nor for the production of *Paraffin* and Benzole, &c., by destructive distillation.

Its large proportions of oxygen and nitrogen injure it somewhat for these purposes: the hydrogen being, to an equivalent amount, monop-

olized in the production of water and ammonia, by union with these gases; but it is a very good coal for domestic and manufacturing purposes generally, and no doubt yields a very good coke.

The dark purple color of the *ammoniacal water*, obtained by its distillation, is due to the presence of sulpho-cyanide of ammonium, which, by action on the iron of the tube of the retort produced the characteristic dark-purple compound, sulpho-cyanide of iron. Besides this compound the ammoniacal water contained hydrosulphate of ammonia and carbonate of ammonia.

No. 156—Coal. *Labeled "(McLean) Airdrie Coal, below the clay parting, six and three-twelfths feet thick, Muhlenburg county, Ky."*

The proximate analysis of this coal was given on page 352, of the former report.

Ultimate Analysis.

Carbon,	76 091
Hydrogen,	5.222
Sulphur,	1.350
Oxygen, nitrogen, and loss,	13.937
Ashes,	3.400
	100.000

Does not differ much in composition from Roberts' coal, but the specimen examined contained rather more sulphur.

No. 157—Coal. *Labeled "Eades Coal, two and a half miles southwest of Greenville, Muhlenburg county, Ky."*

The proximate analysis of this coal is also given on page 352 of the former report.

Ultimate Analysis.

Carbon,	76.855
Hydrogen,	5.244
Sulphur,	.654
Oxygen, nitrogen, and loss,	13.847
Ashes,	3.400
	100.000

Closely resembles the two preceding in composition and properties.

OHIO COUNTY.

No. 405—LIMONITE. *Labeled "Iron Ore? Top of the hill at Mr. French's, seven miles north of Hartford, Ohio county, Ky."*

A porous, yellowish-brown mass, containing a small bi-valve shell; under the lens exhibiting a few minute spangles of mica and grains of sand, united by a ferruginous cement; powder yellowish-brown.

Composition, dried at 212° F.—

Oxide of iron,	39 48	= 27.64 per cent. of *Iron*.
Alumina,	1.81	
Brown oxide of manganese,	1.77	
Phosphoric acid,	.64	
Lime, a trace.		
Magnesia,	1.12	
Potash,	.34	
Soda,	.06	
Silex and insoluble silicates,	47.37	
Combined water,	8.28	
	100.87	

The air-dried ore lost 1 00 per cent. of *moisture*, at 212°.

Rather a poor silicious ore.

No. 413—LIMONITE. *Labeled "Argillaceous Iron Ore, at Livermore's landing, Ohio county, Ky."*

Portion of a flat nodular mass, formed of concentric layers of brownish-yellow hydrated oxide of iron; dull; adhering strongly to the tongue; powder brownish-yellow; when it has been calcined, of a bright spanish-brown color.

Composition, dried at 212° F.—

Oxide of iron,	60.18	= 42.14 per cent. of *Iron*.
Alumina,	4 85	
Phosphoric acid,	.60	
Lime, a trace.		
Magnesia,	.73	
Brown oxide of manganese,	.27	
Potash,	.40	
Soda,	.08	
Silex and insoluble silicates,	19 75	
Combined water,	13 .4	
	100 00	

The air-dried ore lost 1.80 per cent. of *moisture* at 212° F.

No. 455—LIMESTONE. *Labeled "Hydraulic Limestone, five miles north of Hartford, Ohio county, Ky."*

A dark-grey, compact, limestone; glimmering with minute facets of calcareous spar; not adhering to the tongue; powder light-grey.

Specific gravity,	2.721
Composition, dried at 212° F.—	
Carbonic acid,	38.55
Sulphuric acid,	.80
Phosphoric acid,	.12
Lime,	47.06
Magnesia,	2.39
Alumina and oxide of iron,	1.44
Potash,	.29
Soda,	.24
Silex and insoluble silicates,	9.96
	100.85

The air-dried rock lost only 0.30 per cent. of *moisture* at 212° F.

No. 459—COAL. *Labeled "Pitchener's Coal, Green river, two miles above Livermore, Ohio county, Ky."*

A shining pitch-black coal; not very hard; with some little infiltrated pyrites. Heated over the spirit-lamp did not decrepitate much, the fragments softened, swelled up, and agglutinated, forming an inflated coke.

Specific gravity,		1.272	
Proximate Analysis.			
Moisture,	5.50	Total volatile matters,	46.70
Volatile combustible matters,	41 20		
Carbon in the coke,	48.90	Shining cellular coke,	53.30
Ashes, (yellowish-grey,)	4.40		
	100 00		100.00

The *composition* of the ashes was found to be

Silica,	2.18
Alumina and oxide of iron,	1.98
Lime, a trace.	
Magnesia,	.10
Loss,	.14
	4.40

The *ultimate composition* of this coal, dried at 212°, is as follows:

Carbon,	71.618
Hydrogen,	5.377
Sulphur,	1.750
Oxygen, nitrogen, and loss,	16 455
Ashes,	4 800
	100.000

No. 470—Coal. *Labeled "Barret's Coal, two miles north of Hartford, Ohio county, Ky."*

A shining, pitch-black coal; apparently pure, except from some microscopical appearance of pyrites in the fibrous coal which separates the layers, and some efflorescence of sulphate of iron. Over the spirit-lamp it decrepitates a little; burns with a yellow smokey flame; softens and wells up a good deal, the fragments agglutinating into a light cellular coke.

Specific gravity, 1.311

Proximate Analysis.

Moisture,	4.70	Total volatile matters,	42.60
Volatile combustible matters,	37 90		
Carbon in the coke,	52.02	Light shining coke,	57 40
Ashes, (light-chocolate-brown,)	5.38		
	100.00		100.00

The composition of the ashes is as follows:

Silica,	1.24
Oxide of iron and alumina,	3.88
Traces of lime and magnesia, and loss,	.26
	5.38

The *ultimate composition* of this coal, dried at 212°, is as follows:

Carbon,	74.510
Hydrogen,	5.332
Sulphur,	3 054
Oxygen, nitrogen, and loss,	12 504
Ashes,	4.600
	100.000

The per centage of *sulphur* is quite considerable.

No. 461—Coal. *Labeled "Mr. Jackson's Coal, one mile below Cromwell, Green river, Ohio county, Ky."*

A very dark and glossy coal; easily breaking into cuboidal fragments; fibrous coal between some of the layers, but no appearance of pyrites or other impurities. Over the spirit-lamp it does not decrepitate; burns with a very smokey flame; softens very much; agglutinates, and swells into a cellular shining coke.

Specific gravity,			1.272
Proximate Analysis.			
Moisture,	5.60	Total volatile matter,	43.90
Volatile combustible matters,	38.30		
Carbon in the coke,	53.60	Bright cellular coke,	56.10
Ashes, (reddish-grey,)	2.50		
	100.00		100.00

The *composition* of the ashes was found to be—

Silica,	1.19
Alumina, and oxide of iron,	1.28
Lime,	.10
Magnesia,	.06
	2.63

Submitted to *ultimate analysis*, dried at 212°, this coal gave

Carbon,	75.219
Hydrogen,	5 177
Sulphur,	1.704
Oxygen, nitrogen, and loss,	14 900
Ashes,	3.000
	100 000

No. 223—Soil. *Labeled "Soil, one foot deep, Mr. Harris', Morgantown road, Ohio county, Ky. (Coal Measures.)"*

Color of the dried soil light yellowish-grey. Carefully washed in water it left more than 52. per cent. of sand, of which less than 1. per cent. did not pass through fine bolting cloth. This consisted of flattened rounded particles of ferruginous sandstone.

One thousand grains, dried at the ordinary temperature, and digested for a month in water containing carbonic acid, gave up about two and a third grains of *brown extract*, which had the following composition, dried at 212°:

	Grains.
Organic and volatile matters,	0.770
Alumina, oxide of iron, and phosphates,	.317
Lime,	.274
Magnesia,	.123
Brown oxide of manganese,	.049
Sulphuric acid,	.067
Potash,	.081
Soda,	.144
Silica,	.230
Carbonic acid and loss,	.275
	2.330

Dried at 400° the air-dried soil lost 1.74 per cent. of *moisture;* and its *composition*, thus dried, was found to be as follows:

Organic and volatile matters,	5 080
Alumina, and oxides of iron and manganese,	4.349
Carbonate of lime,	.176
Magnesia,	.166
Phosphoric acid,	.101
Sulphuric acid,	.413
Chlorine,	.016
Potash,	.157
Soda,	.015
Sand and insoluble silicates,	90.166
	100.639

OWSLEY COUNTY.

No. 160—Coal. *Labeled "Cannel Coal from Haddock's mine, between south and middle forks of Kentucky river, Owsley county, Ky."*

This coal, of which the *proximate analysis* was given in the former report, page 354, has been submitted to ultimate analysis, with the following results, viz:

Carbon,	76.791
Hydrogen,	6.177
Sulphur,	.241
Oxygen, nitrogen, and loss,	13.791
Ashes,	3.000
	100.000

As it contains a larger relative proportion of hydrogen than any other of the coals examined, except the Breckinridge coal, it was sub-

mitted to destructive distillation at a heat gradually raised to dull redness, and the quantity of liquid combustible products is second only to that obtained from that coal. One thousand grains of this cannel coal, dried at the ordinary temperature, gave, on distillation,

248.50 grains of crude oil, (thick and dark colored);
54 50 grains of ammoniacal water;
589.00 grains of dense coke.

892.00

Leaving 108.00 grains for loss and gaseous product.

The *gas* collected measured 370 cubic inches, and had a very high illuminating power.

This coal, as well as the cannel coal on Troublesome creek, Breathitt county, described by Dr. Owen in the preceding report, might doubtless be profitably employed in the manufacture of Benzole, lubricating oils, Paraffin, &c.

PULASKI COUNTY.

No. 452—CARBONATE OF IRON. *Labeled "Headwaters of Indian and Rockhouse creeks, Grassy Gap Survey, Pulaski county, Ky."*

A dense, fine granular, dark-grey carbonate of iron, with a thin exterior layer of hydrated oxide; powder yellowish-grey.

Specific gravity, - - - - - - - - 3.344

Composition, dried at 212° F.—

Carbonate of iron, - - -	53 02	= 35.60 per cent. of *Iron*.
Oxide of iron, - - -	20.13	
Carbonate of lime, - - -	5.35	
Carbonate of magnesia, - -	7.48	
Carbonate of manganese, -	.71	
Alumina, - - - -	1.95	
Phosphoric acid, - - -	1.13	
Potash, - - - - -	.54	
Soda, - - - - -	.08	
Silex and insoluble silicates, -	9.45	
Organic matter, trace of sulphur, and loss, - - - -	.16	
	100.00	

The air-dried ore lost 0.50 per cent. of *moisture* at 212°.

This could be very economically smelted, because it contains within itself all the materials for the flux and the formation of cinder.

Ores containing about this per centage of iron are more profitably worked than those which are richer.

No. 467—Coal. *Labeled "Sears' Coal, Pitman hill, waters of Pitman and Buck creeks, Pulaski county, Ky."*

A glossy, pitch-black coal; seemingly pretty pure, with only microscopical appearances of pyritous matter in the fibrous coal, which separates the thin layers, into which it easily cleaves. Over the spirit lamp it softens a little, does not decrepitate, nor swell up much; the fragments agglutinate only at the angles in contact.

Specific gravity,		1.274	
Proximate Analysis.			
Moisture,	2.20	Total volatile matters,	41.10
Volatile combustible matters,	38.90		
Carbon in the coke,	57.00	Dense coke,	58.90
Ashes, (light-buff-grey,)	1.90		
	100.00		100.00

The composition of the ash was found to be—

Silica,	0.69
Alumina and oxide of iron,	.88
Magnesia,	.10
Lime, a trace, and loss,	.23
	1.90

On *ultimate analysis* this coal, dried at 212°, gave

Carbon,	78.608
Hydrogen,	5.311
Sulphur,	.380
Oxygen, nitrogen, and loss,	13.451
Ashes,	2.250
	100.000

This coal is remarkable for its small proportions of earthy matters and sulphur.

No. 471—Coal. *Labeled "Lower Bed of Coal, sixty feet under the Main Coal, Cumberland Mines, Pulaski county, Ky."*

A pitch-black, pretty hard coal; cleaving into thin layers, which are separated by fibrous coal, in which there is scarcely any appearance of pyrites or other impurities. Over the spirit-lamp it does not decrepitate; swells up very little; burns with a reddish-yellow smoky flame; leaving a pretty dense shining coke.

Specific gravity, - - - - - - - - -	1.311		
Proximate Analysis.			
Moisture, - - - - -	4.40	Total volatile matters, -	38.20
Volatile combustible matters,	33.80		
Carbon in the coke, - -	58.80	Coke scarcely coherent,	61.80
Ashes, (nearly white,) - -	3 00		
	100.00		100.00

The ashes were found to be composed of

Silica, - - - - - - - - - - - - -	1.69
Alumina, with a trace of oxide of iron, - - - - -	1.38
Lime, - - - - - - - - - - - - -	.10
	3.17

Submitted to *ultimate analysis*, dried at 212°, gave the following results, viz:

Carbon, - - - - - - - - - - - -	76.364
Hydrogen, - - - - - - - - - - -	5.200
Sulphur, - - - - - - - - - - -	.420
Oxygen, nitrogen, and loss, - - - - - - - -	14.716
Ashes, - - - - - - - - - - - -	3.300
	100.000

In its large proportion of oxygen and nitrogen we probably see the cause why it does not soften and swell up much in burning.

This, like the preceding, which it resembles, is also a remarkably pure coal.

No. 546—IMPURE LIMONITE. *Labeled "Iron Ore, found in masses of tons weight, near the mill of Dr. Graham, Rockcastle river, Pulaski county, Ky."*

A dark-red, mottled with lighter-red, fine granular ore, containing grains of sand, and glimmering under the lens; does not adhere to the tongue.

Specific gravity, - - - - - - - - -	2.696	
Composition, dried at 212° F.—		
Sand and insoluble silicates, - - - - - - -		69.18
Oxide of iron, - - - - - - - - -		27.18
Alumina, - - - - - - - - - -		.70
Combined water, - - - - - - - - -		3.50
Magnesia and lime, traces.		
		100.56

Contains too much sand to be a profitable iron ore, yet it might be used to mix with calcareous ores, or, with limestone added, to assist in fluxing ores which were difficult to smelt in consequence of their too great purity from earthy matters.

RUSSELL COUNTY.

No. 226—Soil. *Labeled "Soil and sub-soil, table land of Russell county, Ky., four miles north of Jamestown. (Sub-carboniferous Sandstone, or Knob Formation.)*

Dry soil of a dark buff-grey color; sifted through a seive, with one hundred and sixty-nine apertures to the inch, some ferruginous and quartz pebbles were removed from it. Carefully washed in water it left 57. per cent. of fine sand, of which all but about 5. per cent. passed through fine bolting cloth. These coarser particles appeared, under the lens, as rounded fragments of quartz and ferruginous sandstone, mixed with a few small *entrochites*.

One thousand grains of the air-dried soil, digested for a month in water containing carbonic acid, gave up more than two grains of *soluble brown extract*, which, dried at 212°, had the following composition:

	Grains.
Organic and volatile matters,	0 910
Alumina, oxide of iron, and phosphates,	.287
Lime,	.369
Magnesia,	.080
Brown oxide of manganese,	.059
Potash,	.143
Soda,	.050
Sulphuric acid,	.089
Silica,	.150
Carbonic acid and loss,	.084
	2.221

The air-dried soil lost 3.44 per cent. of *moisture* at 400° F.

Dried at which temperature it was found to contain

Organic and volatile matters,	4.170
Alumina, and oxides of iron and manganese,	4.478
Carbonate of lime,	.176
Magnesia,	.06[illegible]
Phosphoric acid,	.0[illegible]
Sulphuric acid,	.227

Potash,	.063
Soda,	.068
Sand and insoluble silicates,	90.786
Chlorine, a trace.	
	100.122

The large proportion of sand and silicious matters, and the small relative amount of alumina and oxide of iron, and especially of phosphoric acid and the alkalies, explain the poverty of this soil of the Knob Formation. Yet, as the silicious matter is in a state of very fine division, even this, by skillful management in the proper application of manures, may be made and kept quite productive. Whether this could be *profitably* done would depend upon local circumstances.

SIMPSON COUNTY.

No. 480—SUB-SOIL *Labeled "Red sub-soil, northern part of Simpson county, three-fourths of a mile from the Warren county line, Ky. (Sub-carboniferous Limestone Formation.)"*

Dried soil of a handsome brick-red, or light orage-red color. Carefully washed in water it left about 45½ per cent. of fine sand, mixed with some larger rounded fragments of quartz mineral, some clear, some milky, others colored light-red with oxide of iron, and about 4 per cent. of coaser sand about as fine as bar sand, composed of rounded particles of the same minerals.

One thousand grains of the soil, dried at the ordinary temperature, digested for a month in water containing carbonic acid, gave up only about two-thirds of a grain of greyish *extract*, which had the following composition:

Organic and volatile matters,	0.260
Oxide of iron, alumina, oxide of manganese, and phosphates,	.047
Lime,	.064
Magnesia,	.033
Potash,	.027
Soda,	.020
Silica,	.157
	0.608 of a gr.

The air-dried soil lost 4.14 per cent. of *moisture* at 360°; dried at which temperature its composition was found to be as follows:

Organic and volatile matters,	7 02
Oxide of iron,	8 82
Alumina,	11 98
Phosphoric acid,	.24
Carbonate of lime,	.21
Magnesia,	.20
Brown oxide of manganese	.13
Potash,	.19
Soda,	.06
Sand and insoluble silicates,	71.13
Loss,	.02
	100.00

A portion of the *volatile matter* stated above is no doubt *water* combined with the oxide of iron and alumina, which are present in unusually large proportions in this soil, and to the former of which it owes its fine red color. These ingredients give the soil the property of forming quite a fixed compound with *organic matters*, as is shown by the fact that although this soil contains as much as 7. per cent. of organic and volatile substances, one thousand grains, digested for one month, gave up only about a quarter of a grain to the carbonated water. These substances also have a considerable attraction for ammonia, absorb it with great facility, retain it with such tenacity that water will not remove it, and are always found to contain some of it after exposure to the atmosphere. Some of this red soil examined for *ammonia* was found to yield only 0.025 per cent. of that compound, but this is equal to seven hundred and fifty pounds to the acre, to one foot depth. This amount is probably but a part of that really contained in this soil. According to the recent experiments of Th. Way, of England, all the soils examined exhibited considerable power of absorption of ammonia, from an atmosphere containing it, and will remove it from water which holds it in solution. By the analysis of Dr Kroker, in the Giessen Laboratory, and of several chemists in the employ of the Royal Prussian College of Husbandry, in Berlin, all the soils submitted to analysis, for the detection of ammonia, were found to yield quite large proportions, amounting, in some of the German soils, to as much as 18,040 pounds to the acre of ground, to twelve inches of depth, and in a remarkable Russian black soil to nearly 50,000 pounds! From these facts Liebig, in his recent publication *On the theory nad practice of agriculture:*" ("*Uber Theorie and Praxis in der Landwirth-*

schaft." *Braunschweig*, 1856,) not yet translated into English, triumphantly contends, that as nitrogen (contained abundantly in ammonia,) is so constantly and plentifully supplied by the atmosphere, the *mineral ingredients* of the soil are the only essential elements of vegetable structures which are in danger of exhaustion, and which need be restored to the soil to maintain it in a state of fertility.

By comparing the above analysis of this peculiar *sub-soil*, with that of the *surface-soil* from the same locality, detailed in the preceding report, pages 355–6 and 379, marked differences of composition and properties will be noticed.

The surface soil gave nearly three grains of *extract* to the carbonated water, although containing less organic and volatile matters, but it contains only about one-third as much oxide of iron and alumina as this sub-soil, and considerably more fine sand and silicates. The *sub-soil* contains rather more phosphoric acid and alkalies than the *soil;* and, if *gradually* mixed with the surface soil, by deep ploughing, would give greater tenacity and strength to it, as it became exhausted by cropping. The great affinity of this red sub-soil, for organic matters, might, however, cause too great a mixture of it with the soil to be at first rather injurious than beneficial, but the simultaneous application of lime to the land might be useful.

TRIGG COUNTY.

No. 420—LIMONITE. *Labeled "Iron Ore,—"honey-comb ore"—Capt. Williams', waters of Little river, Trigg county, Ky."*

A porous, friable mineral, composed of numerous thin contorted layers of reddish-brown dense limonite, separated by soft ochreous matter; powder light yellowish-brown.

Composition, dried at 212° F.—

Oxide of iron,	56.10 = 39.28 per cent. of *Iron.*
Alumina,	.45
Phosphoric acid,	.38
Sulphur, a trace.	
Lime, a trace.	
Magnesia,	.57
Brown oxide of manganese,	1.05
Potash,	.34
Soda,	.08

Silex and insoluble silicates,	30.15
Combined water,	10.70
Loss,	.18
	100.00

The air-dried ore lost 1.00 per cent. of *moisture* at 212°.

A good silicious limonite.

No. 421—LIMONITE. *Labeled "Iron Ore, Hæmatitic variety, Capt. Williams', waters of Little river, Trigg county, Ky."*

A dense, dark-reddish-brown limonite, with some red and yellow ochreous incrustation, and cavities lined with botryoidal concretions; powder rich brownish-yellow.

Specific gravity,		3.778
Composition, dried at 212° F.—		
Oxide of iron,	79.40	= 55.60 per cent. of *Iron*.
Alumina,	.45	
Phosphoric acid,	.87	
Brown oxide of manganese,	.67	
Magnesia,	.60	
Potash,	.21	
Soda,	.05	
Silex and insoluble silicates,	5.75	
Combined water,	11.98	
Loss,	.02	
	100.00	

The air-dried ore lost 0.70 per cent. of *moisture*, at 212°.

A very rich limonite, which will not only require the addition of limestone but also of some silicious matter or ore to form a sufficient amount of cinder in the furnace to protect the reduced iron from the direct influence of the oxygen of the blast. The ore described just preceding this would, no doubt, answer this purpose admirably.

No. 457—LIMESTONE. *Labeled "Hydraulic Limestone near Mr. Hendricks', four miles above the mouth of Little river, Trigg county, Ky."*

A dull, fine, granular, grey limestone; not adhering to the tongue; exhibiting a few small specks of of calcareous spar; powder of a light grey color.

Specific gravity,	2.702
Composition, dried at 212° F.—	
Carbonic acid,	40.90
Phosphoric acid,	.06
Lime,	43.91
Magnesia,	7.00
Alumina, oxide of iron, &c.,	.36
Potash,	.21
Soda,	.09
Silex and insoluble silicates,	8·36
	100.89

The air-dried rock lost 0.30 per cent. of *moisture* at 212° F.

No. 458—LIMESTONE. *Labeled "Hydraulic Limestone."*

Specific gravity,	2.696
Composition, dried at 212° F.—	
Carbonic acid,	38.85
Phosphoric acid,	.92
Sulphuric acid,	.29
Lime,	28.61
Magnesia,	14.77
Alumina,	1.23
Oxide of iron,	.73
Potash,	.27
Soda,	.30
Silica and insoluble silicates,	13.68
Loss,	.35
	100.00

The air-dried rock lost 0.20 per cent. of *moisture* at 212°.

UNION COUNTY.

No. 237—SOIL. *Labeled "Soil, taken ten inches below the surface on Pond creek bottom, eight miles north-east of Caseyville, Union county, Ky; called there "Black Bottom;" land of Esquire Gains,* (*No.* 1.) (*Coal Measures.*)

Dried soil of a mouse color. Washed carefully with water it left about 28 per cent. of mouse-grey fine sand, which contained about 3. per cent. of coarser quartz grains, mixed with rounded particles of a ferruginous mineral.

One thousand grains, digested in water containing carbonic acid for a month, gave up about two and a quarter grains of *brown extract*, which, dried at 212°, has the following composition, viz:

Organic and volatile matters,	1.190
Alumina, oxides of iron and manganese, and phosphates,	.039
Lime, colored with oxide of manganese,	.386
Magnesia,	.083
Sulphuric acid,	.188
Potash,	.046
Soda,	.187
Silica,	.161
	2.280

The air-dried soil lost 2.76 per cent. of *moisture*, at 365° F.

Its composition, thus dried, was found to be—

Organic and volatile matters,	4.580
Alumina,	2.986
Oxide of iron,	2.666
Carbonate of lime,	.396
Magnesia,	.390
Brown oxide of manganese,	.056
Phosphoric acid,	.115
Sulphuric acid and chlorine, not estimated.	
Potash,	.139
Soda,	.116
Sand and insoluble silicates,	88.426
Loss,	.130
	100.000

No. 235—Sub-soil. *Labeled "Sub-soil from the land of Esquire Gains, on the points making to Pond creek, taken a quarter of a mile distant from No.* 1, (*the preceding,*) *Union county, Ky.*"

Color of the dried soil buff-grey; when calcined of a brick-red. Washed carefully with water it left a considerable proportion of fine sand, (weight lost,) all of which passed through the finest bolting cloth.

One thousand grains of the air-dried soil, digested for a month in water containing carbonic acid, gave up nearly a grain and a half of light-brown extract, composed of—

	Grains.
Organic and volatile matters,	0.700
Alumina, oxides of iron and manganese, and phosphates,	.048
Carbonate of lime,	.128
Carbonate of magnesia,	.105
Sulphuric acid,	.051
Potash,	.058
Soda,	.030
Silica,	.360
	1.480

The air-dried sub-soil lost 3.16 per cent. of *moisture*, at 400° F.

Its composition, when thus dried, is as follows:

Organic and volatile matters,	2.740
Alumina, and oxides of iron and manganese,	9.530
Carbonate of lime,	.276
Magnesia,	.287
Phosphoric acid,	.147
Sulphuric acid,	.288
Chlorine,	.003
Potash,	.185
Soda,	.056
Sand and insoluble silicates,	86.130
Loss,	.358
	100.000

No. 236—Soil. *Labeled "Soil, derived from the shaley rock above the Anvil Rock, forming remarkable flat Post Oak glades, Shawneetown road, two and a quarter miles north-east of Mulford Page's land, Union county, Ky. (Coal Measures.")*

Color of the dried soil light-grey. Carefully washed with water one thousand grains of the air-dried soil left five hundred and seventeen grains of *fine sand*, of which one hundred and eighteen grains were too coarse to go through fine bolting cloth, and consisted principally of nearly spherical particles of ferruginous sandstone and iron ore, with rounded grains of quartz—hyaline, milky, yellow, and red.

One thousand grains of the soil, digested in water containing carbonic acid for a month, gave up about two grains of light clove-brown colored *extract*, which contained the following ingredients:

Organic and volatile matters,	0.589
Alumina, oxides of iron and manganese, and phosphates,	.197
Lime,	.104
Magnesia,	.130
Sulphuric acid,	.136
Potash,	.085
Soda,	.163
Silica,	.290
Carbonic acid and loss,	.226
	1.920

Dried at 370° this soil lost 3.54 per cent. of *moisture*, and had the following *composition*, viz:

Organic and volatile matters,	3.670
Alumina,	2.230
Oxide of iron,	5.080
Brown oxide of manganese,	.080
Carbonate of lime,	.136
Magnesia,	.633
Phosphoric acid,	.088
Sulphuric acid,	.466
Chlorine,	.003
Potash,	.087
Soda,	.062
Sand and insoluble silicates,	87.250
Loss,	.215
	100.000

No. 220—MARL. *Labeled "Marl, taken from a bed four feet thick, overlaying a bed of coal eleven inches thick, near the top of a hill, on the land of Francis H. Shouse, Union county, Ky."*

In greenish, slate-colored lumps, containing fragments of encrinal stems, small cyathophilli, pieces of fossil bi-valve shells, and fragments of small coral stems.

One thousand grains, washed with water, with careful trituration in a mortar, left 598 grains of mixed sand and fragments of fossils, of which 309 grains, principally of *fine sand*, passed through fine bolting cloth.

Dried at 400° this marl lost 1.92 per cent. of *moisture*, and had the following *composition:*

Organic and volatile matters,	7.060
Alumina, and oxides of iron and manganese,	6.700
Carbonate of lime,	50.850
Magnesia,	.698
Phosphoric acid,	.280
Sulphuric acid,	1.366
Chlorine,	.062
Potash,	.310
Soda,	.166
Sand and insoluble silicates,	32.670
	100.162

This might be used as a top-dressing to increase the fertility of poor silicious or exhausted soils, in its neighborhood, but would not pay its carriage for any great distance.

No. 185—Coal. *Labeled "Five feet, or main Mulford coal, Union county, Ky."*

A glossy deep black coal; firm, but not very hard; having a little fibrous coal between the layers, but no marked appearance of pyrites. Over the spirit-lamp it does not decrepitate; softens and swells very much, and agglutinates into a very inflated coke.

Specific gravity,	1.321

This coal, of which the *proximate analysis* was given by Dr. Owen in his first report, page 49, has been submitted to *ultimate analysis*, and examined, as to its product of bituminous oils and illuminating gas, by destructive distillation.

Ultimate Analysis.

Carbon,	76.200
Hydrogen,	5.644
Sulphur,	1.746
Nitrogen,	.552
Oxygen and loss,	8.258
Ashes,	7.600
	100.000

The products of the distillation of 1,000 grains of this coal, at a heat gradually increased to redness, in an average of two experiments, were as follows:

136.50 grains of thick dark crude oil;
64.75 grains of ammoniacal water;
684.00 grains of coke;

Leaving 115.75 grains for gas and loss.

The gas collected measured 567.50 cubic inches, on an average, and possessed high illuminating powers.

It will be seen, therefore, that whilst this coal cannot be profitably employed in the manufacture of the bituminous oils, Benzole, and *Paraffin*, it is a very good coal for both gas and coke. Its *ultimate analysis* shows but a small proportion of oxygen and nitrogen. The only drawback to its use is the considerable proportion of sulphur which it is found to contain. This ingredient, however, like the earthy matters which form the ash, is found to vary in its proportion even within the compass of a single lump of the coal.

No. 188—Coal. *Labeled "Ice-house Coal, Mulford's mine, Union county, Ky."*

A not very glossy, but quite dark-colored coal; not very hard, but firm; presenting irised appearances, and some incrustation with sulphate of lime, but no pyritous matter, and little fibrous coal. Over the spirit-lamp it swells up considerably, and agglutinates into a cellular coke.

Specific gravity,	1.325

The proximate analysis of this coal was also given by Dr. Owen in first his report, page 51.

Ultimate Analysis.

Carbon,	73.419
Hydrogen,	4.977
Sulphur,	2.824
Nitrogen,	1.658
Oxygen and loss,	10.322
Ashes,	6.800
	100.000

Submitted to destructive distillation, as above described, the Ice-house Coal gave, from a thousand grains,—

108.00 grains of heavy, thick, dark, *crude oil;*
73.00 grains of dark colored *ammoniacal water*, having the odor of creosote;
714.00 grains of *coke*, (rather dense);
Leaving 105 00 grains for *gas* and loss.

The gas collected measured 465. cubic inches, and did not possess very high illuminating power. It was greatly contaminated with sulphuretted hydrogen, from the large proportion of sulphur contained in the coal.

For comparison with these Kentucky coals, I have appended at the end of this report an ultimate analysis of the Youghiogheny coal, of Pennsylvania, which is generally preferred in this region for the manufacture of illuminating gas.

No. 166—Coal. *Labeled "Coal from Casey's mine, near Caseyville, Union county, Ky."*

This coal, of which the *proximate analysis* was given in the former report, page 361, has been submitted to *ultimate analysis*, with the following results:

Carbon,	74.309
Hydrogen,	5.244
Sulphur,	.880
Oxygen, nitrogen, and loss,	11.967
Ashes,	7.600
	100.000

WARREN COUTNY.

No. 417—Limonite. *Labeled "Hydrated Oxide of Iron, in the ridge above the conglomerate, amongst sandstone; waters of Claylick creek, seven miles above the mouth of Barren river, Warren county, Ky."*

Exterior crust an irregular layer of dense, hard, dark-brown limonite, with a few minute specks of mica; interior friable, yellowish, and reddish ochreous matter.

Composition, dried at 212° F.—

Oxide of iron,	67.14 = 47.02 per cent. of *Iron*.
Alumina,	.80
Phosphoric acid,	.56
Carbonate of lime,	.27
Magnesia,	.67

Brown oxide of manganese,	1.37
Potash,	.37
Silex and insoluble silicates,	17.95
Combined water,	11.16
	100.59

The air-dried ore lost 0.70 per cent. of *moisture* at 212°.

WAYNE COUNTY.

No. 450—LIMONITE. *Labeled "Bog Iron Ore, Meadow creek, Wayne county, Ky."*

A friable, dark-brown mineral; adhering to the tongue; presenting many irregular cavities, lined with lighter colored material; powder of a dark-brown color, becoming of a lighter-brown by calcination.

Composition, dried at 212° F.—

Oxide of iron,	23.70 = 16.59 per cent. of *Iron*.
Alumina,	6.02
Phosphoric acid,	1.13
Lime, a trace.	
Magnesia,	.71
Brown oxide of manganese,	6.62
Potash,	.42
Soda,	.16
Silex and insoluble silicates,	52.35
Combined water,	8.91
	100.00

The air-dried ore lost as much as 5.80 per cent. of *moisture* at 212° F.

Too poor to be smelted alone, and containing too much phosphoric acid to be desirable for mixture with the richer ores of iron. The proportion of oxide of manganese in this ore is quite considerable.

No. 453—LIMONITE. *Labeled "Iron Ore from the Old Iron Works, Wayne county, Ky."*

A dark, reddish-brown, dense limonite, with numerous irregular cavities. Powder of a rich maroon color.

Specific gravity,	3.252

Composition, dried at 212° F.—

Oxide of iron,	58.30	= 40.82 per cent. of *Iron*.
Alumina,	1.35	
Phosphoric acid,	.70	
Carbonate of lime,	.45	
Magnesia,	.37	
Potash,	.21	
Soda,	.03	
Silex and insoluble silicates,	35.35	
Combined water,	3.99	
	100.75	

The air-dried ore lost 1.90 per cent of *moisture* at 212° F.

A very good silicious iron ore, which requires only the addition of limestone to flux it in the furnace.

No. 229—Soil. *Labeled "Average quality of the "Barren" soil of Wayne county, Ky; hickory and black oak land, waters of Meadow creek; based on a reddish ferruginous sub-soil. (Sub-carboniferous Limestone Formation, or Stylina Chert.")*

Color of the dried soil dark-brownish-grey. Washed with water, one thousand grains of this soil left four hundred and ninety-eight and a half grains of brown-grey *sand*, generally *very fine*, and containing ninety-one grains of coarser sand, the particles of which, examined with the lens, were hyaline, milky, and yellow quartz, with small rounded fragments of a ferruginous mineral.

One thousand grains of the air-dried soil, digested for a month in water containing carbonic acid, gave up more than two grains and a half of *brown extract*, dried at 212°, which was found to consist of the following ingredients, viz:

	Grains.
Organic and volatile matters,	1.170
Alumina, oxide of iron, and phosphates,	.223
Lime,	.330
Magnesia,	.120
Sulphuric acid,	.151
Potash,	.096
Soda,	.067
Silica,	.140
Oxide of manganese, chlorine, and loss,	.254
	2.551

The air-dried soil lost 3.16 per cent. of *moisture* at 380° F.; dried at which temperature, it was found to have the following *composition*, viz:

Organic and volatile matters,	5.370
Alumina,	4.326
Oxide of iron,	2.526
Carbonate of lime,	.256
Magnesia,	.246
Brown oxide of manganese,	.236
Phosphoric acid,	.036
Potash,	.115
Soda,	.136
Sand and insoluble silicates,	86.066
Sulphuric acid, chlorine, and loss,	.687
	100.000

The only essential ingredient of this soil, which falls far below the average proportion, is the *phosphoric acid*. The application to it of bone-dust, or other *phosphatic* manures, would no doubt be greatly beneficial. Guano, Poudrette, *super-phosphate of lime*, &c., in mixture with ordinary barn-yard manure, would greatly increase its fertility.

No. 234—Soil. *Labeled "Meadow creek soil, Dougherty farm, Wayne county, Ky." "See Dr. Owen's notes."*

In lumps, like dried clay; nearly black; of the color of onion seed. (*Sub-carboniferous Limestone Formation.*)

Washed with water, one thousand grains of this soil left only 177½ grains of fine black sand, &c., which contain only twenty-two grains of coarser particles, part of which were blackened vegetable remains, which, when removed by burning, left about 16½ grains coarse sand, consisting of rounded particles of milky quartz, carnelian?, and a hard ferruginous mineral.

One thousand grains of the air-dried soil, digested for a month in water containing carbonic acid, gave up more than eight and a half grains of *brown extract*, dried at 212°. The infusion, before evaporation, had a smell like that of stable manure, or rotten straw; and the *extract*, when moistened, had the same odor.

The composition of this watery extracts was as follows:

	Grains.
Organic and volatile matters,	4.120
Alumina, oxide of iron, and phosphates,	.348
Carbonate of lime,	3.773
Magnesia,	.023
Potash,	.034
Soda,	.058
Silica,	.178
Oxide of manganese and sulphuric acid, not estimated.	
	8.534

It is probable that much of the lime stated as carbonate of lime was, in the extract, united with *organic acids*, which, when burnt out, left it in combination with carbonic acid. This soil contains a considerable proportion of such compounds, and hence the large amount of *extract* taken up by the carbonated water.

Dried at 365° F., the air-dried soil lost 8.28 per cent. of *moisture!* Thus dried its *composition* is as follows:

Organic and volatile matters,	21.560
Alumina,	10.240
Oxide of iron,	3.120
Lime,	1.021
Magnesia,	.922
Brown oxide of manganese,	.078
Phosphoric acid,	.229
Sulphuric acid, not estimated.	
Potash,	.351
Soda,	.123
Sand and silicates,	62.506
	100.150

A remarkable soil, from the very large proportion of organic matters which it contains. Its contents of lime, phosphoric acid, potash, and soda, are also above the average. If properly drained it would prove a very productive soil. Its very dark color would cause it to become very warm under the action of the sun, in consequence of its great power of absorbing heat.

WHITLEY COUNTY.

No. 231—Soil. *Labeled "Soil, from the Coal Measures of Whitley county, slope of the Clear fork, where the ferruginous shales prevail. Natural growth Beech, White Oak, and Hickory."*

Color of the dried soil yellowish-grey or buff-grey. It contains flat, angular fragments of ferruginous sandstone and iron ore. Washed carefully with water, one thousand grains left 466. grains of dirty buff-grey *sand*, mostly fine enough to pass through the finest bolting cloth, but containing 144 grains of *coarser sand*, the particles of which, examined with the lens, were rounded quartz grains—hyaline, milky, and yellow—with small fragments of a ferruginous mineral, with the angles rounded.

One thousand grains of the air-dried soil, digested for a month in water containing carbonic acid, gave up more than two grains of *brown extract*, dried at 212°, of which the *composition* was—

	Grains.
Organic and volatile matters,	1.160
Alumina, oxide of iron, and phosphates,	.218
Carbonate of lime,	.058
Magnesia,	.023
Sulphuric acid,	.129
Potash,	.054
Soda,	.151
Silica,	.090
Oxide of manganese and loss,	.339
	2.222

Dried at 390° this soil lost 3.28 per cent. of *moisture*, and presented the following *composition:*

Organic and volatile matters,	6.300
Alumina,	5.260
Oxide of iron,	5.660
Carbonate of lime,	.076
Magnesia,	.121
Brown oxide of manganese,	.420
Phosphoric acid,	.165
Sulphuric acid,	.322
Potash,	.170
Soda,	.147
Sand and silicates,	80.786
Loss,	.573
	100.000

No. 447—CARBONATE OF IRON. *Labeled "Carbonate of Iron, the so-called sil er ore of Swift's mine, Log Mountain, Whitley county, Ky." ("White Mineral Hydrated Silicate of Alumina?")*

A dark-grey nodular carbonate; not adhering to the tongue; exhibiting minute quartz crystals, specks of pyrites, and incrusted, in parts, with quartz and another white mineral, which was found to be the silicate of alumina; powder of a mouse-grey color.

Composition, dried at 212° F.—

Carbonate of iron,	78.35	= 39.20 per cent. of *Iron*.
Oxide of iron,	3.36	
Carbonate of lime,	.88	
Carbonate of magnesia,	2.67	
Carbonate of manganese,	1.49	
Alumina,	.58	
Phosphoric acid,	.63	
Sulphur,	.26	
Potash,	.29	
Soda,	.45	
Silex and insoluble silicates,	9.88	
Organic matter, trace of copper, and loss,	1.16	
	100.00	

The air-dried ore lost 0.20 per cent. of *moisture*, at 212°.

No. 193—CARBONATE OF IRON. *Labeled "Nodular Carbonate of Iron, found in the shale at the Falls of the Cumberland river, Whitley county, Ky. The so-called silver ore of Cumberland Falls."*

Of a dull dark-grey color, with infiltrations of a small quantity of whitish mineral, (silicate of alumina,) in the fissures; scarcely adhering to the tongue; powder of a yellowish-umber color.

Composition, dried at 212° F.—

Carbonate of iron,	73.13	= 38.81 per cent. of *Iron*.
Oxide of iron,	4.94	
Carbonate of lime,	1.15	
Carbonate of magnesia,	1.59	
Carbonate of manganese,	3.74	
Alumina,	.79	
Phosphoric acid,	.16	
Sulphur,	.09	
Potash,	.39	

Soda, - - - - - -	.19
Bituminous matters, - -	3.25
Silex and insoluble silicates, -	9.95
Moisture and loss, - - -	.63
	100.00

The air-dried ore lost 0.50 per cent. of *moisture* at 212°.

The above analysis of this somewhat *notorious* ore was made at this laboratory before it was known to me that Dr. Owen had also made a full examination of the same mineral, the results of which are published on page 235 of his first report. Indeed, this ore has been frequently examined, in consequence the wide prevalent belief, a few years ago, that it contained a considerable proportion of silver. Whatever may have been the motives prompting those who originated the statement that the Cumberland Falls Iron Ore was rich in silver, it is certain that a great number of person were deluded into the purchase of shares in a stock company, which was organized for working this new Potosi. The excitement, about the latter end of the year 1850, was so great on this subject that individuals in other states were induced to leave their homes in order to embark in this flattering pursuit; and even now, the writer is informed, a hope still lingers in the minds of some in the neighborhood of the falls that some day a man "well versed in the working of metals" may come along, who, by his metalurgic skill, will change their iron ore into silver—a feat which was for a time played off before the excited stockholders, to the extent of exhibiting five or ten cents worth of silver from his crucibles, by a Cornish miner, who had been employed by the prime movers of the speculation.

The ore is a very good iron ore, approaching the so-called *black-band* ore in its composition, but not containing as much bituminous matter as that variety. It could be quite economically smelted into a good quality of iron.

No. 448—Limonite. *Labeled "Iron Ore, head waters of Mud creek, Whitley county, Ky."*

A dense, compact, limonite, of a dark-brown color; nearly black; exhibiting some lustre; some surfaces covered with red and yellow ochreous mineral; a few irregular cavities throughout the mass; powder of a rich light yellowish-brown.

Specific gravity,		3.711
Composition, dried at 212° F.—		
Oxide of iron,	80.50	= 56.37 per cent. of *Iron*.
Alumina,	1.88	
Brown oxide of manganese,	.18	
Phosphoric acid,	.37	
Carbonate of lime,	.18	
Magnesia,	.80	
Potash,	.20	
Soda,	.19	
Silex and insoluble silicates,	2.48	
Combined water,	12.66	
Loss,	.56	
	100.00	

The air-dried ore lost 1.30 per cent. of *moisture* at 212° F.

A very pure hydrated oxide of iron—so pure that some poorer ore must be mixed with it to smelt it successfully in the high furnace.

No. 449—CARBONATE OF IRON. *Labeled "Carbonate of Iron, well at Mr. Sears', mouth of Poplar creek, Whitley county, Ky."*

A dark grey, fine granular, dense ore; in parts changed into brown and yellowish-brown; adhering to the tongue; powder dark-yellowish-grey.

Specific gravity,		3.432
Composition, dried at 212° F.		
Carbonate of iron,	67.72	= 37.60 per cent. of *Iron*.
Oxide of iron,	6.99	
Carbonate of lime,	3.38	
Carbonate of magnesia,	10.05	
Carbonate of manganese,	.70	
Alumina,	1.58	
Phosphoric acid,	.76	
Potash,	.30	
Soda,	.11	
Silex and insoluble silicates,	8.48	
	100.07	

The air-dried ore lost 0.50 per cent. of *moisture* at 212°.

No. 451—LIMONITE. *Labeled "Iron Ore, south part of Pine Mountain, Whitley county, Ky."*

A dark red-brown friable limonite; irregularly fine cellular; powder of a dull red color.

Composition, dried at 212° F.—

Oxide of iron,	63 60 = 44.53 per cent. of *Iron*.
Alumina,	2.98
Phosphoric acid,	.31
Sulphur,	.85
Brown oxide of manganese,	.31
Lime, a trace.	
Magnesia,	.30
Potash,	.34
Soda,	.29
Silex and insoluble silicates,	17.25
Combined water,	13.75
Loss,	.02
	100.00

The air-dried ore lost 4.00 per cent. of *moisture* at 212°.

This ore would require no addition but that of limestone to flux it in the furnace.

WOODFORD COUNTY.

No. 547—LIMESTONE. *Labeled "Leptæna Limestone, under the fine Woodford soil, near Versailles, Woodford county, Ky. (Lower Silurian Blue Limestone.")*

Very full of fossil remains, (shells, coral, and crinoid stems;) fresh fracture, of a dark-grey color, glimmering with minute facets of calcareous spar; weathered surfaces dirty-buff, and very irregular from rapid disintegration; powder of a light-buff-grey color.

Composition, dried at 212° F.—

Carbonate of lime,	91.33 = 51.25 *Lime*.
Carbonate of magnesia,	.56
Alumina, and oxides of iron and manganese,	1.53
Phosphoric acid,	.70
Sulphuric acid,	.33
Potash,	.34
Soda,	.43
Silex and insoluble silicates,	5.18
	100.40

The air-dried rock lost 0.20 per cent. of *moisture* at 212° F.

No. 548—LIMESTONE. *Labeled "Hill at Shryock's ferry, Woodford county, Ky. (Bird's-eye Limestone? of the Lower Silurian Formation.")*

A compact, very fine grained rock, with casts of fucoid stems (?) passing perpendicularly through it, which are filled with pure calcareous spar; of a handsome yellowish-grey color; powder white.

Specific gravity, - - - - - - - - 2.705

Composition, dried at 212° F.—

Carbonate of lime, - - -	94.75 =	53.17 of *Lime*.
Carbonate of magnesia, - -	1.96	
Alumina, and oxide of iron, &c.,	.63	
Phosphoric acid, a trace.		
Sulphuric acid, - - -	.30	
Potash, - - - - -	.23	
Soda, - - - - -	.32	
Silica and insoluble silicates, -	2.18	
	100.37	

The air-dried rock lost 0.20 per cent. of *moisture* at 212°.

This limestone being harder, of less easy disintegration under atmospheric influences, and containing less phosphoric acid and alkalies than the preceding, will not contribute so much mineral fertilizing matter to its super-incumbent soil as that rock, or as the one which immediately follows this.

No. 549—LIMESTONE. *Labeled, "Bellerophon Limestone, ("Niggerhead,") near Versailles, Woodford county, Ky."*

A light-grey, granular limestone, full of fossils, glistening with small facets of calcareous spar, and exhibiting some yellowish-brown infiltrations of oxide of iron.

Composition, dried at 212° F.—

Lime, - - - - -	54.12 =	96.24 carbonate of Lime.
Magnesia, - - - -	.45	
Carbonic acid, - - -	41.90	
Alumina, and oxide of iron, &c.,	1.04	
Phosphoric acid, - - -	.63	
Sulphuric acid, - - -	1.78	
Potash, - - - -	.48	
Soda, - - - - -	.39	
Silex and insoluble silicates, -	.78	
	101.57	

The air-dried rock lost 6.20 per cent. of *moisture* at 212° F.

No. 550—Soil. *Labeled "Virgin Soil, from Judge R. C. Graves' farm, water-shed between Greers' creek and Clear creek, near Versailles, Woodford county, Ky. Natural growth—hackberry, ash, walnut, mulberry, box elder, &c. One of the best soils of Ky."*

Color of the dried soil dirty-brown, or light-umber, with a slight tint of reddish. One thousand grains of this soil, carefully washed with water, left about 688. grains of light-umber colored *sand*, of which only about 90 grains was too coarse to go through the finest bolting cloth. This *coarser portion of the sand*, is composed of small rounded grains of soft iron ore, and of harder dark ferruginous mineral, with very few rounded quartzose particles.

One thousand grains of the air-dried soil, digested for two months in water containing carbonic acid, gave up more than six grains of yellowish-brown *extract* of the following *composition*, dried at 212°, viz:

	Grains.
Organic and volatile matters,	0.210
Alumina, oxide of iron, and phosphates,	.888
Brown oxide of manganese,	.498
Carbonate of lime,	3.377
Magnesia,	.230
Sulphuric acid,	.562
Potash,	.100
Soda, a trace.	
Silica,	.149
	6.014

The air-dried soil lost 4.70 per cent. of *moisture* at 400°; dried at which temperature its composition is as follows:

Organic and volatile matters,	7.771
Alumina, and oxides of iron and manganese,	12 961
Carbonate of lime,	2.464
Magnesia,	.173
Phosphoric acid,	.319
Sulphuric acid,	.150
Potash,	.394
Soda,	.130
Sand and insoluble silicates,	75.266
Loss,	.372
	100.000

No. 551—SOIL. *Labeled "Same soil as the preceding, from a field in constant cultivation since* 1808, *when a crop of hemp was raised; it has been fourteen years in hemp; average of the last year's* (1855) *crop of corn eighteen to twenty barrels,* (*of five bushels each,*) *to the acre; it has produced thirty-four bushels of wheat to the acre; Judge Graves' farm, near Versailles, Woodford county, Ky.*"

Color of the soil like that of the preceding, but a little lighter. Carefully washed with water one thousand grains of this soil left 490 grains of light-umber colored *sand*, of which fifty-four and a half grains would not pass through fine bolting cloth, and were composed principally of small rounded particles of soft iron ore, and of red and brown ferruginous quartz, and a few irregular fragments of milky quartz.

One thousand grains of the air-dried soil, digested for two months in water containing carbonic acid, gave up more than three and a half grains of *grey-brown extract*, dried at 212°, the composition of which was—

	Grains.
Organic and volatile matters,	0.530
Alumina, and oxide of iron and phosphates,	.198
Carbonate of lime,	2.248
Magnesia,	.163
Sulphuric acid,	.223
Potash,	.131
Soda,	.035
Silica,	.089
Brown oxide of manganese and loss,	.103
	3.720

The air-dried soil lost 4.60 per cent. of *moisture* at 400° F.; dried at which temperature its *composition* is as follows:

Organic and volatile matters,	5.513
Alumina, and oxides of iron and manganese,	13.344
Carbonate of lime,	2.734
Magnesia,	.333
Phosphoric acid,	.306
Sulphuric acid,	.037
Potash,	.205
Soda, not estimated.	
Sand and insoluble silicates,	77.594
	100.066

By comparison of this analysis of the soil of the *old field* with that of the *virgin soil* of the same locality, given above, the following instructive facts may be observed, viz: that by cultivation the soil has lost much of its soluble materials, which are dissolved by water containing carbonic acid, as well as of its *organic and volatile matters;* it is therefore lighter colored, and has a somewhat lower power of absorbing heat and moisture, than the virgin soil.

When we examine critically what mineral ingredients have been removed by the long series of cropping, we do not observe that the loss has fallen on the *sand and silicates*, or on the *alumina and oxide of iron, &c.*, but upon those substances which always exist in soils in small relative proportions, and which are essential to all vegetable growth, viz: the potash, soda, lime, phosphoric acid, and sulphuric acid. From some accidental cause the *magnesia*, which is also an element of vegetable tissues, appears to be in larger proportion in the old soil than in the new. Upon the whole, however, there is less loss of these valuable ingredients than might have been expected, probably from the circumstance that in the cultivation of hemp, with which the ground had been occupied for a considerable portion of the time, when the plant is rotted on the ground on which it is grown, and nothing finally removed from it but the lint or fibre, very little is carried off from the soil except lime and potash, and the other ingredients in minor proportion. If the whole hemp plant is removed from the soil, and water-rotted, not even the hemp-herds being restored to it by burning, the deterioration which results is much greater. Had this soil been cultivated wholly in corn, small grain, and such crops as tobacco, potatoes, &c., the chemical analysis would have shown a much greater loss from it of the elements of vegetable nutrition. Probably, also, the corn raised on this ground was habitually fed to hogs and cattle on the spot—a very common practice in Kentucky—so that, finally, nothing was removed from it, of its essential mineral ingredients, but that quantity which entered into the composition of the bones, flesh, and fluids of these animals.

No. 552—Sub-soil. *Labeled "Sub-soil from a field which has been in cultivation ever since* 1808, *farm of Judge R. C. Graves, two miles south of Versailles, Woodford county, Ky."*

Color of the dried sub-soil dark yellowish dirty-brown.

One thousand grains, when washed in water, left 664. grains of brown-grey *sand*, of which only 75. grains were too coarse to pass through the finest bolting cloth, and this was principally rounded particles of soft iron ore, which could be crushed in the fingers, and a few rounded quartzose grains.

One thousand grains of the air-dried soil, digested in water containing carbonic acid for two months, gave up nearly five grains of yellowish-brown *extract*, dried at 212°, which had the following composition:

	Grains.
Organic and volatile matters,	0.850
Alumina, oxide of iron, and phosphates,	.379
Carbonate of lime,	2.817
Magnesia,	.093
Sulphuric acid,	.419
Potash,	.177
Soda,	.010
Silica,	.129
Oxide of manganese and loss,	.076
	4.950

The air-dried sub-soil lost 4.52 per cent. of *moisture* at 400°.

Dried at which temperature its *composition* is as follows:

Organic and volatile matters,	6.460
Alumina, and oxides of iron and manganese,	13.773
Carbonate of lime,	3.476
Magnesia,	.354
Phosphoric acid,	.447
Sulphuric acid,	.042
Potash,	.498
Soda,	.095
Sand and insoluble silicates,	75.434
	100.607

This sub-soil is as rich as the original virgin soil.

No. 553—Sub-soil. *Labeled "Red clay, under the sub-soil, from Judge R. C. Graves' farm, near Versailles, Woodford county, Ky."*

Color of the dried sub-soil dirty light-reddish-brown.

One thousand grains left, after careful washing in water, 680 grains of reddish-brown sand, of which 403 grains were too coarse to go through the finest bolting-cloth, and consisted mainly of rounded par-

ticles of yellowish-brown and dark-brown iron ore, so soft as to be easily crushed in the fingers, with a very few small quartzose fragments.

One thousand grains of the air-dried sub-soil, digested for two months in water containing carbonic acid, gave up only *one grain* of *brownish extract*, dried at 212°, of which the composition was—

	Grain.
Organic and volatile matters,	0.300
Alumina, and oxides of iron and manganese, and phosphates,	.078
Lime,	.163
Magnesia,	.073
Sulphuric acid,	.185
Potash,	.067
Soda,	.013
Silica,	.099
Carbonic acid and loss,	.022
	1.000

Dried at 400° the air-dried sub-soil lost 5.04 per cent. of *moisture;* thus dried its *composition* is as follows:

Organic and volatile matters,	6.065
Alumina, and oxides of iron and manganese,	33.377
Carbonate of lime,	.138
Magnesia,	.0 0
Phosphoric acid,	.383
Sulphuric acid,	.198
Potash,	.234
Soda,	.127
Sand and insoluble silicates,	59.360
Loss,	.038
	100.000

In view of the large proportion of alumina and oxide of iron, &c., in this 'red clay' it is probable that some of the 6.065 grains, stated above as the *organic and volatile matters*, is simply water.

This clay contains rather more phosphoric and sulphuric acids than the super-incumbent soil, but much less of carbonate of lime; the potash is in about average proportion. Its great peculiarity is the large amount of *alumina and oxide of iron* which it contains; and these, by their strong affinity for organic matters, prevent the solution of much solid matter by the carbonated water.

From the foregoing analyses of the soils and sub-soils of this part of Woodford county it is evident, that whilst deep ploughing into the immediate sub-soil would be quite beneficial to growing crops, the *heavy, red clay* under the sub-soil would not add any thing peculiarly valuable to this rich soil, which already has enough of alumina and oxide of iron in its composition to make it a loam very favorable for cultivation.

ILLINOIS.

No. 554—Soil. *Labeled "Soil taken from just under the newly upturned original sod of the prairie, opposite to Keokuk, Iowa, a few (about eight) miles back from the Mississippi river, on the Illinois side."*

The dried soil is of a dark mouse-color, almost black; without any appearance of pebbles or gravel; under the microscope showing very fine glimmering grains of sand. This was not submitted to the solvent action of water charged with carbonic acid, to which it would doubtless give up a considerable amount of *solid extract.*

Dried at 300° it lost 3.28 per cent. of *moisture;* and, thus dried, was found to have the following *composition,* viz:

Organic and volatile matters,	9.050
Alumina,	2 405
Oxide of iron,	2 350
Carbonate of lime,	.890
Magnesia,	.526
Phosphoric acid,	.175
Sulphuric acid, not estimated.	
Potash,	.197
Soda,	.100
Sand and insoluble silicates,	84.470
	100.163

This analysis of the prairie soil of the north-western part of Illinois was introduced for the purpose of comparison with the soils of Kentucky. The specimen analyzed was collected by the writer himself, in October, 1855.

Notwithstanding the luxuriance of the growth of the first crops on the prairie soil, occasioned partly by the large amount of available nourishing matter afforded by the decay of the thick sod, it is evident, from the above analysis, that, taking into consideration *durability* as well as *immediate fertility,* as ascertained by the chemical analysis of

the soil itself, apart from the sod, there are many of our Kentucky soils—which take the second rank when compared with those of the *blue-grass region*—which yet are fully equal to the prairie soil. The reader may turn, for comparison, to the analysis of Mr. Barlow's soil, Barren county; to that of the virgin soil of Mr. O'Bannon's farm, Jefferson county; and to that of the virgin soil, on Benson creek, Franklin county, &c., &c., all in the present volume.

Compared with the *first rate* soil of Kentucky, that of the prairies contains a much smaller proportion of *alumina and oxide of iron*, as well as of *lime, magnesia, phosphoric acid, and alkalies*. It contains a much larger amount of *fine sand*, and doubtless a larger proportion of the *coarser sand*, than our best soils; and, therefore, whilst its large quantity of *organic matters* is held in the soil with a small force of attraction, (because of the large proportion which the *sand and silica* bear to the *alumina and oxide of iron*,) and hence they are readily soluble and immediately available in the production of luxuriant crops, these very circumstances will cause its more speedy exhaustion; and, when this accumulated deposit has been consumed by thriftless husbandry, this soil must sink down to a second-rate position. Yet, from its lightness, it is admirably adapted to garden purposes, sustained, as it should be, by the judicious supply of manures.

PENNSYLVANIA.

No. 555—Coal. *Labeled "Youghiogheny Coal, Pennsylvania."*

A good specimen obtained from the Lexington Gas Works, and analyzed for the purpose of comparison of our Kentucky coals with a coal of well known good qualities.

Specific gravity, - - - - - - - -	1.329		
Proximate Analysis.			
Moisture, - - - -	1.00	Total volatile matters, -	36.00
Volatile combustible matters, -	35 00		
Carbon in the coke, - -	58.40	Light spongey coke, -	64.00
Ashes, (lilac-grey,) - -	5.60		
	100.00		100.00

Ultimate Analysis.

Carbon,	78.437
Hydrogen,	5.689
Nitrogen,	1.319
Oxygen and loss,	8.555
Ashes,	.600
Sulphur, not estimated.	
	100.000

It will be seen that several of the Kentucky coals compare very favorably with this well known soft bituminous coal, which is much esteemed by the blacksmith, and for *gas* and *coke:* we may refer particularly to Garrard's coal, Clay county, and to several of the coals of Union and Crittenden counties, which are good coking coals.

To make the comparison more extensive this coal was submitted to distillation, at a temperature slowly raised to the red-heat, to ascertain the relative amount of *oils* and *gas* produced. One thousand grains of the air-dried coal gave, of

	Grains.
Thick brownish-black crude oil,	136
Purplish ammoniacal water,	52
Light cellular coke,	710
Leaving for gas and loss,	102
	1000

The gas collected measured 545. cubic inches, and had pretty good illuminating power, but not better than that from Mulford's coal, if as good.

This result does not, of course, represent the relative quantity of illuminating gas which the coal would yield if heated under conditions favorable for the production of gas. When distilled, as this and all the Kentucky coals examined were treated, at the lowest heat which would cause their decomposition, in order to produce as much as possible of the liquid and solid hydrocarbons, the quantity of gas obtained is always very much less than could be produced from the same coal suddenly exposed to a red heat, in the gas retort; but, as all the coals examined were submitted to the same low temperature, it is believed that the relative quantity of gas collected would give a correct idea of their gas producing powers under more favorable conditions.

TABLE 1. (*A*)

IRON ORES, LIMONITES. *Showing the per centage of each ingredient.*

37 Number in the report.	County.	Specific Gravity.	Peroxide of iron.	Carbonate of iron.	Brown oxide of manganese.	Carbonate of lime.	Magnesia.	Alumina.	Phosphoric acid.	Sulphur.	Potash.	Soda.	Combined water.	Silica.	Per centage of iron.
489	Bullitt,	2.984	62.01	-	0.78	0.18	1.02	0.68	0.89	0.58	0.36	0 20	12.00	21.18	43.46
473	Carter,	-	78.42	-	3.17	trace.	.30	1.48	.73	-	.21	.18	11 94	3.77	54.93
412	Clinton,	3.503	74.30	-	1.68	-	.35	1.48	.18	trace.	not es	timated.	12 24	9.95	52 03
414	Edmonson,	-	60.90	-	.75	trace.	1.15	.65	.57	-	.36	.32	11.15	23.68	42.64
415	Edmonson,	-	74 70	-	.35	trace.	.15	.45	.55	-	not es	timated	11.19	12.65	52.31
419	Edmonson,	-	62.12	-	.05	trace.	.20	2 45	.43	.02	.38	.42	13.25	20.55	43.50
307	Greenup,	-	80.30	-	.35	-	.40	not est.	.60	-	.34	.01	12,12	6.55	56.21
474	Greenup,	-	68.30	-	-	.28	2.64	3.65	.27	-	.27	.22	12.09	12.28	47 83
476	Greenup,	-	72 80	-	.45	.18	1.19	2.17	-	-	.48	.02	11.20	10.57	50 98
316	Greenup,	-	76.90	-	.25	-	.28	1.21	.64	-	.23	.16	9.09	11.77	53.85
317	Greenup,	3.292	68.20	-	.26	trace.	1.02	2.98	99	-	not es	timated.	8.57	17.17	47.76
318	Greenup,	-	61.10	-	.95	.45	1.09	.85	trace.	-	.38	.10	11.67	23.85	42 78
478	Greenup,	3.083	58.30	-	.65	.15	.77	1.05	1.25	-	.40	.08	8 31	29.77	40.82
289	Greenup,	-	24.70	-	.05	-	.67	3.75	trace.	-	.32	.01	5.66	64.42	17.29
309	Greenup,	2.770	41 40	-	.75	1.15	1.50	3.36	.54	-	.23	.01	10.54	41.47	28.99
293	Greenup,	3.026	77.50	-	1.03	.76	.79	1.23	.40	.50	.20	.14	9.62	7.77	54 25
431	Greenup,	-	74.50	-	2.43	.77	1.81	1.00	.33	.57	.15	.13	3.86	14.93	52.17
430	Greenup,	-	38.38	-	1.23	trace.	.60	3.54	1.01	.05	.28	.18	8.12	46.83	26 87
290	Greenup,	-	80 03	-	2.03	.64	2.87	1.44	.66	-	.25	.16	2 01	9.93	56.02
291	Greenup,	3.018	73.90	-	1.13	trace.	.39	1.71	.62	.09	.19	.05	11.51	10.43	51.75
292	Greenup,	3.406	81.40	-	1.63	trace.	.35	.77	.24	.07	.26	.22	6.72	8.33	57.00
441	Greenup,	-	51.10	-	1.83	trace.	.68	1.07	.76	.32	.38	.10	8.13	35.93	35.78
442	Greenup,	-	83 83	-	1.73	trace.	.32	.43	.94	.21	.30	.11	11.30	.83	58.70
444	Greenup,	-	53.44	24.79	1.44	0.87	.62	.09	1.26	.11	.34	.08	6 89	9.93	49.39
446	Greenup,	-	66.76	-	1.23	trace.	.26	1.00	1.41	trace.	.34	trace.	11.59	17.87	46 75
422	Greenup,	-	66.03	-	.55	trace.	.76	4.15	.67	.06	.46	.11	.71	27.15	46.24
424	Greenup,	-	63.60	-	.55	trace.	.99	.25	.70	.06	.25	.05	10.77	23 23	44.54
425	Greenup,	-	85.91	-	2.17	.17	.85	1.25	.09	-	.23	.18	7.90	1.25	60.16

TABLE 1. (*A*)—Continued.

Number in the report.	County.	Specific gravity.	Peroxide of iron.	Carbonate of iron.	Brown oxide of manganese.	Carbonate of lime.	Magnesia.	Alumina.	Phosphoric acid	Sulphur.	Potash.	Soda.	Combined water.	Silica.	Per centage of iron.
428	Greenup,	-	84.45	-	.09	-	1.43	1.20	.38	.06	.44	.10	2.80	9 05	59.14
429	Greenup,	-	69.60	-	.75	trace.	.35	.55	.42	.07	.42	.01	12.18	15 65	48 74
299	Greenup,	-	53.46	-	.85	33.85	3.15	trace.	.87	.02	.23	.07	6 45	1.05	37.44
436	Greenup,	-	88.51	-	1.95	trace.	.78	.15	.19	.03	.09	.17	6.00	2 23	61 98
437	Greenup,	-	80.20	-	.05	-	.51	.05	.86	.48	.02	-	11.31	6.45	56.14
438	Greenup,	-	49.90	-	.27	8.05	4.19	7.00	1.45	-	.41	-	9.61	19.15	35.06
439	Greenup,	-	73.34	-	9 41	1.27	.83	.27	.36	-	.40	.03	9 54	4.55	51.36
408	Grayson,	-	63.60	-	.87	.27	1.22	2.36	.89	-	.25	-	12 02	19.15	44.54
418	Monroe,	-	76.90	-	.95	.27	.73	.27	.30	-	.20	.08	11.79	9 35	53.85
405	Ohio,	-	39.48	-	1.77	trace.	1.12	1.81	.60	-	.34	.06	8.28	47 37	27.64
413	Ohio,	-	60.18	-	.27	trace.	.73	4.85	.60	-	.40	08	13 14	19.75	42.14
546	Pulaski,	2.696	27.18	-	-	-	-	.70	-	-	-	-	3 50	69 18	-
420	Trigg,	-	56.10	-	1.05	.57	trace.	.45	.38	trace.	.34	.08	10.70	30.15	39.28
421	Trigg,	3 778	79.40	-	.67	-	.60	.45	.87	-	.21	.05	11.98	5 75	55.60
417	Warren,	-	67.14	-	1.37	.27	.67	.80	.86	-	.37	-	11.16	17.95	47 02
450	Wayne,	-	23.70	-	6.62	trace.	.71	6.02	1.13	-	.42	.16	8.91	52.35	16.59
453	Wayne,	3.252	58.30	-	-	.45	.37	1.35	.70	-	.21	.03	3.99	35 35	40.82
448	Whitley,	3.711	80.50	-	.18	.18	.80	1.88	.37	-	.20	.19	12.66	2.48	56.37
451	Whitley,	-	63.60	-	.31	trace.	.30	2.98	.31	0.85	.34	.29	13.75	17.25	44.53

TABLE 1. (*B*)

Iron Ores, Carbonates of Iron.

Number in report.	County.	Specific gravity.	Carbonate of iron.	Oxide of iron.	Carbonate of lime.	Carbonate of magnesia.	Carbonate of manganese.	Alumina.	Phosphoric acid	Sulphuric acid.	Sulphur.	Potash.	Soda.	Bituminous matter.	Silica.	Water.	Per centage of iron.
488	Bullitt,	3.446	57.59	7.77	6.28	11.76	1.32	1.55	0.71	-	0.29	0.75	0.27	-	11.18	-	32.62
493	Bullitt,	3.445	53.64	7.71	6.08	13.99	1.94	.55	.10	1.37	.55	.69	.20	-	11.48	2.25	31.30
409	Butler,	3.026	70.20	9.92	2.55	7.04	1.60	1.51	.64	-	trace.	.42	.01	-	7.65	-	39.45
416	Edmonson,	3.507	65.1-	7.98	1.95	8.45	1.83	.95	.36	.67	-	.57	.05	2.89	9.17	-	37.04
482	Greenup,	-	70.27	10.16	2.45	5.52	1.46	.15	.73	-	-	.40	.09	-	8.15	-	40.70
475	Greenup,	3.155	28.01	14.42	29.37	5.57	.18	1.38	.29	-	-	.42	.33	-	19.98	-	23.62
479	Greenup,	3.497	67.84	5.89	3.25	4.28	1.97	1.45	.60	-	-	.50	.09	-	13.78	-	37.46
312	Greenup,	-	56.92	14.14	1.25	5.28	2.04	1.05	.99	-	-	.61	.01	.80	16.15	-	37.10
311	Greenup,	-	60.49	5.25	3,15	6.52	.83	.41	trace.	-	-	.34	.29	-	21.82	-	32.57
294	Greenup,	-	54.42	30.24	.45	.83	1.29	1.86	.43	-	.35	.38	.20	2.58	6.97	-	47.51
440	Greenup,	-	43.90	23.06	3.87	3.28	.65	.33	.23	-	.18	.23	.23	2.60	22.15	-	35.02
443	Greenup,	3.360	67.50	1.28	2.15	4.57	1.18	.35	.36	-	.17	.29	.09	-	21.45	-	33.12
445	Greenup,	3.567	47.84	-	3.25	3.65	6.00	.55	trace.	-	11.51	.34	.08	1.94	4.75	-	41.63
300	Greenup,	3.566	60.40	21.38	3.17	3.46	1.52	.65	.63	-	trace.	.40	.13	-	6.03	2.23	43.82
406	Laurel,	3.126	32.29	5.01	2.95	3.60	.64	1.55	1.00	-	-	.42	.01	.98	51.55	-	19.10
410	Laurel,	3.395	68.46	3.41	.75	3.73	1.31	1.43	.52	-	-	.34	.07	.79	19.65	-	35.45
411	Laurel,	3.352	66.01	2.67	5.85	9.19	.86	.35	.63	-	-	.34	.33	-	12.68	-	33.05
407	Lincoln,	3.334	47.97	10.66	7.25	12.13	3.03	2.99	.36	-	.21	.57	.24	-	13.95	-	30.77
452	Pulaski,	3.344	53.02	20.13	5.35	7.48	.71	1.95	1.13	-	-	.54	.08	.16	9.45	-	35.60
447	Whitley,	-	78.35	3.36	.88	2.67	1.49	.58	.63	-	.26	.29	.45	1.16	9.38	-	39.20
199	Whitley,	-	73.13	4.94	1.15	1.59	3.74	.79	.16	-	.09	.39	.19	3.25	9.95	-	38.81
449	Whitley,	3.432	67.72	6.99	3.38	10.05	.70	1.58	.76	-	-	.30	.11	-	8.48	-	37.60

TABLE 2. Coals.

Number in report.	County.	Specific gravity.	Moisture.	Volatile combustible matters	Carbon in the Coke.	Ashes.	Total volatile matters.	Coke.	Carbon.	Hydrogen.	Sulphur.	Nitrogen.	Oxygen.	Bituminous oil per 1000 grains.	Designation.
462	Christian,	1.280	4 60	34.90	58.36	2 14	39.50	60.50	76.676	4.533	1.440	15.191		-	Woolich's.
460	Clay,	1.259	2.70	34.90	61 10	1 30	37.60	62 40	80.619	5.444	.575	1.457	10.305	-	Garrard's.
25	Crittenden,	-	-	-	-	3 80	-	-	78.500	5 333	1.040	1 344	9.983	-	Sneed's.
189	Daviess,	1.275	-	-	-	2.00	-	-	77.891	5 422	.300	1.821	12 566	-	Wolf Hill.
502	Daviess,	1.328	6.70	36.00	51.30	6.00	42.70	57.30	71.019	5 022	2.090	15.069		-	Triplett's.
101	Greenup,	-	-	-	-	4.00	-	-	79 091	5.111	.734	11.604		-	Ashland, (main.)
468	Hancock,	1.282	6.50	34.90	53.20	5.40	41.40	58.60	73.255	5.155	.520	15 470		-	Hawesville, (1st bed.)
519	Hancock,	1.392	3 00	39.10	45 40	12.50	42.10	57.90	63.436	4.622	5.866	12.476		-	Judge Mayhall's.
520	Hancock,	1.266	6.30	39.80	51.40	2.50	46.10	53.90	75 328	5.600	.890	15 882		-	Mr. Pate's.
243	Hancock,	1.318	1.30	54.40	32 00	12.30	55.70	44.30	68.128	6.489	2 476	2.274	5 833	318. grs.	Breckinridge.
463	Hopkins,	1.277	3.20	35 40	57.80	3.60	38.60	61.40	75 491	5 088	1.520	14.101		-	Mr. Hall's.
465	Hopkins,	1.422	5.00	28.40	53.50	13.10	33.40	66.60	66.000	4.244	.820	13.436		-	Mr. Samuel's.
135	Hopkins,	-	-	-	-	2.40	-	-	77.400	4.999	1.060	1.620	12.521	-	Wright's Mountain.
466	Lawrence,	1 326	3 60	35 90	53.50	7.00	39.50	61.50	72.655	5.111	1.750	13.084		-	McHenry's.
469	Lawrence,	1.358	4.10	33.70	53.00	9.20	37.80	62.20	70.200	4.777	1.470	13.953		-	Kerner's.
240	Livingston,	1.356	-	-	-	8.60	-	-	78.000	4 977	.630	0.628	7.165	148. grs.	Union County.
464	Muhlenburg,	1 271	3 80	41.50	53 60	1.10	45 30	54 70	79.577	5.199	.640	13.384		-	Walker's.
191	Muhlenburg,	1.263	5 80	32 50	56 70	5.00	38.30	61.70	74.455	4.933	.906	1.030	13.076	102.10	Roberts', (main.)
156	Muhlenburg,	-	-	-	-	3.40	-	-	76.091	5.222	1.350	13 937		-	Airdrie.
157	Muhlenburg,	-	-	-	-	3.40	-	-	76 855	5.244	.654	13.847		-	Eade's.
459	Ohio,	1.272	5 50	41.20	48.90	4.40	46.70	53.30	71.618	5.377	1.750	16.455		-	Pitchner's
470	Ohio,	1.311	4.70	37.90	52.02	5.38	42.60	57.40	74.510	5.332	3.054	12.504		-	Barrett's.
461	Ohio,	1 272	5.60	38.30	53.60	2.50	43.90	56.10	75.219	5.177	1.704	14.900		-	Jackson's.
160	Owsley,	-	-	-	-	3.00	-	-	76.791	6 177	.241	13.791		248.5 grs.	Haddock's Cannel.
467	Pulaski,	1.274	2.20	38.90	57.00	1.90	41.10	58.90	78 608	5.311	.380	13.451		-	Scar's.
471	Pulaski,	1.311	4.40	33.80	58.80	3.00	38.20	61.80	76.364	5.200	.420	14.716		-	Cumberland.

185	Union,	1.321	–	–	–	7.60	–	–	76.200	5.644	1.746	.552	8.258	136.5 grs.	Mulford's five foot.
188	Union,	1.325	–	–	–	6.80	–	–	73.417	4.977	2.824	1 658	10.322	108. grs.	Ice House.
166	Union,	–	–	–	–	7.60	–	–	74.309	5.244	.880	11 967		–	Casey's.
555	(Pennsylvania)	1.329	1.00	3.500	58.40	5.60	36.00	64.00	78.437	5.689	not est	1.319	8.555	–	Youghiougheny.

TABLE 3. Iron Furnace Slags.

Number in report.	County.	Silica.	Alumina.	Lime.	Magnesia.	Protoxide of iron.	Protoxide of manganese.	Potash.	Soda.	Oxygen in the silica.	Oxygen in the bases.	Proportion of O. in the bases to O. in the silica.	Furnace.
491	Bullitt,	54.60	15 90	11.93	8.09	3.29	1.08	4.25	1.31	28.350	16.780	1 : 1.69	Bellemont.
492	Bullitt,	53.36	17.26	9.74	8.09	6.35	.89	4.09	1.02	27.700	16 540	1 : 1.67	Bellemont.
330	Greenup,	58.00	20 50	12 06	2.19	3.51	1.21	2.12	.55	28.884	15.551	1 : 1.78	Buena Vista.
423 (a)	Greenup,	48.80	33.27	12.50	1.24	1.19	.51	1.62	.18	25.338	15.499	1 : 1.63	Caroline, (gran'lr.)
423 (b)	Greenup,	48.86	33.05	12.86	2.74	1.13	.51	1.54	.15	25.369	16.169	1 : 1.57	Caroline, (glassy.)

TABLE 4. Sandstone, &c.

Number in report.	County.	Specific gravity.	Sand, &c.	Carbonate of magnesia.	Carbonate of lime.	Potash.	Soda	Alumina and oxide of iron.	Sulphuric acid.	Phosphoric acid.	
496	Bullitt,	2.427	93.68	0.84	trace.	0.21	0.59	3.95	trace.	- -	
497	Bullitt,	2.415	94.78	2.29	0.18	.27	.14	2 85	trace.	- -	
498	Bullitt,	2.453	94 75	.70	.16	.96	.10	3 48	trace.	- -	
505	Fayette,	-	87 83	1.40	trace	.27	.14	8.65	.22	0.25	Underlying the Beech
506	Fayette,	-	83.45	2.30	1.79	.41	.01	10.25	.92	.50	Ridge.

TABLE 5. Pig Iron.

Number in report.	County	Specific gravity	Iron.	Graphite.	Combined carbon.	Total carbon.	Manganese.	Silicon	Slag.	Alumina.	Calcium.	Magnesium.	Potassium.	Sodium.	Phosphorus.	Sulphur.	Furnace.
435	Greenup,	7 009	90 00	1.77	0.90	2 67	0.33	4 28	1.15	0.13	0 14	0.21	0.17	0.14	0.61	0.12	Laurel.
434	Greenup,	6.886	89.54	1.87	.16	2 03	.54	5.57	1.25	.13	.19	.20	.17	.11	.46	.10	Laurel.

TABLE 6. LIMESTONES.

Number in report.	County.	Specific gravity.	Carbonate of lime.	Carbonate of magnesia.	Lime.	Magnesia.	Carbonic acid.	Alumina and oxide of iron.	Phosphoric acid.	Sulphuric acid.	Carbonate of iron.	Carbonate of manganese.	Potash.	Soda.	Bituminous matter.	Silica.
484	Anderson,	-	96.65	-	54.23	-	-	1.26	0.92	0.25	-	-	0.57	0.39	-	0.88
485	Anderson,	-	83.95	0.91	47.11	-	-	2.23	.25	.34	-	-	.38	.47	-	11.28
486	Anderson,	2.653	86.45	1.57	48.52	-	-	1.83	.12	trace.	-	-	.62	.11	-	9.57
490	Bullitt,	2.766	63.13	27.76	35.43	-	-	4.34	.19	3.77	-	-	.44	.15	-	1.61
494	Bullitt,	2.799	63.45	29.64	-	-	-	3.15	-	.27	-	-	.20	.21	-	2.18
495	Bullitt,	2.765	50.25	31.05	-	-	-	5.37	trace.	1.46	-	-	.59	.20	-	10.32
507	Fayette,	2.660	92.73	.63	52.03	-	-	2.42	.86	.34	Chlorine	0.05	.23	.28	-	2.18
508	Fayette,	2.711	77.63	10.00	43.56	-	-	3.23	.70	3.12	-	-	.32	.15	-	4.98
511	Fayette,	2.716	51.57	29.33	-	-	-	3.57	.37	.34	-	-	.71	.82	-	11.58
512	Fayette,	2.703	55.54	40.80	31.16	-	-	.96	-	.02	-	-	.36	.22	-	2.79
513	Fayette,	2.615	55.99	37.33	-	-	-	.72	.25	.33	-	-	2.35	.25	-	3.38
514	Franklin,	2.699	-	-	50.19	0.66	40.15	1.24	.44	.68	-	-	.23	.29	-	6.94
515	Franklin,	2.700	76.75	.19	-	-	-	2.25	.09	.85	-	-	.48	.44	-	18.86
516	Franklin,	-	92.65	1.54	51.99	-	-	1.19	.09	1.27	-	-	.30	.13	-	3.68
481	Greenup,	2.691	73.90	2.08	-	-	-	1.19	.46	-	-	-	.27	.05	-	21.67
477	Greenup,	-	91.47	2.75	-	-	-	.48	-	-	1.82 oxide	.05	.13	.10	-	3.38
433	Greenup,	2.699	97.90	.74	54.93	-	-	.53	-	-	- 22.19 oxide	-	.28	.08	-	1.27
432	Greenup,	2.731	50.33	1.83	-	-	-	.77	.77	.70	1.49 oxide	.47	.38	.20	-	21.43
426	Greenup,	-	65.13	-	-	1.41	-	.13	.17	.40	25.80 oxide	.17	.11	.06	-	1.27
427	Greenup,	2.729	84.47	3.47	-	-	-	.25	.62	-	7.73 oxide 1.77	.26	.32	.14	-	.55

TABLEs 6—Continned. LIMESTONE.

Number in report.	County.	Specific gravity.	Carbonate of lime.	Carbonate of manganese.	Lime.	Magnesia.	Carbonic acid.	Alumina and oxide of iron.	Phosphoric acid	Sulphuric acid.	Carbonate and oxide of iron.	Carbonate of manganese.	Potash.	Soda.	Bituminous matters.	Silica.	
456	Grayson,	2.651	46.83	26.84	26.28	-	-	0.38	0.12	0.33	3.44	trace.	0.50	0.37	-	20.78	Hydraulic.
521	Jefferson,	-	50.43	18.67	28.29	-	-	2.93	.06	1.58	-	-	.32	.13	-	25.78	Hydraulic.
528	Jefferson,	-	50.76	45.00	28.49	-	-	1.78		.04	-	-	.21	.35	-	2.48	Magnesian.
530	Jefferson,	-	56.36	37.07	31.62	-	-	1.28		trace.	-	-	.33	.35	-	5.68	Magnesian.
325	Lawrence,	-	50.95	4.53	-	-	-	1.91	.36	-	7.63	-	.57	.31	2.00	32.17	-
455	Ohio,	2.721	-	-	47.06	2.39	38.55	1.44	.12	.80	-	-	.29	.24	-	9.96	Hydraulic?
457	Trigg,	2.702	-	-	43.91	7.00	40.90	.36	.06	-	-	-	.21	.09	-	8.36	Hydraulic?
458	Trigg,	2.596	-	-	28.61	14.77	38.85	1.96	.92	.29	-	-	.27	.30	-	13.68	Hydraulic?
547	Woodford,	-	91.33	.56	51.25	.26	40.38	1.53	.70	.33	-	-	.34	.43	-	5.18	Leptæna.
548	Woodford,	2.705	94.75	1.96	53.17	.93	42.61	.63	trace.	.30	-	-	.23	.32	-	2.18	Bird's-eye?
549	Woodford,	-	-	-	54.12	.45	41.90	1.04	.63	1.78	-	-	.48	.39	-	.78	Bellerophon.

TABLE 7. Soils, Marls, and Sub-soils.

Number in the report.	County.	Dissolved from 1000 grains by water containing carb. acid.	Moisture.	Organic and volatile matters.	Alumina.	Oxide of iron.	Oxide of manganese.	Carbonate of lime.	Magnesia and carbonate.	Phosphoric acid.	Sulphuric acid.	Chlorine.	Potash.	Soda.	Sand and silicates.	Formation, &c.
		Grains.	per ct.	per c.	per ct.	per ct.	per ct.	per ct.	per ct	per ct.	per ct.	per ct.	per ct.	per ct.	per ct.	
233	Adair,	2 471	2.50	4.440		4 841		0.196	0.046	0.065	0.232	0.005	0.075	0.092	90.416	Lower Silurian.
218	Ballard,	0 733	1 80	2.110	2.580	2.240	0.090	.150	.860	.410	-	-	.120	.020	91.720	Quaternary.
219	Ballard,	1 293	2.14	2.920	2.250	3.390	0 360	trace.	.470	.180	-	-	.190	trace.	90.210	Quaternary.
225	Barren,	3 872	2.34	5.200	3.460	2.206	.234	.366	.205	.159	.197	-	.197	.090	87.686	Sub carb. Limestone.
227	Barren,	0.820	3.90	4.730	10.380	6.398	.256	.096	.522	.075	.466	-	.142	.082	77.067	Sub-carb. Limestone.
312	Breckinridge,	1 775	6 72	7 040		12.170		.976	.413	.101	.198	.002	.556	.190	78.680	Do. marly shale.
216	Christian,	0 960	2.24	2.960	2.390	2.360	.270	.130	.790	.270	-	-	.190	.040	90.260	A sub soil.
500	Clarke,	2.093	4.16	6 100	3 940	4.920	.400	.470	.620	.480	not est.	-	.320	.080	82.650	Lower Silurian.
501	Clarke,	1 370	2 96	4.010	7.710	7.060	.290	.990	1 040	.380	not est.	-	.360	.030	78 030	Lower Silurian.
222	Clinton,	1.481	1.96	3.970	1.766	2.466	.076	.076	.131	.090	not est.	-	.085	.099	90.720	Sub carb. Limestone.
232	Cumberland,	5.122	2.40	5.770	1.230	3.140	.076	.336	.438	.127	.734	.006	.220	.029	87.110	Knob Formation.
230	Daviess,	3 592	1.62	3.350	2.026	2·146	.126	.176	258	.088	not est	-	.096	.053	91.920	Coal Measures.
504	Fayette,	3 520	4.12	4 881		10.306		.276	.133	.254	.109	-	.139	.047	83.834	Lower Silurian (beech woods.)
509	Fayette,	4.350	7.30	5.242		19.206		1.196	.426	.434	.054	-	308	.086	72 994	Red sub-soil.
510	Fayette,	1.112	6.38	4.913		20.300		.116	.034	.383	.082	-	.309	.159	73 874	Red sub soil.
517	Franklin,	3 680	5 18	9.133		8.100		.316	517	.243	.068	-	.173	.049	80.754	Lower Silurian.
518	Franklin,	2 637	1.98	3 790		4 589		196	.066	.151	.054	-	.135	.026	90.734	Lower Silurian.
518a	Franklin,	2.366	2.525	4.206	2.120	2 915	.004	.173	.233	.128	.043	-	.130	.051	90.170	Lower Silurian.
518b	Franklin,	0 830	3.30	3.179	4.470	4.825	.005	.092	312	.148	.033	-	.282	.012	86.380	Lower Silurian.
522	Jefferson,	-	4 42	7.996		7.418		394	.240	.205	.082	-	.200	.043	83.134	Upper Silurian.
523	Jefferson,	-	2.80	4.506		6.948		316	.200	.191	.067	-	.158	.070	88.318	Upper Silurian.
524	Jefferson,	-	2.98	2 844		6.335		.256	.226	.099	.082	-	.181	.028	89 900	Upper Silurian.
525	Jefferson,	-	3.60	3.112		17 020		.194	.366	497	.068	-	.297	.111	77.434	Upper Silurian.
526	Jefferson,	-	3.94	4.039		11.840		.236	.216	.126	.109	-	.239	.043	82.694	Upper Silurian.

TABLE 7—Continued. Soils, Marls, and Sub-soils.

Number in the report.	County.	Dissolved from 1000 grains by water containing carb. acid.	Moisture.	Organic and volatile matters.	Alumina.	Oxide of iron.	Oxide of manganese.	Carbonate of lime.	Magnesia and carbonate.	Phosphoric acid	Sulphuric acid.	Chlorine.	Potash.	Soda	Sand and silicates.	Formation, &c.
		grains.	per ct.	per c	per ct.	per ct.	per ct.	per ct.	per ct.	per ct	per ct.	per ct.	per ct.	per ct.	per ct.	
527	Jefferson,	–	2.700	–		33 900	4.280	.580	1.220	–	–	–	–	–	50.180	Upper Silurian (ir. grav.
529	Jefferson,	–	3.220	3.761		6.952		.156	.240	.088	.340	–	.177	.031	88 294	Upper Silurian.
924	Laurel,	2.404	3.600	6.190		8 926	0.078	.116	.280	.139	.355	0 009	.239	.021	83 626	Coal Measures.
917	Logan,	.585	2.800	3.140	4.770	3.660	.186	.300	.400	.140	not esti	mated.	.120	.030	89.270	Sub carb. Limestone
928	Monroe,	2 853	1 820	4.130	2.700	2.126	.116	.106	.200	.075	not esti	mated.	.119	.122	89.393	Knob.
923	Ohio,	2.330	1.74	5.080		4.349		.176	.166	.101	.413	.066	.157	.015	90.166	Coal Measures.
926	Russell,	2 221	3 44	4.170		4.478		.176	.066	.088	.227	–	.063	.068	90.786	Knob.
480	Simpson,	0.608	4 14	7.020	11.980	8.820	.130	.210	.290	.240	not esti	mated.	.190	.060	71.130	Sub cb. lime. red sub soil.
937	Union,	2 280	2.76	4 580	2.986	2 666	.056	.396	.390	.115	not est	.003	.139	.116	88.426	Coal Measures.
935	Union,	1.480	3 16	2.740		9.530		.276	.287	.147	.288	–	.185	.056	86.130	Coal Measures, sub-soil.
936	Union,	1.920	3.54	3.670	2.230	5.080	.080	.136	.633	.088	.466	.003	.087	.062	87.250	Coal Measures.
920	Union,	–	1.92	7.060		6.700		50.850	.698	.280	1.366	.062	.310	.166	32.670	Coal Measures (marl.)
929	Wayne,	2.551	3.16	5.370	4.326	2 526	.236	.256	.246	.036	not esti	mated.	.115	.137	86 066	Sub carb. Limestone.
934	Wayne,	8.534	8.28	2.560	10.240	3.120	.078	1.021	.922	.229	not est.	–	.351	.123	62 506	Sub carb. Limestone.
931	Whitley,	2 222	3.28	6.300	5.260	5 66	.420	.076	.121	.165	.322	–	.170	.147	80.786	Coal Measures.
550	Woodford,	6.014	4.70	7.771		12.961		2.464	.173	.319	.150	–	.394	.130	75.266	Lower Silurian.
551	Woodford,	3.720	4.60	5 513		13 341		2.734	.333	306	017	–	.205	not es.	77.594	Lower Silurian, old field
552	Woodford,	4 950	4 52	6.450		13.773		3.476	.354	.447	.082	–	.498	.095	75 4 4	Lower Silurian, sub soil.
553	Woodford,	1.000	5 04	6.065		33.377		.138	.080	.383	.198	–	.234	.127	59 360	Lower Silurian, red clay
554	(Illinois,)	–	3.28	9.050	2.405	2.350		.899	.526	.175	–	–	.197	.100	84.470	Prairie Soil.

TABLE 8. Mineral Waters. (In 1,000 grains of the Water.)

Number in report.	County.	Specific gravity.	Carbonate of iron.	Carbonate of manganese.	Carbonate of lime.	Carbonate of magnesia.	Sulphate of lime.	Sulphate of magnesia.	Sulphate of potash.	Sulphate of soda.	Chloride of magnesium.	Chloride of sodium.	Silica.	Total saline contents.	Gases.	Name of spring.
														Grains.		
531	Lincoln,	-	0.021	0.005	0.195	0.041	-	0.056	0.013	-	-	0.013	0.040	0.384	Carbonic acid.	Grove.
532	Lincoln,	-	.028	.005	.117	.020	0.015	.112	.028	-	-	.018	.046	.442	Carbonic acid.	Brown.
533	Lincoln,	-	0.015		.139	.131	-	.066	.022	0.024	-	.008	.041	.446	Carbonic acid.	Field.
534	Lincoln,	1.00007	-	-	.013	.065	-	.012	.008	-	-	.017	.022	.164	Sulphuretted hy. & car. acid.	Howard's.
535	Lincoln,	1.0041	trace.	-	.673	.116	.203	3.454	.067	.774	-	.081	.060	5.428	Carbonic acid.	Epsom.
536	Lincoln,	1.0068	trace.	-	.912	.131	.185	3.520	.170	1.013	-	.304	.056	6.884	Carbonic acid.	Foley's.
538	Lincoln,	1.0060	trace.	-	.506	.375	1.566	2.989	.298	.398	-	1.000	.021	7.153	Carbonic acid.	Sowder's.
539	Lincoln,	-	.007		.118	.024	-	.027	.010	-	-	.088	.017	.291	Carbonic acid.	Bryant's chaly
540	Lincoln,	-	0.021	-	.095	.057	.010	.070	.026	-	-	.015	.046	.320	Carbonic acid.	Do. Pasture.
541	Lincoln,	-	trace.	-	.093	.048	trace.	.006	.025		0.042	.175	.015	.404	Car. acid and sulp hydrogen.	Valley sulphur.
542	Lincoln,	-	trace.	-	-	-	.104	.069	.016	.205	-	.933	.015	1.342	Do.	Knob sulphur.
543	Lincoln,	-	.026	-	.058	.116	.012	.023	.007	trace.	-	-	.030	.272	Do.	Stone's sulphur
544	Lincoln,	-	.019	-	.480	.013	.966	.904	.066	.028	-	.278	.090	2.844	Carbonic acid.	Well

TABLE 9. Comparative Vegetable Ash Analyses.

By whom analyzed—	Merz.	Way and Ogston.					G. Reich.
Kind of vegetable, &c	Tobacco.	White potatoes.		Red clover.	Turnip.		Hemp.
					Green topped white.		
	Dried leaves.	Tubers.	Stalks.	T. pra tense.	Root.	Leaves.	Whole plant.
Potash,	26.96	50.89	11.44	36.45	48.56	12.68	15.82
Soda,	2.76	2.41	–	–	–	–	3.40
Lime,	39.53	2.65	37.02	22.62	6.73	28.73	35.55
Magnesia,	9.61	4.21	6.00	4.08	2.26	2.85	7.67
Oxide of iron,	–	1.06	3.78	.26	.66	.80	1.08
Sulphuric acid,	2.78	3.19	5.12	1.85	12.86	7.83	2.76
Hydrochloric acid,	–	–	–	–	–	–	3.40
Silica,	4.51	.91	8 22	.59	.96	2.05	7.70
Carbonic acid,	–	12.14	14.09	23.47	14.82	14.64	8.38
Phosphoric acid,	–	17.15	2.27	6.71	7.65	3.15	14.24
Phosphate of iron,	4.20	–	–	–	–	–	–
Chloride of potassium,	–	–	–	2.39	–	15.56	–
Chloride of sodium,	9.65	5.38	12.06	1.53	5.44	10.67	–
Total,	100.00	99.99	100.00	99.95	99.94	99.96	100.00
Per centage of ash,							
(*a*) in dried vegetable,	23.33	2.98	15.00	9.56	7.40	15.20	*4.60
(*b*) in fresh vegetable,	–	.71	2.25	1.85	.59	1.82	–

* Fresh or dried?