# CHEMICAL REPORT

OF THE

# MINERALS, ROCKS, AND SOILS,

MADE BY

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CHEMICAL ASSISTANT.

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# INTRODUCTORY LETTER.

CHEMICAL LABORATORY OF THE GEOLOGICAL SURVEY,
*Lexington, Ky., September* 24, 1855.

DEAR SIR: I herewith transmit to you my Summary Report of the Chemical Analyses made for the Geological and Chemical Survey of Kentucky.

It contains the results of more than two hundred days of incessant labor, but yet exhibits the composition of a *very small proportion* of the valuable minerals of the State, as you will doubtless demonstrate in *your* forthcoming Report. Sufficient is shown, however, even in this brief and partial sketch, to prove the great wealth, *in substantial riches*, of the Commonwealth of Kentucky.

Blessed with the most fertile soil in the world, on its central geological formations; the decomposing soft limestones and marls of which continually renew its supply of phosphates, sulphates, and the alkalies, &c., &c., as they are removed by cropping; a great portion of its eastern and western boundaries include mineral wealth in the greatest abundance, in the form of iron ores, coals, limestones, clays, salt, &c., &c., of great variety, requiring only capital, skill, and industry, which they must eventually invoke to their exploration, to change the regions containing them—some of them now very sparsely settled and little known—into the locations of numerous and lucrative manufactories, and centres of an active and extensive commerce.

By an examination of the descriptions and composition of the iron ores which were analyzed, it well be seen that they are, generally, of the most profitable and productive kinds.

The limonites are in great variety; and almost all of them are comparatively soft and porous; thus, easily to be reduced in the furnace. Some with an excess of *silicious* matters, others of *calcareous;* and generally containing earthy materials enough to form a sufficient amount of the necessary furnace slag, (or cinder, so called,) either alone or with admixture of some of the neighboring poorer ores or limestones.

Very few of them contain much phosphoric acid, or other injurious ingredients; and even those which, at some furnaces, are considered "*impracticable*," or difficult to smelt, are found to be hard to manage mainly because of their richness itself; and require only the admixture of poorer ores, or some argillaceous, silicious, and calcareous substances, abundant everywhere, to flux them and make them yield their content of iron.

The proportion of this metal, in some of them, may seem to be small; but it is well known to practical men that the most profitable ores of iron are those which contain less than fifty per cent. of that metal; and many containing not much more than half that proportion are economically smelted.

The *black band* iron ores, from the lower portion of the State, and from Greenup county, are interesting. Most of them which were examined proved to be as good as those of Europe, from which iron is most cheaply made. A few disappointed the hopes which were excited by their appearance, and proved to be too poor in iron to be considered workable, or too much contaminated with phosphate of lime. Doubtless, in many parts of the extensive coal fields of the State, this valuable kind of iron ore, of good quality, may be found in great abundance.

The economy introduced into the iron manufacture, by the use of this ore, in Scotland, is illustrated by the celebrated David Mushet, in his voluminous practical "*Papers on Iron and Steel*," by the comparative statement of the burthen and produce, at the Clyde iron works, of two furnaces, blowing each for one week, and using pit-coal and the hot-blast, as follows:

| | *Tons.* | *Cwts.* | *Qrs.* |
|---|---|---|---|
| 1. With black band ironstone— | | | |
| Coals to the ton of iron, | 1 | 6 | 3 |
| Roasted ore, ("mine,") | 1 | 14 | 1 |
| Limestone, | 0 | 3 | 3 |
| 2. With clay ironstone— | | | |
| Coals, to the ton of iron, | 2 | 3 | 2 |
| Roasted ore, | 2 | 6 | 2 |
| Limestone, | 0 | 11 | 2 |
| Saving from the use of the black band— | | | |
| Coals, per ton of iron, | 0 | 15 | 3 |
| Limestone, | 0 | 7 | 3 |
| Additional produce of iron in the week, | 20 | 4 | 0 |

The iron manufacture in this State is only in its infancy. We now produce only charcoal iron, of the best quality, while we import, annually, immense quantities of *common* iron, for railroad and other purposes.

With the black band, or some of our other good fusible ores, and the use of coal and the hot-blast, the cheaper kinds of iron, so extensively used, could doubtless be made to great advantage in Kentucky, and thus a foreign drain on our capital would be checked, and a new source of wealth established. This will be found necessary for self-defence if our railroad improvements are much extended, as they doubtless will be; and will be the more easily effected as the price of labor, from well known causes, is becoming higher in Europe.

For this kind of manufacture those of our coals which contains but little sulphur, and less than five per cent. of ashes, would be well suited, more especially the variety called *dry* or *splint* coal, which abounds in our State, which need not be coked before it is used in the furnace, and thus is cheaper than coke. This kind of coal, while it does not soften or swell up much when heated, so as to choke up the furnace and check the blast, gives out much combustible gas to aid in reducing the ore, and carbonating the iron.

I have not thought proper to give a detail of the processes used in the chemical investigation; they have been various, according to the requirements of the specimen under examination—generally those described in that monument of industry and accuracy, the "*Handbuch der Analytischen Chemie, Von Heinrich Rose,*" (last German edition)—but sometimes modified to suit the circumstances of the case. In the

separation and estimation of the alkalies, and the separation of magnesia from the alkalies—processes which so frequently occur in mineral analysis—the important improvements of Dr. J. Lawrence Smith, (detailed in Silliman's Journal,) were found to be greatly better than the old methods.

The total amount of carbon in the specimens of pig-iron was ascertained by means of iodine—a method with which I am not entirely satisfied. The phosphorus, in that metal, was estimated by solution in fuming nitric acid, and evaporation to dryness to render the silica insoluble, re-solution in hydro-chloric acid, and precipitation of the oxides of iron and manganese with sulphuret of ammonium and a sufficient quantity of caustic potash. The alumina and phosphoric acid, dissolved by the caustic solution, were separated by known methods—the latter being weighed as phosphate of magnesia.

In the examination of the *soils* it was thought proper to substitute, for the ordinary process of digestion in water, to ascertain the proportion of readily soluble matters, that of digestion for some weeks in water which had been saturated, under pressure, with carbonic acid gas. This plan was adopted in order more nearly to imitate the process of nature in the solution of the nutritious ingredients of the soil for the food of plants. The water which falls as rain, &c., being always charged with carbonic acid, the proportion of which is increased in it, when it percolates the soil, by the slow oxidation of the organic matters; and this, with the very small amount of nitric or hypo-nitric acid sometimes produced in the atmosphere during electrical excitements, and the soluble organic matters themselves, are the principal means by which the fixed or mineral elements of plants, indispensable to their organization, are dissolved and introduced into their tissues.

The investigation of the soils was not as thorough as it should have been, the time allotted to the chemical analyses having been nearly consumed by other objects before they were commenced; their examination was therefore too hurried, and consequently the proportions of some of their more minute ingredients, (of the most valuable also,) such as the chlorides, sulphates, and phosphates, were not, in all cases, separately made out.

Amongst the *ores*, the *coals*, the *rocks*, the *soils*, the *mineral waters*, &c., &c., of the State, a wide unexplored field still remains for examination.

Hoping that this brief and imperfect investigation may be but the beginning of a still further and complete study of the geological history and the mineral riches of the State of Kentucky,

I remain yours respectfully,

ROBERT PETER.

DAVID DALE OWEN, M. D.,
*Principal Geologist of Kentucky.*

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# A SUMMARY

OF THE

# CHEMICAL ANALYSES

OF

# Ores, Soils, Coals, Limestones, Pig-Iron, Iron Furnace Cinder, &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.

## BALLARD COUNTY.

No. 1—Soil. *Labeled "Soil from heavy timbered land, southern part of Ballard county, Kentucky," between the waters of Bowles and west branch of Mayfield creeks.*

Color yellowish grey, or dirty buff, in its dried state. Carefully washed with water it left about forty-seven per cent. of *very fine sand*, which was nearly of the color of the soil; a larger proportion could doubtless be obtained by devoting more time to the washing, for it is so fine as easily to be washed away with the lighter particles, and to escape ordinary observation.

One thousand grains of the air-dried soil were digested, for about a month, in a closely stoppered bottle, at a temperature not above 100° F., in water which had been saturated under pressure with carbonic acid gas; the liquid, filtered and evaporated to dryness at 212° F., left 1.53 grains of *solid matter*, which had been dissolved by the acidulated water.

This solid *extract*, when treated with pure water, left, of *insoluble matter*, 0.603 gr., which had been dissolved by the carbonic acid, and which was of the following composition, viz:

| | |
|---|---|
| Silica, | 0.137 |
| Carbonate of magnesia, | .259 |
| Brown oxide of manganese, | .117 |
| Alumina, oxide of iron, and traces of phosphates, | .067 |
| Potash, | .005 |
| Traces of carbonate of lime and loss, | .018 |

The portion of the extract which was dissolved by the water was of a dark brown color, and weighed 0.9 gr. when dried at 212° F.; when ignited over the spirit lamp a portion of it was burnt off, with a mixed smell of burnt animal matter and burning peat, leaving 0.4 gr. of fixed residuum. The composition of this *soluble* portion was found to be as follows:

| | |
|---|---|
| Organic and volatile matter, | 0.500 |
| Carbonate of lime, | .098 |
| Carbonate of magnesia, | .112 |
| Carbonate of manganese, | .051 |
| Alumina, oxide of iron, with traces of phosphates, | .007 |
| Potash, | .036 |
| Soda, | .067 |
| Loss, | .029 |

The lime, magnesia, oxides of manganese and iron, and the alumina and phosphates were, in the extract, doubtless combined with the organic acids, which are included above under the general name of *organic matter*, and which, when burnt off, leave most of these fixed substances in combination with carbonic acid. Water saturated with carbonic acid was used, in this process of analysis, to enable me to estimate the relative amount of soluble materials immediately available for the nourishment of vegetables. The water which falls from the atmosphere always contains some of this acid which, with the organic acids resulting from animal and vegetable decomposition, is the principal agent in the solution of the nutritive elements of the soil for the support of plants.

Had sufficient time been at my disposal I should have examined this soil more minutely, for other soluble ingredients, as ammonia, the nitrates, chlorides, and sulphates, but having nearly approached the end of the present term of labor, before the soils were commenced, I was obliged to be contented with a less extensive investigation.

One hundred grains of the air-dried soil, exposed to the temperature of 340° F., lost of *moisture* 1.84 grains. Treated in the usual manner, by digestion in hydrochloric acid, &c., its composition, dried at 340°, was found to be as follows, viz:

| | |
|---|---|
| Organic and volatile matters, | 3.040 |
| Carbonate of lime, | .034 |
| Carbonate of magnesia, | .461 |
| Carbonate of manganese, | .411 |
| Alumina, oxide of iron, and traces of phosphates, | 3.930 |
| Potash, | .108 |
| Soda, | .037 |
| Silica and silicates insoluble in hydrochloric acid, | 92.010 |
| | 100.031 |

No. 2—Soil. *Labeled "Soil from the north-western part of Ballard county, Ky., near Col. Gholson's."*

Color of the dry soil of a dark brownish grey. Washing with water gave about fifty-three per cent. of *very fine sand*, of a dirty buff color, which is doubtless only a portion. Treated with water acidulated with carbonic acid, as above described, this soil gave up 1.943 gr. of solid matter, (dried at 212°); which re-dissolved in pure water left 0.955 gr. of *insoluble matter*, which had been dissolved by the carbonic acid, of the following composition, dried at 212°:

| | |
|---|---|
| Silica, | .170 |
| Carbonate of lime, | .227 |
| Carbonate of magnesia, | .321 |
| Carbonate of manganese, | .200 |
| Alumina, oxide of iron, and traces of phosphates, | .037 |

The portion which dissolved in the pure water weighed, when dried at 212°, 0.988 gr. Heated to redness in a platinum capsule the organic matter was consumed, giving out a smell of burnt horn, leaving 0.425 gr. of fixed residuum. The composition of the soluble portion was found to be as follows, viz:

| | |
|---|---|
| Organic and volatile matters, | 0.530 |
| Carbonate of lime, | .127 |
| Carbonate of magnesia, | .181 |
| Carbonate of manganese, trace. | |
| Potash, | .096 |
| Soda, | .054 |

One hundred grains of the air-dried soil gave up 2.44 grains of

*moisture*, when dried at 320° F. Its composition, thus dried, was found to be as follows, viz:

| | |
|---|---|
| Organic and volatile matters, | 4,120 |
| Carbonate of lime, | .134 |
| Carbonate of magnesia, | .280 |
| Carbonate of manganese, | .081 |
| Alumina, oxide of iron, and trace of phosphates, | 4.850 |
| Potash, | .139 |
| Soda, | .063 |
| Silica and insoluble silicates, | 89.650 |
| Loss, | .683 |
| | 100.000 |

No. 3—LIGNITE. *Labeled "Lignite, bluff of Fort Jefferson, Ballard county, Ky."*

A dull brownish-black friable substance, full of irregular cracks or fissures, which appear to have been produced by shrinkage or drying; quite absorbant of moisture, adhering slightly to the tongue; fresh fracture, presenting a dull pitch-like lustre in some of the layers, approaching, in some parts, the lustre of coal. Over the spirit lamp, on platinum foil, it burnt at first with a smokey flame, somewhat like coal, but with the odor of peat; it continues to burn like punk or rotten wood, when removed from the flame, until it is reduced to a bulky ash.

Its specific gravity is, 1.219

Composition, dried at the ordinary temperature—

| | | | |
|---|---|---|---|
| Moisture, | 13.20 | Total volatile matters, | 50.60 |
| Volatile combustible matters, | 37.40 | | |
| Carbon, | 38.10 | Black residuum, | 49 40 |
| Ashes, (buff-colored,) | 11.30 | | |
| | 100.00 | | 100.00 |

Its composition, when thoroughly dried at 212°, may be stated as follows, viz:

| | |
|---|---|
| Volatile combustible matters, | 43.088 |
| Fixed carbon, | 43.894 |
| Ashes, | 13.018 |

The buff-colored ashes were found to contain a trace of phosphoric acid, and notable quantities of oxide of iron, alumina, and lime.

No. 4—CLAY. *Labeled "Potters' clay, four miles south of Blandville, Ballard county, Kentucky; Mr. Samuel's farm."*

Color, light yellowish-grey; exhibits minute spangles of mica before

the lens; heated before the blowpipe becomes first dark-colored then burns white.

Composition, dried at 212°—

| | |
|---|---|
| Silica, | 71.94 |
| Alumina, with a trace of oxide of iron, | 20.70 |
| Lime, | .37 |
| Magnesia, | .35 |
| Potash, | .63 |
| Water, with a trace of organic matter, | 6.20 |
| | 100.19 |

This was examined for the general ingredients by fusion with mixed carbonates of soda and potash, &c., and for the alkalies by fusion with carbonate of lime and chloride of ammonium.

BATH COUNTY.

No. 5—LIMONITE. *Iron ore from Messrs. Robert & A. G. Carter's furnace, Bath county, Kentucky, five miles beyond the Olympian Springs, adjoining the White Sulphur Springs; (fourteen miles from Owingsville and fifty-three miles from Lexington.)*

Ore beds described to be from eight to twelve inches thick, on a basis of limestone, covered by blue clay and fire clay.

Ore, a compact, hard, apparently pure hæmatite; powder of a dark, brownish, red color.

Specific gravity, 3.266

Composition, dried at 212° F—

| | | |
|---|---|---|
| Oxide of iron, (peroxide,) | 79.90 | 55.95 per cent. of *Iron*. |
| Oxide of manganese, | 1.80 | |
| Alumina, | 1.10 | |
| Carbonate of lime, | 0.10 | |
| Carbonate of magnesia, | 1.53 | |
| Silex and insoluble silicates, | 9.00 | |
| Water and loss, | 6.57 | |
| | 100.00 | |

The air-dried ore lost 3.1 per cent. of hygrometric *moisture* when dried at 212°.

No. 6—COAL. *From the same locality as the preceding. Reported to be in beds four feet thick, or in two beds, each of two feet, separated by two feet of black shale.*

A *splint coal;* cleaving in rather thin lays, separated by fibrous car-

bonaceous matter, (fibrous coal;) cross fracture of a pitch black color and lustre; fissures and edges of the layers coated with ochreous oxide of iron. The fibrous matter presented the appearance of vegetable impressions, and is to some extent infiltrated with pyrites.

Specific gravity, - - - - - - - 1.321

Heated on platinum foil over the spirit lamp, it swelled up somewhat, but did not soften very much; does not appear to be a good *coking* coal.

Composition dried at 212°—

| | | |
|---|---|---|
| Volatile combustible matters, | 38.00 | |
| Carbon in the coke, - - | 53.90 | Coke, 62. per cent. |
| Ashes, (light grey color,) - | 8.10 | |
| | 100.00 | |

The recent coal lost three per cent. of moisture when dried at 212°. The ashes contain a small proportion of sulphate of lime.

By a separate process the total per centage of *sulphur* in this coal was found to be about 0.99.

The locality from whence these two minerals are obtained is described as an outlier of the coal formations.

BUTLER COUNTY.

No. 7—Grey Carbonate of Iron. *Labeled "Carbonate of iron, shale bank, Alum Spring, Butler county, Kentucky."*

A hard, compact mineral, of a dark grey color; streak, light grey; fracture, flat-conchoidal; structure, fine granular. Outer surface, to the thickness of about one-sixteenth of an inch, reddish-yellow from the per-oxidation of the iron.

Specific gravity, - - - - - - - 3.490

Composition, dried at 212° F.—

| | | |
|---|---|---|
| Carbonate of iron, - - | 65.96 | 36.90 per cent. Iron. |
| Peroxide of iron, - - | 7.19 | |
| Carbonate of lime, - - | 5.90 | |
| Carbonate of magnesia, - | 6.03 | |
| Carbonate of manganese, - | 1.57 | |
| Phosphoric acid, - - | 2.64 | |
| Potash, - - - - | .23 | |
| Soda, - - - - | .06 | |
| Bituminous matter, - - | 1.03 | |
| Silex and insoluble silicates, | 8.70 | |
| Water and loss, - - - | .69 | |
| | 100.00 | |

The air-dried ore lost 0.8 per cent. of *moisture* when dried at 212° F.

No. 8—Coal. *Labeled "Tygert's coal bank, on the waters of Hickory Camp creek, Butler county, Kentucky."*

A friable, pitch-black coal; fissures stained with ochreous oxide of iron; charcoal-like fibrous coal between the layers.

| | | | |
|---|---|---|---|
| Specific gravity, | | 1.291 | |
| Composition, dried at the ordinary temperature— | | | |
| Moisture, | 7.20 | Total volatile matters, | 38.60 |
| Volatile combustible matters, | 31.40 | | |
| Carbon in the coke, | 56.90 | Coke, (moderately light,) | 61.40 |
| Ashes, (light yellowish grey,) | 4.50 | | |
| | 100.00 | | 100.00 |
| Composition, dried at 212°— | | | |
| Volatile combustible matters, | | 33.84 | |
| Carbon in the coke, | | 61.27 | |
| Ashes, | | 4.89 | |
| | | 100.00 | |

*Sulphur* is found in it in the proportion of 0.29 per cent. The ashes contain no appreciable quantity of sulphate of lime.

Heated over the spirit lamp, on platinum foil, it swelled up and softened considerably, leaving a cellular coke. It appears to be a pretty good coking coal.

A singular fact was observed in relation to this coal, which, however, may possibly be accidental, as the experiment was not repeated. Some of the coal in very fine powder, folded in paper, placed in the sand-bath at the temperature of about 400° F., took fire spontaneously.

No. 9—Coal. *Labeled. "Pardon Sheldon's coal, head waters of Welch creek, Butler county, Kentucky."*

A very pure looking, soft coal, of a pitchy-black color and strong lustre, not soiling the fingers; presenting no appearance of fibrous coal, nor of pyritous or other impurities.

| | |
|---|---|
| Specific gravity, | 1.247 |

Heated over the spirit lamp, on platinum foil, it softened and swelled up a good deal—the volatile matter burning off with a very smoky flame, leaving a light spongy coke. It appears to be a good coking coal.

Composition, dried at the ordinary temperature—

| | | | |
|---|---|---|---|
| Moisture, | 4.00 | Total volatile matters, | 38.70 |
| Volatile combustible matters, | 34.70 | | |
| Carbon in the coke, | 60.70 | Coke, (light, spongy,) | 61.30 |
| Ashes, (dirty salmon color,) | .60 | | |
| | 100.00 | | 100.00 |

Composition, dried at 212° F.—

| | |
|---|---|
| Volatile combustible matters, | 36.146 |
| Carbon in the coke, | 63.229 |
| Ashes, | .625 |
| | 100.000 |

The total per centage of *sulphur* is 0.268. The salmon-colored ashes contain only a small trace of sulphate of lime. This coal is remarkable for the very small amount of ashes which it leaves.

No. 10—Soil. *Labeled "Soil and sub-soil, four miles south of Rochester—ridge land—Butler county, Kentucky."*

The dry soil is of a dirty buff color. Washed with water it left more than 47. per cent. of very *fine sand*, containing a few larger rounded grains of silicious mineral.

One thousand grains, treated, as before described, with water charged with carbonic acid gas, gave up 1.884 grains of *solid matter*, dried at 212° F. This *extract*, treated with pure water, left of *insoluble matter*, which had been dissolved by the carbonic acid, 0.837; the composition of which is as follows, viz:

| | |
|---|---|
| Silica, | 0.190 |
| Carbonate of lime, | .077 |
| Carbonate of magnesia, | .503 |
| Alumina, oxide of iron and trace of phosphates, | .067 |

The portion which was dissolved by the water weighed, when dried at 212° F., 1.047 grains. Ignited in a platinum capsule, there were burnt out of it, with a smell of burning animal matter,

| | |
|---|---|
| Organic and volatile substances, | 0.600 |

The residue consisted of

| | |
|---|---|
| Carbonate of lime, | .167 |
| Carbonate of magnesia, | .140 |
| Carbonate of manganese, | .042 |
| Potash, | .082 |
| Soda, | .013 |

Also, a slight trace of alumina and phosphates.

One hundred grains of the soil dried at 320° Fah., when analyzed by the usual mode gave the following results, viz:

| | |
|---|---|
| Organic and volatile matters, | 3.460 |
| Carbonate of lime, | .097 |
| Carbonate of magnesia, | .305 |
| Carbonate of manganese, | .025 |
| Potash, | .204 |
| Soda, | .074 |
| Alumina, oxide of iron and trace of phosphates, | 5.030 |
| Silica and insoluble silicates, | 90.590 |
| Loss, | .215 |
| | 100.000 |

This soil contains very nearly as much potash as the rich soil of Fayette county, but does not yield as large a proportion of the phosphates.

CARTER COUNTY.

No. 11—IRON ORE. *Labeled "Mr. Wallace's iron ore, near falls of Blain, Carter* county, Kentucky."*

A dark reddish-brown mineral, with interspersed spots of dull yellowish; appearance generally dull, but slightly glimmering, like spar, in the yellowish portions. Powder of a brownish-buff color.

| | | |
|---|---|---|
| Specific gravity, | | 2.731 |
| Composition, dried at 212° F.— | | |
| Oxide of iron, | 23.20 | 19.24 per cent. of *Iron.* |
| Carbonate of iron, | 6.28 | |
| Carbonate of lime, | 51.35 | |
| Carbonate of magnesia, | 1.53 | |
| Carbonate of manganese, | 3.41 | |
| Alumina, | 1.95 | |
| Phosphoric acid, | .24 | |
| Potash, | .23 | |
| Soda, | .18 | |
| Silica and insoluble silicates, | 9.67 | |
| Water and loss, | 1.96 | |
| | 100.00 | |

The air-dried ore lost 1. per cent. of *moisture* when dried at 212°. Containing a large proportion of carbonate of lime, and a small amount of alumina, this mineral may be valuable to flux, in the furnace, with ores containing too large a proportion of aluminous or silicious matter.

* This ore was inadvertently labeled Carter county; it should have been Lawrence county.

By itself it would not give good results, because of its small relative quantity of iron, and large excess of lime.

No. 12—LIMONITE. *Labeled "Ore from Tygert's, Carter county, Kentucky, on the sub-carboniferous limestone."*

A dark reddish-brown mineral; dirty ochreous on the exterior; adhering to the tongue. Powder dirty yellowish-brown color.

| | | |
|---|---|---|
| Specific gravity, | | 3.256 |
| Composition, dried at 212° F.— | | |
| Peroxide of iron, | 71.50 | = 50.07 per cent. of *Iron*. |
| Alumina, | 2.45 | |
| Magnesia, | 1.03 | |
| Brown oxide of manganese, | 1.37 | |
| Potash, | .34 | |
| Soda, | .12 | |
| Silica and insoluble silicates, | 11.97 | |
| Combined water, | 11.59 | |
| | 100.37 | |

The air-dried ore lost 1.7 per cent. of *moisture* when dried at 212°.

No. 13—LIMONITE. *Labeled "Best ore, Sandy furnace, Carter county, Kentucky."*

A dark reddish-brown ore, in irregular layers, separated by soft yellow ochreous mineral. Powder of a brownish-yellow color.

| | | |
|---|---|---|
| Composition, dried at 212° F.— | | |
| Peroxide of iron, | 67.40 | = 42.20 per cent. of *Iron*. |
| Alumina, | .87 | |
| Carbonate of lime, | .57 | |
| Magnesia, | 1.80 | |
| Brown oxide of manganese, | .95 | |
| Potash, | .50 | |
| Soda, | .16 | |
| Silica, and insoluble silicates, | 17.57 | |
| Combined water, | 11.55 | |
| | 101.38 | |

The air-dried ore lost 2.2 per cent. of moisture when dried at 212°.

These two are very rich and valuable ores, requiring, however, the use of lime to flux them in the furnace, which may, perhaps, be profitably substituted by the use of the next described mineral, in proper proportions.

No. 14—Ferruginous Limestone. *Labeled "Green Rock, which cuts out the ore, Sandy Furnace, Carter county, Ky."*

A dull looking bluish-grey-green rock, mottled with lighter green and dirty yellowish-brown; small spangles of mica and specks of spar visible under the lens; as hard as ordinary limestone; powder of a greenish-grey color.

| | | |
|---|---|---|
| Specific gravity, | | 2.809 |
| Composition, dried at 212° F.— | | |
| Carbonate of iron, | 14.26 | = 18.55 per cent. of *Iron*. |
| Oxide of iron, | 16.77 | |
| Carbonate of lime, | 35.15 | |
| Carbonate of magnesia, | 6.54 | |
| Carbonate of manganese, | .84 | |
| Alumina, | 5.85 | |
| Potash, | .29 | |
| Soda, | .08 | |
| Silica and insoluble silicates, | 19.17 | |
| Water and loss, | 1.05 | |
| | 100.00 | |

No. 15—Coal. *Labeled "Kilgore's Coal, Williams' creek, on the Lexington and Big Sandy railroad—fourteen miles from Ashland—Carter county, Ky."*

A pure looking splint coal, having a lamellar fracture, with vegetable impressions between the layers, not in the form of fibrous coal, but smooth and hard, not soiling the fingers; cross-fracture pitch-black, lustrous; no appearance of pyrites or other impurities; heated over the spirit lamp it swelled up somewhat, but did not soften much.

| | | | |
|---|---|---|---|
| Specific gravity, | | | 1.313 |
| Composition, dried at the ordinary temperature— | | | |
| Moisture, | 5.40 | Total volatile matters, | 41.00 |
| Volatile combustible matters, | 35.60 | | |
| Carbon in the coke, | 55.00 | Coke, (pretty dense,) | 59.00 |
| Ashes, (pale grey,) | 4.00 | | |
| | 100.00 | | 100.00 |
| Composition, dried at 212° F.— | | | |
| Volatile combustible matters, | | | 37.632 |
| Carbon in the coke, | | | 58.140 |
| Ashes, | | | 4.228 |
| | | | 100.000 |

Sulphur was found in this coal in the proportion of 0.710 per cent. The ashes contained no sulphate of lime.

No. 16—Coal. *Labeled "Cannel Coal from Barrett's creek, Carter county, Ky., six miles north-west of Grayson."*

A dull looking coal, with a slaty structure, not soiling the fingers; not very easily broken; exterior stained with oxide of iron; fracture across the laminæ of a dull, jet-like lustre; the surfaces of the layers as dull as black slate. Heated over the spirit lamp it decrepitated strongly, burnt at first with a smoky flame; did not swell up or change its form.

| | | | |
|---|---|---|---|
| Specific gravity, - - - - - - - - | 1.443 | | |
| Composition, dried at the ordinary temperature— | | | |
| Moisture, - - - - | 4.00 | Total volatile matters, - | 37.50 |
| Volatile combustible matters, - | 33.50 | | |
| Carbon in the coke, - - - | 42.70 | Dense coke, - - - | 62.50 |
| Ashes, (dark lilac color,) - - | 19.80 | | |
| | 100.00 | | 100.00 |
| Composition, dried at 212° F.— | | | |
| Volatile combustible matters, - - - - | 34.896 | | |
| Carbon in the coke, - - - - - - | 44.478 | | |
| Ashes, - - - - - - - - - | 20.626 | | |
| | 100.000 | | |

*Sulphur* was found in it in the proportion of 7.905 per cent. The value of this coal is greatly injured by its very large proportion of ashes and of sulphur. The ashes contained no perceptible amount of sulphate of lime.

No. 17—Coal. *Labeled "Gallion's Coal, Williams' creek, on the Lexington and Big Sandy railroad, eighteen miles from Ashland, in Carter county, Ky."*

A very pure looking coal, of a pitch-black color, and strong lustre; not soiling the fingers; moderately hard; very little fibrous coal, with vegetable impressions between the layers, and but little appearance of pyritous matter. Heated over the spirit lamp it decrepitated, softened very much and swelled up; it is probably a coking coal.

| | | | |
|---|---|---|---|
| Specific gravity, | | 1.312 | |
| Composition, dried at the ordinary temperature— | | | |
| Moisture, | 5.00 | Total volatile matters, | 45.80 |
| Volatile combustible matters, | 40.80 | | |
| Carbon in the coke, | 49.50 | Moderately dense coke, | 54.20 |
| Ashes, (dark lilac color,) | 4.70 | | |
| | 100.00 | | 100.00 |
| Composition, dried at 212°— | | | |
| Volatile combustible matters, | | 42.947 | |
| Carbon in the coke, | | 52.105 | |
| Ashes, | | 4.948 | |
| | | 100.00 | |

*Sulphur* was found in it in the proportion of 2.410 per cent. The ashes contained only a trace of sulphate of lime.

This coal would be more valuable for manufacturing purposes did it contain less sulphur. It is possible, however, that the specimen examined presented more than the average proportion of pyrites—this injurious ingredient of coals being generally very irregularly diffused.

### CHRISTIAN COUNTY.

No. 18—Coal. *Labeled "Keath's Coal, near Pond river, north-east part of Christian county, Ky."*

A soft friable coal, not soiling the fingers; of a dull pitch-black appearance; seems to be free from pyrites or earthy impurities. Small fragments heated over the spirit lamp softened, swelled up, and agglutinated into a light spongy coke. Appears to be a good coking coal.

| | | | |
|---|---|---|---|
| Specific gravity, | | 1.307 | |
| Composition, dried at the ordinary temperature— | | | |
| Moisture, | 2.80 | Total volatile matters, | 43.90 |
| Volatile combustible matters, | 41.10 | | |
| Carbon in the coke, | 48.90 | Coke, | 56.10 |
| Ashes, (pale reddish-grey. | 7.20 | | |
| | 100.00 | | 100.00 |
| Composition, dried at 212°— | | | |
| Volatile combustible matters, | | 42,284 | |
| Carbon in the coke, | | 50.309 | |
| Ashes, | | 7.407 | |
| | | 100.000 | |

*Sulphur* was found in this coal in the proportion of 2.16 per cent. The ashes contained 0.100 per cent. of sulphate of lime. Dried at 212° the air-dried coal lost 2.8 per cent. of moisture.

No. 19—Coal. *Labeled "(Lacey's) Atchison's Coal, McFarland's branch of the west fork of Pond river, north-east part of Christian county, Ky."*

A soft bituminous coal, of a pitch-black color; considerable lustre. Some fibrous coal, exhibiting vegetable impressions, between the layers. Fragments heated over the spirit lamp softened, swelled moderately, and agglutinated into a spongy coke.

| | | | |
|---|---|---|---|
| Specific gravity, - - - - - - - - - | | 1.278 | |
| Composition, dried at ordinary temperature— | | | |
| Moisture, - - - - | 4.00 | | |
| Volatile combustible matters, - | 37.70 | Total volatile matters, - | 41.70 |
| Carbon in the coke, - - | 53.30 | | |
| Ashes, (lilac colored,) - - | 5.00 | Coke, (bright, spongy,) | 58.30 |
| | 100.00 | | 100.00 |
| Composition, dried at 212°— | | | |
| Volatile combustible matters, - - - - | | 39.271 | |
| Carbon in the coke, - - - - - | | 55.520 | |
| Ashes, - - - - - - - - - | | 5.209 | |
| | | 100.000 | |

The total amount of *sulphur* was found to be 1.363 per cent. The ashes contained a small trace of *sulphate of lime.*

No. 20—Soil. *Labeled "Soil from southern part of Christian county, Ky., between Dr. Quarles' and Oak Grove."*

Color pretty dark greyish-brown. Washed with water it left more than thirty-four per cent. of *very fine sand,* of a dark drab color.

One thousand grains, treated with water containing carbonic acid, yielded 3.822 grains of *solid extract,* dried at 212°, which, when treated with pure water, left of *insoluble matter,* which had been dissolved by the carbonic acid, 2.457 grains, of the following composition, viz:

| | |
|---|---|
| Silica, - - - - - - - - - - - - | .130 |
| Carbonate of lime, - - - - - - - - - - | .830 |
| Carbonate of magnesia, - - - - - - - - - | .115 |
| Carbonate of manganese, - - - - - - - - - | .642 |
| Alumina, oxide of iron, and trace of phosphates, - - - - | .740 |

Sulphate of lime, a trace.

The *soluble matter*, dissolved by the water, weighed, when dried at 212°, 1.365 grains, out of which was burnt, with the smell of burnt horn,

| | |
|---|---|
| Organic and volatile matters, | .960 |

The residue contained

| | |
|---|---|
| Carbonate of lime, | .067 |
| Carbonate of magnesia, | .196 |
| Potash, | .096 |
| Soda, | .046 |

With traces of alumina and phosphates.

One hundred grains of the soil, dried at 300°, analyzed by the ordinary method, after digestion in hydrochloric acid, &c., were found to contain—

| | |
|---|---|
| Organic and volatile matters, | 5.680 |
| Carbonate of lime, | .220 |
| Carbonate of magnesia, | .280 |
| Carbonate of manganese, | .415 |
| Alumina, oxide of iron, and trace of phosphates, | 5.470 |
| Potash, | .154 |
| Soda, | .061 |
| Silica and insoluble silicates, | 87.430 |
| Sulphate of lime and loss, | .290 |
| | 100.000 |

The air-dried soil lost 2.6 per cent. of *moisture*, when dried at 300° F.

No. 21—Magnesian Limestone. *Labeled "Hydraulic Limestone, near Esquire Lindsey's, Christian county, Ky."*

A dull, rather soft, rock, of a fine granular structure, light drab color; fragments may be broken off and crushed to powder in the fingers, without much difficulty; adheres to the tongue.

Composition, dried at 212°—

| | |
|---|---|
| Carbonate of lime, | 52.20 |
| Carbonate of magnesia, | 37.95 |
| Alumina, oxide of iron, &c., | 2.27 |
| Silica and insoluble silicates, | 6.38 |
| Potash, | .28 |
| Moisture and loss, | .92 |
| | 100.00 |

The carbonates of lime and magnesia are very nearly in equivalent proportions in this limestone. It contains a much smaller proportion of clay than is usually found in hydraulic limestone.

No. 22—FERRUGINOUS LIMESTONE. *Labeled "Iron? hill at Keath's, north-east part of Christian county, Ky., near Pond river."*

A compact, fine-grained mineral; general color dark grey, with a slight tinge of green; exterior portion ochreous; dark reddish-brown matter lining the fissures, and extending from exterior to the interior. Powder cinnamon colored, or the color of ground *lapis calaminaris*.

| | |
|---|---|
| Specific gravity, | 2.786 |
| Composition, dried at 212°— | |
| Carbonate of lime, | 65.69 |
| Carbonate of iron, | 8.00 |
| Oxide of iron and alumina, | 13.23 |
| Magnesia, | 1.57 |
| Oxide of manganese, | .34 |
| Silica and insoluble silicates, | 11.37 |
| Alkalies, not estimated. | |
| | 100.20 |

The air-dried ore lost 0.7 per cent. of *moisture*, when dried at 212° F. This mineral contains only about ten or twelve per cent. of iron. It might be useful as a fluxing material, in the smelting of silicious or argillaceous ores, and deserves trial as a water cement.

CRITTENDEN COUNTY.

No. 23—LIMONITE. *Labeled "Iron Ore from Sneed's mines, on Tradewater river, Crittenden county, Ky." (From Dr. Wm. C. Sneed.)*

Above the coal a compact, dark reddish-brown mineral, mottled, with softer included portions, of an ochreous appearance. Powder of a brownish-yellow color.

| | | |
|---|---|---|
| Specific gravity, | 2.684 | |
| Composition, dried at 212°— | | |
| Peroxide of iron, | 39.60 | = 27.73 per cent. of *Iron*. |
| Alumina, | 1.00 | |
| Brown oxide of manganese, | .20 | |
| Phosphoric acid, | .67 | |
| Lime, | .58 | |
| Magnesia, sulphuric acid, traces. | | |
| Silica and insoluble silicates, | 51.30 | |
| Combined water and loss, | 6.65 | |
| | 100.00 | |

The air-dried mineral lost 0.8 per cent. of *moisture*, when dried at 212 °F.

No. 24—Clay Ironstone. *Labeled "Iron Ore from Sneed's mines, on Tradewater, Crittenden county, Ky."*

Found in a layer six to twelve inches thick, separated by twelve inches of shale from the three and a half feet thick bed of coal below.

A compact dark grey mineral, resembling fine-grained limestone; quite hard; powder of a light grey color.

| | | |
|---|---|---|
| Specific gravity, | | 3.225 |
| Composition, dried at 212°— | | |
| Carbonate of iron, | 12.42 | = 15.86 per cent. of *Iron*. |
| Peroxide of iron, | 14.07 | |
| Carbonate of lime, | 18.48 | |
| Carbonate of magnesia, | 1.49 | |
| Phosphate of lime, | 29.49 | |
| Alumina, | 2.91 | |
| Potash, | .57 | |
| Soda, | .15 | |
| Bituminous matter, | 1.32 | |
| Oxide of manganese, a trace. | | |
| Silica and insoluble silicates, | 16.07 | |
| Water and loss, | 3.03 | |
| | 100.00 | |

This mineral is remarkable for its very large proportion of phosphate of lime, which causes it to contain nearly sixteen and a half per cent. of phosphoric acid, and which must render it useless as an iron ore. For the same reason, and in consequence of the considerable amount of alkalies which it presents, it may possibly be made a valuable mineral manure, if burnt, ground to powder, and applied to land deficient in phosphates and the alkalies.

No. 25—Coal. *Labeled "Specimen of Coal from Sneed's coal mines, on Tradewater, Crittenden county, Ky."*

The bed is described as three feet eight inches in thickness. Seven miles from the Ohio river.

A very black, and apparently very pure, soft bituminous coal, resembling the Pittsburg coal in its external appearance. Some fibrous coal between the layers, exhibiting vegetable impressions, and some little appearance of pyrites. Some fragments heated over the spirit lamp softened and swelled up a good deal, leaving a coke of moderate density.

| | | |
|---|---|---|
| Specific gravity, - - - - - - | | 1.316 |
| Composition, dried at 212° F.— | | |
| Volatile combustible matters, - | 37.00 | |
| Carbon in the coke, - - - | 55.40 | Coke 63. per cent. |
| Ashes, (purplish-grey,) - - | 7.60 | |
| | 100.00 | |

The air-dried coal lost 2. per cent. of moisture when dried at 212°. The total amount of *sulphur* amounts to 1.04 per cent., of which .04 is in sulphate of lime of the ash.

No. 26—SULPHURET OF ZINC. *Labeled "Lead mines, one and a half miles south of Sulphur Springs, on Hurricane creek, Crittenden county, Kentucky."*

A dark brown mineral; drusy, with minute quartz crystals and a little calcareous spar; containing also some galena, (sulphuret of lead;) which substances are mixed throughout the mass. Powder of a dark olive-grey color.

Composition—

| | |
|---|---|
| Sulphuret of zinc, - - - - - - - - | 60.30 |
| Sulphuret of lead, - - - - - - - - | 2.60 |
| Alumina and oxide of iron, - - - - - - | 10.19 |
| Carbonate of lime, - - - - - - - - | 3.37 |
| Magnesia, - - - - - - - - - - | .20 |
| Silex and insoluble silicates, - - - - - - | 26.38 |
| | 103.04 |

This ore contains more than 40. per cent. of zinc. It contains traces of copper, manganese, and phosphoric acid. If found in large quantities it might be made valuable in the preparation of the zinc white paint, (oxide of zinc,) which is now much used as a substitute for the white lead.

### FAYETTE COUNTY.

No. 27—SOIL. *From a woodland pasture, (land which had never been in cultivation,) about eight miles from Lexington, near Newtown turnpike, head waters of North Elkhorn creek, farm of Mrs. Dallam.*

*Color*, dark greyish-brownish, or chocolate. Washed carefully with water this soil left more than 62. per cent. of *exceedingly fine sand*, somewhat lighter colored than the soil itself. This sand, washed with hydrochloric acid and dried again, weighed about 55. per cent.

This very fine sand, or quartz powder, the presence of which is not

generally suspected in our rich loam soil, is so fine as to pass through the finest bolting cloth, of about five thousand apertures to the inch —leaving only about 0.4 of one per cent. of quartzy grains, not as large as small mustard seed.

Dried at 320° F., this soil lost 4.44 per cent. of *moisture*. Its composition, thus dried, was found to be as follows, viz:

| | |
|---|---|
| Organic and volatile matters, | 8.000 |
| Carbonate of lime, | .494 |
| Carbonate of magnesia, | .420 |
| Oxides of iron and manganese, | 6.170 |
| Alumina, | 4.181 |
| Phosphate of lime, | .560 |
| Potash, | .205 |
| Soda, | .062 |
| Silica and insoluble silicates, | 79.910 |
| | 100.000 |

The silicious residue, (79.9 per cent.,) from the action of hydrochloric acid, when examined by the microscope exhibited a large proportion of clear quartzy particles; in which respect, however, it resembled, nearly, the silicious residue of most of the soils examined.

The unusual fertility of this celebrated blue limestone (blue grass) soil is attributable—1. To its state of extreme division. 2. Its large proportion of phosphates and the alkalies. 3. The great amount of organic matter, &c., which it contains. The latter ingredient—the organic matter—gives the soil its dark color, makes it light and very retentive of moisture and gases favorable to vegetable growth; it materially aids in the solution of the mineral elements of vegetable nutrition, and by its own decomposition furnishes directly to plants a rich supply of food.

The *specific gravity* of this soil is 2.443, but in consequence of its great porosity this does not give a correct idea of the weight of a cubic foot of it. A cubic foot of a solid substance having the above mentioned specific gravity would weight more than one hundred and seventy-nine pounds; but by actual experiment—by weighing a portion of this dried soil compressed into a specific gravity bottle—it was found to weigh only at the rate of about seventy-one and a half pounds to the cubic foot, (71.543 pounds.) This gives for the weight of the soil on an acre of ground, (43.560 square feet,) to the depth of one foot only, more than three millions of pounds, (3.116.413$\frac{000}{100}$ pounds.)

Taking this immense quantity of matter into consideration, which really represents, in the case of many plants, not one-half of that from which they draw their nourishment, it must be evident that quantities of valuable nutritious matter, sufficient for the support of vegetable growth, may exist in a soil, and yet may entirely escape the most delicate processes, and be unappreciable, in the quantities generally taken by the chemist for his analyses, by his finest balances.

According to these data, the quantity of potash in this Fayette county soil, taken to the depth of one foot only, is more than six thousand three hundred and eighty-eight pounds—a quantity which seems almost inexhaustible by the most wasteful culture.

That the proportion of the valuable ingredients of the soil is much diminished by its continued cultivation in corn and grain crops is exhibited in the analysis of the next succeeding soil, which was taken from the same locality as this, but which had been for more than fifty years subjected to constant cultivation.

No. 28—Soil. *From an old field long in cultivation; same locality as the last; adjoining field.*

*Color*, light chocolate, or grey-brown. Washed carefully with water this soil left more than 68. per cent of *very fine sand*, of a light snuff color, mixed with a few very small rounded particles of iron ore; and about 0.4 of one per cent. of small rounded quartzy particles, some of which are transparent, some milky, yellow, red, and green; all finer than mustard seed, yet presenting the appearance of microscopic boulders.

Dried at 340° this soil lost 4.58 per cent. of *moisture*. Its composition was found to be as follows, viz:

| | |
|---|---|
| Organic and volatile matters, | 5.980 |
| Carbonate of lime, | .530 |
| Carbonate of magnesia, | .547 |
| Carbonate of manganese, | .204 |
| Phosphate of lime, | .450 |
| Oxide of iron, | 7.190 |
| Alumina, | 4.528 |
| Potash, | .139 |
| Soda, | .031 |
| Silica and insoluble silicates, | 80.430 |
| | 100.029 |

FULTON COUNTY.

No. 29—Soil. *Labeled "Soil from Bluffs at Hickman, where milk-sickness is most prevalent, [does it contain more than the ordinary quantity of magnesia?] Fulton county, Ky."*

The dry soil is of a dirty buff color. The air-dried soil lost 1.72 per cent. of *moisture* when dried at 380°. Washed with water it left about 36. per cent. of very *fine sand.* One thousand grains subjected to the action of water containing carbonic acid yielded 1.150 grains of solid matter, dried at 212°. This treated with pure water left 0.85 grains of *insoluble matter*, which had been dissolved by the carbonic acid; having the following composition, viz:

| | |
|---|---|
| Silica, | .140 |
| Carbonate of lime, | .357 |
| Carbonate of magnesia, | .125 |
| Carbonate of manganese, | .085 |
| Alumina, oxide of iron, and traces of phosphates, | .067 |
| Loss, | .076 |

The portion dissolved by the water weighing, when dried at 212°, 0.3 of a grain, was ignited, when it lost of

| | |
|---|---|
| Organic and volatile matter, | 0.100 |
| The residue gave— | |
| Carbonate of lime, | .007 |
| Carbonate of magnesia, | .021 |
| Carbonate of manganese and loss, | .092 |
| Potash, | .060 |
| Soda, | .020 |

The composition of this soil, dried at 380° F., was found to be as follows, viz:

| | |
|---|---|
| Organic and volatile matters, | 1.720 |
| Carbonate of lime, | 1.540 |
| Carbonate of magnesia, | .517 |
| Brown oxide of manganese, | .036 |
| Alumina, oxide of iron, and traces of phosphates, | 4.470 |
| Potash, | .108 |
| Soda, | .052 |
| Silica and insoluble silicates, | 92.350 |
| | 100.793 |

Nothing remarkable, in the mineral ingredients of this soil, appears, to account for the peculiar sickness prevalent in the region from whence it came.

No. 30—Soil. *Labeled "Soil under the gravel bed at Hickman, Fulton county, Ky."*

Color of the dried soil brownish-buff. Washed with water it left about fifty-six per cent. of very *fine sand*, containing a few spangles of mica. The air-dried soil lost 3.8 per cent. of moisture, when dried at 300° F.

One thousand grains treated with water containing carbonic acid gave up 1.275 grains of solid matter, dried at 212° F.; this, treated with pure water, left 1.043 grains of insoluble matter, which had been extracted by the carbonic acid, which had the following composition, viz:

| | |
|---|---|
| Silica, | .190 |
| Carbonate of lime, | .527 |
| Carbonate of manganese, | .269 |
| Sulphate of lime and loss, | .057 |

The *soluble portion*, which weighed 0.232 gr., yielded the following ingredients, viz:

| | |
|---|---|
| Organic and volatile matters, | .100 |
| Carbonate of lime, a trace. | |
| Carbonate of magnesia, | .048 |
| Potash, | .043 |
| Soda, | .041 |

Submitted to general analysis, dried at 300°, this soil yielded the following results, viz:

| | |
|---|---|
| Organic and volatile matters, | 2.600 |
| Carbonate of lime, | .393 |
| Carbonate of magnesia, | .503 |
| Alumina, oxide of iron, and trace of phosphates, | 9.510 |
| Potash, | .170 |
| Soda, | .080 |
| Silica and insoluble silicates, | 87.030 |
| | 100.386 |

GREENUP COUNTY.

No. 31—Limonite. *Labeled "Block ore, best quality, over the coal and under the hearth sandstone, eight inches thick, Pennsylvania Furnace, Greenup county, Ky."*

A pretty pure limonite; harder portions of a dried blood-brown color; softer parts ochreous, yellow, and reddish. Powder of a brownish-yellow color.

| | | |
|---|---|---|
| Specific gravity, | | 2.918 |
| Composition, dried at 212° F.— | | |
| Oxide of iron, | 41.70 | = 29.20 per cent of *Iron*. |
| Phosphate of alumina, | 1.25 | |
| Phosphoric acid, | 2.30 | |
| Brown oxide of manganese, | .58 | |
| Magnesia, | .20 | |
| Potash, | .13 | |
| Combined water, | 8.01 | |
| Silex and insoluble silicates, | 45.05 | |
| Loss, | .78 | |
| | 100.00 | |

The air-dried ore lost 1.4 per cent. of *moisture*, when dried at 212° F.

No. 32—LIMONITE. *Labeled "Little Block Ore, average four inches, immediately under the hearth sandstone, Pennsylvania Furnace, Greenup county, Ky."*

A compact limonite of a reddish-brown color; some minute spangles of mica throughout it. Powder of a light reddish-brown color.

| | | |
|---|---|---|
| Specific gravity, | | 2.978 |
| Composition, dried at 212° F— | | |
| Oxide of iron, | 49.69 | = 34.79 per cent. of *Iron*. |
| Alumina, | 2.53 | |
| Phosphoric acid, | .22 | |
| Oxide of manganese, | .45 | |
| Magnesia, | .33 | |
| Potash, | .38 | |
| Soda, | .11 | |
| Combined water, | 7.68 | |
| Silica and insoluble silicates, | 38.35 | |
| Loss, | .26 | |
| | 100.00 | |

The air-dried ore lost 1.2 per cent. of moisture when dried at 212°.

No. 33—LIMONITE. *Labeled "Limestone Ore, over limestone, eighteen inches, Pennsylvania Furnace, Greenup county, Ky."*

A pretty compact limonite; portions dense, and dark reddish-brown, others ochreous, bright red; small crystals and geodes of carbonate of lime diffused throughout it. Powder dirty orange-red color.

| | | |
|---|---|---|
| Specific gravity, | | 3.052 |
| Composition dried at 212°— | | |
| Oxide of iron, | 60.00 | = 42.00 per cent of *Iron*. |
| Carbonate of lime, | 20.67 | |
| Carbonate of magnesia, | 3.84 | |
| Alumina, | .68 | |
| Potash, | .17 | |
| Soda, | .06 | |
| Combined water, | 4.07 | |
| Silica and insoluble silicates, | 10.70 | |
| | 100.19 | |

The air-dried ore lost two per cent of *moisture* when dried at 212° F. This ore is remarkable from its large proportion of carbonate of lime, making it valuable to mix with more silicious ores, like the preceding, for the purpose of fluxing.

No. 34—LIMONITE. *Labeled "Limestone Ore over the limestone, Pennsylvania Furnace, Greenup county, Ky."*

A dense and hard limonite; generally of a dark reddish-brown, or dried blood color; ochreous, reddish and yellowish, between the layers; portions somewhat cellular; some minute spangles of mica, and microscopical crystals, probably of calcareous spar. Powder of brownish-yellow ochre color.

| | | |
|---|---|---|
| Specific gravity, | | 3.105 |
| Composition, dried at 212°— | | |
| Oxide of iron, | 72.70 | = 50.91 per cent. of *Iron*. |
| Alumina, | 2.00 | |
| Brown oxide of manganese, | .57 | |
| Magnesia, | .37 | |
| Potash, | .42 | |
| Soda, | .17 | |
| Combined water, | 11.48 | |
| Silica and insoluble silicates, | 13.17 | |
| | 100.88 | |

The air-dried ore lost 1.6 per cent. of *moisture* when dried at 212°.

No. 35—LIMONITE. *Labeled "Top hill ore, average eight inches (four inches to one foot) thick, Pennsylvania Furnace, Greenup county, Ky."*

A dull earthy looking, brown and reddish-brown ore; adheres to the tongue; presenting striæ of different shades of color; outer por-

tions dirty olive-grey; more dense interior part dark reddish-brown. Powder of a dull, dark, brick color.

| | | |
|---|---|---|
| Specific gravity, | | 3.011 |
| Composition, dried at 212° F.— | | |
| Oxide of iron, | 54.60 | = 38.23 per cent. of *Iron*. |
| Carbonate of lime, | 13.85 | |
| Phosphate of alumina, | 4.55 | |
| Phosphoric acid, | .74 | |
| Magnesia, | 2.79 | |
| Potash, | .36 | |
| Soda, | .32 | |
| Combined water, | 9.28 | |
| Silica and insoluble silicates, | 13.37 | |
| Loss, | .14 | |
| | 100.00 | |

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

No. 36—LIMONITE. *Labeled "Better quality of Impracticable Ore, Pennsylvania Furnace, Greenup county, Ky."*

A dark reddish-brown ore; porous; adhering to the tongue; fine granular, or somewhat fine oolitic, with small angular grains in parts. Powder of a dark reddish-brown color, like "Spanish Brown."

| | | |
|---|---|---|
| Specific gravity ? | | |
| Composition, dried at 212° F.— | | |
| Oxide of iron, | 87.00 | = 60.90 per cent. of *Iron*. |
| Alumina, | .60 | |
| Phosphoric acid, | .68 | |
| Brown oxide of manganese, | .65 | |
| Magnesia, | .82 | |
| Potash, | .30 | |
| Soda, | .21 | |
| Sulphur, a trace. | | |
| Combined water, | 6.59 | |
| Silica and insoluble silicates, | 3.47 | |
| | 100.32 | |

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

This specimen was examined with great care, by a variety of processes, to detect the presence of injurious ingredients, and none are found in it in objectionable quantities.

The true reason of the difficulty experienced in the smelting of this ore is in its *very purity;* in the large amount of oxide of iron which it contains; in the absence of lime, and the small proportion of the materials which fuse together to form the *slag* or *cinder;* without a sufficient quantity of which, in the iron furnace, the reduced iron is not protected from the oxydating influence of the blast. This ore could easily be worked into good iron by mixing it with a proper proportion of earthy (silicious and aluminous) materials, and of limestone, or by using it with ores which are less rich in oxide of iron.

No. 37—CARBONATE OF IRON. *Labeled "Impracticable hard Limestone Ore, four feet thick over the limestone, Pennsylvania Furnace, in Greenup county, Ky."*

Fresh fracture, dark reddish-brown; exterior, silver-grey, from the presence of a whitish incrustation or cement, between the fine crystalline grains of which the mineral is mainly composed, and which give it a somewhat sparkling appearance, like a fine-grained impure coccolite. Some of the grains are reddish, and apparently translucent, but they are generally of a dried blood-brown color, and opaque, imbedded in the white cementing material. *Powder* of a lilac grey color; that of portions inclined to buff.

Composition, dried at 212° F.—

| | | |
|---|---|---|
| Carbonate of iron, | 72.86 | 39.42 per cent. of *Iron.* |
| Oxide of iron, | 7.42 | |
| Carbonate of lime, | 3.17 | |
| Carbonate of magnesia, | 2.80 | |
| Carbonate of manganese, | 1.18 | |
| Phosphoric acid, | .04 | |
| Sulphur, | .15 | |
| Alumina, | 1.97 | |
| Potash, | .32 | |
| Soda, | .10 | |
| Silica and insoluble silicates, | 9.47 | |
| Water and loss, | .52 | |
| | 100.00 | |

The air-dried ore lost 0.7 per cent. of moisture, when dried at 212° F.

This ore would also yield good iron in profitable proportion, if properly fluxed. Like the preceding, it contains rather too small a propor-

tion of the ingredients which make *cinder*. It is probably very fusible into a black slag, when suddenly heated alone in the high furnace.

No. 38—CARBONATE OF IRON. *Labeled "Impracticable part of Limestone Ore, Pennsylvania Furnace, Greenup county, Ky. (Does it contain sulphur, zinc, arsenic, or other impurities?)"*

Resembles the preceding as to its granular and concretionary characters, but is more sparkling, apparently from the presence of minute spangles of mica. *Powder* of a brownish-buff color.

| | | |
|---|---|---|
| Specific gravity, | | 3.176 |
| Composition, dried at 212° F.— | | |
| Carbonate of iron, | 78.51 | 41.80 per cent. of *Iron*. |
| Oxide of iron, | 5.57 | |
| Carbonate of lime, | 2.36 | |
| Carbonate of magnesia, | 2.81 | |
| Carbonate of manganese, | 1.11 | |
| Alumina, | 1.77 | |
| Phosphoric acid, | .04 | |
| Potash, | .17 | |
| Soda, | .64 | |
| Silica and insoluble silicates, | 4.87 | |
| Sulphur, a mere trace. | | |
| Water and loss, | 2.15 | |
| | 100.00 | |

The air-dried ore lost 0.8 per cent. of *moisture*, when dried at 212° F.

The remarks appended to the preceding ore are equally applicable to this.*

No. 39—LIMESTONE. *Labeled "Limestone used as a flux, Pennsylvania Furnace, Greenup county, Ky."*

A dark grey limestone, pretty compact, sparkling with minute crystalline facets, and containing a few organic remains, the most conspicuous of which, in the small specimen examined, is a portion of a very small encrinal stem.

*Other ores were received from this furnace, but the limited time allotted to the chemical investigation prevented their analysis for the present.

| | |
|---|---|
| Specific gravity, | 2.776 |
| Composition, dried at 212° F.— | |
| Carbonate of lime, | 95.25 |
| Carbonate of magnesia, | 2.74 |
| Oxide of iron, alumina, trace of phosphate of lime, | 1.27 |
| Potash, | .09 |
| Soda, | .08 |
| Silica and insoluble silicates, | .57 |
| | 100.000 |

The air-dried rock lost 1. per cent. of *moisture* when dried at 212° F. Quite a pure carbonate of lime; but which, in view of the general richness and purity of the Pennsylvania furnace ores, is not as well suited for use there, as a flux, as a limestone which contains a larger proportion of extraneous ingredients.

No. 40—Iron Furnace Slag. *Labeled "Dark purple Slag, produced when making soft grey iron; Pennsylvania Furnace, Greenup co., Ky."*

A glass of a dark, smoky, purple color, when seen through thin edges. Of somewhat difficult fusion before the plow-pipe; in the oxydating flame swelling up and becoming white because of the formation in it of numerous small air bubbles. With soda, gave the manganese re-action; with borax, that of iron. In fine powder, which is white, hydrochloric acid decomposed it perfectly, after digestion in the sand-bath.

| | | | | |
|---|---|---|---|---|
| Specific gravity, | | | 2.807 | |
| Composition, dried at 212°— | | | | |
| Silica, | 55.00 | Containing oxygen, | | 28.557 |
| Lime, | 27.10 | " | 7.706 | |
| Magnesia, | 1.95 | " | .779 | |
| Protoxide of iron, | 1.57 | " | .348 | |
| Protoxide of manganese, | .27 | " | .060 | |
| Alumina, | 12.30 | " | 5.749 | |
| Potash, | 1.73 | " | .293 | |
| Soda and loss, | .08 | " | .020 | |
| | 100.00 | | 14.955 : | 28.557 |
| Oxygen, in the bases and in the silica, nearly as | | | 1. : | 1.91 |

The composition of this cinder approaches, very nearly, to what is called a bi-silicate, i. e., a silicate in which the oxygen in the silica is just double that contained in the base, or bases, combined with it. A very trifling addition of limestone would produce a perfect bi-silicate,

which is considered the *model cinder* for charcoal furnaces. This, however, is sufficiently near it for all practical purposes.

No. 41—IRON FURNACE SLAG. *Labeled "Pea-green cellular cinder, produced when making strong grey iron of a closer texture than with the dark bottle cinder, but furnace making more iron; Pennsylvania Furnace, Greenup county, Ky."*

A pea-greenish-grey colored slag, full of bubbles of various sizes, from very minute up to the size of an almond kernel. Powder nearly white. Before the blow-pipe, fuses, with some difficulty, into a bottle-green glass.

Composition, dried at 212° F.—

| | | | | |
|---|---|---|---|---|
| Silica, | 60.64 | Containing of oxygen, | 31.846 | |
| Lime, | 14.65 | " | 4.166 | |
| Magnesia, | 2.55 | " | 1.019 | |
| Alumina, | 13.30 | " | 6.217 | |
| Protoxide of iron, | 4.62 | " | 1.025 | |
| Protoxide of manganese, | .88 | " | .198 | |
| Potash, | 2.55 | " | .432 | |
| Soda, | .81 | " | .076 | |
| | 100.00 | | 13.135 | : 31.846 |
| Oxygen nearly as | | | 1. | : 2.42 |

No. 42—PIG-IRON. *Labeled "Pig-iron, Pennsylvania Furnace, Greenup county, Ky."*

A moderately fine-grained grey cast-iron; flattens a little under the hammer, but soon breaks to pieces; yields easily to the file and the cold chisel.

Specific gravity, 6.770

Composition—

| | | | |
|---|---|---|---|
| Iron, | 92.08 | | |
| Graphite, | 3.03 | Total carbon, | 3.93 |
| Combined carbon, | .90 | | |
| Manganese, | .36 | | |
| Silicon, | 2.91 | | |
| Slag, | .16 | | |
| Aluminium, | .07 | | |
| Magnesium, | .24 | | |
| Potassium, | .12 | | |
| Phosphorus, sulphur, and loss, | .13 | | |
| | 100.00 | | |

No. 43—Coal. *Labeled "Four feet Coal, about twenty feet above the block ore, including one foot of bituminous shale; sixteen inches of coal above the shale; twenty inches of coal below the shale. Pennsylvania Furnace, Greenup county, Ky."*

Rather dull looking coal, breaking readily into laminæ, which are separated by fibrous coal with vegetable impressions, which are generally infiltrated with pyritous matter. Heated over the spirit lamp it decrepitated, softened, and swelled up into a light spongy coke. Appears to be a coking coal.

| | | | |
|---|---|---|---|
| Specific gravity, | | | 1.287 |
| Composition, dried at the ordinary temperature— | | | |
| Moisture, | 6.00 | Total volatile matters, | 40.20 |
| Volatile combustible matters, | 34.20 | | |
| Carbon in the coke, | 56.20 | Moderately dense coke, | 59.80 |
| Ashes, (dark purple-grey,) | 3.60 | | |
| | | | 100.00 |

| | |
|---|---|
| Composition, dried at 212°— | |
| Volatile combustible matters, | 36.383 |
| Carbon in the coke, | 59.787 |
| Ashes, | 3.830 |
| | 100.000 |

The per centage of sulphur was found to be 1.694. The ashes contained only a trace of sulphate of lime.

No. 44—Limonite. *Labeled "Black vein, twenty feet under the three feet coal; Buena Vista Furnace, Greenup county, Ky."*

A heavy, compact mineral, presenting irregular veins and mottling of a dark grey color, in a dark red-brown mass. Powder of a light snuff-brown color.

| | | | |
|---|---|---|---|
| Specific gravity, | | | 3.044 |
| Composition, dried at 212° F.— | | | |
| Oxide of iron, | 61.18 | 46.51 per cent. of *Iron.* | |
| Carbonate of iron, | 7.48 | | |
| Carbonate of lime, | 2.15 | | |
| Carbonate of magnesia, | 2.02 | | |
| Carbonate of manganese, | 2.93 | | |
| Alumina, | 2.27 | | |
| Potash, | .45 | | |
| Combined water and loss, | 10.29 | | |
| Silica and insoluble silicates, | 11.23 | | |
| Sulphur, a trace. | | | |
| | 100.00 | | |

The air-dried ore lost 1.7 per cent. of *moisture* when dried at 212°.

No. 45—LIMONITE. *Labeled "Yellow Kidney Ore, thirty feet above the three feet coal, Buena Vista Furnace, Greenup county, Ky."*

Of a dark brown color of various shades; exterior, and some portion of the mass and cavities in the interior, ochreous, yellow, and soft.

| | | |
|---|---|---|
| Specific gravity, | | 3.132 |
| Composition, dried at 212° F.— | | |
| Oxide of iron, | 68.10 | = 47.69 per cent. of *Iron*. |
| Alumina, | 2.93 | |
| Phosphoric acid, | .43 | |
| Oxide of manganese, | 1.64 | |
| Magnesia, | .67 | |
| Potash, | .54 | |
| Soda, | .13 | |
| Combined water, | 11.67 | |
| Silica and insoluble silicates, | 13.05 | |
| Carbonic acid and loss, | .84 | |
| | 100.00 | |

The air-dried ore lost 1.5 per cent. of *moisture* when dried at 212° F.

No. 46—LIMONITE. *Labeled "Earthy Kidney Ore, thirty feet over the three feet coal, Buena Vista Furnace, Greenup county, Ky."*

An earthy looking ore, adhering to the tongue; color, varying in layers, from dirty reddish-brown to dirty yellow ochre.

| | | |
|---|---|---|
| Specific gravity about | | 3. |
| Composition, dried at 212° F.— | | |
| Oxide of iron, | 58.90 | = 41.24 per cent. of *Iron*. |
| Alumina, | 4.15 | |
| Carbonate of lime, | 3.15 | |
| Oxide of manganese, | .97 | |
| Magnesia, | 2.40 | |
| Potash, | .58 | |
| Soda, | .47 | |
| Combined water, | 11.26 | |
| Silica, and insoluble silicates, | 17.87 | |
| Loss, | .25 | |
| | 100.00 | |

The air-dried ore lost 1.3 per cent. of moisture when dried at 212°.

No. 47—IRON FURNACE SLAG. *Labeled "Dark Glassy Cinder, Buena Vista Furnace, Greenup county, Ky."*

A perfect glass, of a smoky-purplish tint when viewed through the thin edges. Fusing rather more easily than the previously described ones; like No. 64 swells up in the oxidating flame by the formation of numerous air bubbles, which give it a white appearance.

| | | | | |
|---|---|---|---|---|
| Specific gravity, | | | | |
| Composition, dried at 212°— | | | | |
| Silica, | 56.90 | Containing oxygen, | | 29.544 |
| Lime, | 13.20 | " | 3.753 | |
| Magnesia, | 3.46 | " | 1.383 | |
| Alumina, | 20.50 | " | 9.582 | |
| Protoxide of iron, | 2.43 | " | .539 | |
| Protoxide of manganese, | .51 | " | .115 | |
| Potash, | 3.16 | " | .536 | |
| Soda, | .36 | " | .092 | |
| | 100 52 | | 16.000 : | 29.544 |
| Oxygen nearly as | | | 1. : | 1.85 |

No. 48—PIG-IRON. *Labeled "Pig-iron, Buena Vista Furnace, Greenup county, Ky."*

A grey iron of a much finer texture than No. 41; extends somewhat under the hammer, but soon breaks to pieces; yields easily to the file and the cold chisel.

| | | | |
|---|---|---|---|
| Specific gravity, | | 6.903 | |
| Composition— | | | |
| Iron, | 91.88 | | |
| Graphite, | 1.65 | Total carbon, | 5.80 |
| Combined carbon, | 3.15 | | |
| Silicon, | 3.27 | | |
| Manganese, | .35 | | |
| Slag, | .30 | | |
| Aluminum, | .07 | | |
| Traces of phosphorus and sulphur. | | | |
| | 100.67 | | |

No. 49—CARBONATE OF IRON. *Labeled "Grey Limestone Ore, Bellefonte Furnace, Greenup county, Ky."*

A dark bluish-grey ore; porous; adhering somewhat to the tongue; friable; appearing to be made of small grains, the color of which varies

from dark yellowish to black, united by a whitish cement. Powder, light grey color.

| | | |
|---|---|---|
| Specific gravity, | | ? |
| Composition, dried at 212° F.— | | |
| Carbonate of iron, | 62.24 | = 31.93 per cent. of *Iron*. |
| Oxide of iron, | 2.68 | |
| Carbonate of lime, | 2.75 | |
| Carbonate of magnesia, | 3.43 | |
| Carbonate of manganese, | 1.12 | |
| Alumina, | 5.15 | |
| Phosphoric acid, | .54 | |
| Potash, | .44 | |
| Soda, | .15 | |
| Silica and insoluble silicates, | 18.17 | |
| Water, bitumous water, and loss, | 3.33 | |
| | 100.00 | |

The air-dried ore lost 0.6 per cent. of *moisture* when dried at 212° F. This ore resembles No. 36 in structure and composition, but contains less iron and more silica and alumina, which renders it more manageable in the furnace.

No. 50—CARBONATE OF IRON. *Labeled "Blue Limestone Ore, Bellefonte Furnace, Greenup county, Ky."*

A porous, granular ore; adhering to the tongue; of a dirty buff-grey color. Powder, dirty buff color. (This paper contained another specimen, which seemed to be a limonite—not analyzed.)

| | | |
|---|---|---|
| Specific gravity, | | 3.011 |
| Composition, dried at 212°— | | |
| Carbonate of iron, | 56.58 | 30.74 per cent of *Iron*. |
| Oxide of iron, | 4.86 | |
| Carbonate of lime, | 2.95 | |
| Carbonate of magnesia, | 2.17 | |
| Carbonate of manganese, | 1.68 | |
| Alumina, | .25 | |
| Potash, | .44 | |
| Soda, | .38 | |
| Silica and insoluble silicates, | 30.10 | |
| Water, trace of phosphoric acid, and loss, | .59 | |
| | 100.00 | |

The air-dried ore lost 0.1 per cent. of *moisture* when dried at 212° F.

No. 51—LIMESTONE. *Labeled "Limestone used as a flux at Bellefonte Furnace, when working best, Greenup county, Ky."*

A grey, fine-granular limestone, containing organic remains, (univalve and by-valve shells,) and glimmering with minute crystals of calcareous spar. Powder nearly white.

| | |
|---|---|
| Specific gravity, | 2.687 |
| Composition, dried at 212°— | |
| Carbonate of lime, | 97.17 |
| Carbonate of magnesia, | 1.39 |
| Oxide of iron, alumina, and a trace of phosphates, | 1.17 |
| Potash, | .11 |
| Soda, | .09 |
| Silicious residue, | .55 |
| | 100.00 |

Dried at 212° it lost only 0.4 per cent. of *moisture.*

No. 52—IRON FURNACE SLAG. *Labeled "Cinder, produced at Bellefonte Furnace, when working best, Greenup county, Ky."*

A glassy cinder, of a smoky-purple color when viewed through the thin edges; before the blow-pipe, fused more easily than those previously examined, swelling up and becoming white by the formation of numerous bubbles.

| Composition— | | | |
|---|---|---|---|
| Silica, | 52.20 | Containing oxygen, | 27.104 |
| Lime, | 17.15 | " | 3.085 |
| Magnesia, | 3.25 | " | 1.299 |
| Alumina, | 23.30 | " | 10.911 |
| Protoxide of iron, | .16 | " | .045 |
| Protoxide of manganese, | .27 | " | .061 |
| Potash, | 2.20 | " | .373 |
| Soda, | .91 | " | .283 |
| Loss, | .56 | | |
| | 100.00 | 16.007 | : 27.104 |
| Oxygen as | | 1. | : 1.69 |

No. 53—PIG-IRON. *Labelled "Pig Iron produced from the limestone ore, Bellefonte Furnace, Greenup county, Kentucky."*

Coarser grained than No. 41, and rather darker grey; flattens a little under the hammer, but soon breaks to pieces; yields easily to the file.

| | | |
|---|---|---|
| Specific gravity, | | 6.915 |
| Composition— | | |
| Iron, | 94.54 | |
| Graphite, | 2.25 | Total carbon, 3.33 |
| Combined carbon, | 1.08 | |
| Manganese, | .35 | |
| Silicon, | 1.26 | |
| Slag, | .18 | |
| Aluminium, | .08 | |
| Potassium, | .21 | |
| Sodium, | .03 | |
| Magnesium, | .17 | |
| | 100.15 | |

No. 54—LIMONITE. *Labeled "Main Block Ore; ten to twelve inches thick over the impure ("bastard") limestone, near top of hills, Buffalo Furnace, Greenup county, Kentucky."*

A dark brown, pretty compact limonite, with the appearance of infiltrated calcareous spar throughout it; exterior of the layer earthy, ochreous. Powder of a brownish-yellow ochre color.

| | | |
|---|---|---|
| Specific gravity, | | 3.124 |
| Composition, dried at 212° F.— | | |
| Oxide of iron, | 49.45 | = 34.63 per cent. of *Iron.* |
| Carbonate of lime, | 7.35 | |
| Phosphate of alumina, | .45 | |
| Magnesia, | 2.58 | |
| Oxide of manganese, | 1.15 | |
| Phosphoric acid, | 1.53 | |
| Potash, | .69 | |
| Soda, | .19 | |
| Silica and insoluble silicates, | 25.65 | |
| Water and loss, | 10.96 | |
| | 100.00 | |

The air dried ore lost 1.4 per cent. of *moisture* when dried at 212° F.

No. 45—LIMONITE. *Labeled "Little Block Ore, over the Main Block, near tops of hills, Buffalo Furnace, Greenup county, Ky."*

A dull looking, reddish-brown ore, porous, adhering to the tongue; presenting the appearance of horizontal stratification; contains a few spangles of mica. Powder of a reddish-iron-rust color.

| | | |
|---|---|---|
| Specific gravity, | | 3.176 |
| Composition, dried at 212° F.— | | |
| Oxide of iron, | 66.90 | = 46.85 per cent. of *Iron.* |
| Alumina, | 2.65 | |
| Oxide of manganese, | .65 | |
| Magnesia, | .33 | |
| Phosphoric acid, | .25 | |
| Potash, | .27 | |
| Soda, | .31 | |
| Combined water, | 8.79 | |
| Silica and insoluble silicates, | 19.75 | |
| Loss, | .10 | |
| | 100.00 | |

The air-dried ore lost .2 per cent. of *moisture* when dried at 212°.

No. 56—LIMONITE. *Labeled "Block Kidney Ore, over the Main Block Ore, near tops of hills, Buffalo Furnace, Greenup county, Ky."*

The specimen is a portion of a mass with curved layers of different shades of color, from reddish-brown to yellow-ochre; friable, porous, adhering to the tongue. Powder of a yellowish-brown or snuff color.

| | | |
|---|---|---|
| Specific gravity, | | 2.845 |
| Composition, dried at 212° F.— | | |
| Oxide of iron, | 63.50 | = 44.54 per cent. of *Iron.* |
| Alumina, | 3.55 | |
| Oxide of manganese, | 1.95 | |
| Magnesia, | .40 | |
| Potash, | .34 | |
| Soda, | .17 | |
| Combined water, | 12.05 | |
| Silica and insoluble silicates, | 17.95 | |
| Trace of phosphoric acid and loss, | .09 | |
| | 100.00 | |

The air-dried ore lost 1.3 per cent. of *moisture* when dried at 212° F.

No. 57—LIMONITE. *Labeled "Dark brown-red variety of Little Block Ore, over Main Block Ore, Buffalo Ore Banks, Greenup county, Kentucky."*

A dull, reddish-brown porous limonite, adhers to the tongue; contains minute whitish specks. Powder, dark red-brown color.

| | | |
|---|---|---|
| Specific gravity, | | 3.120 |

Composition, dried at 212° F.—

| | | |
|---|---|---|
| Oxide of iron, | 60.50 | = 42.35 per cent. of *Iron.* |
| Oxide of manganese, | 3.15 | |
| Alumina, | 2.95 | |
| Magnesia, | .40 | |
| Potash, | .19 | |
| Soda, | .37 | |
| Combined water, | 6.95 | |
| Silica and insoluble silicates, | 25.35 | |
| Trace of phosphoric and loss, | .14 | |
| | 100.000 | |

The air-dried ore lost 2.2 per cent. of *moisture* when dried at 212° F.

No. 58—LIMONITE. *Labeled "Main Block ore, Buffalo Furnace, over impure (bastard) limestone, tops of hills, Greenup county, Ky."*

Irregular form, concretionary; exterior dirty yellow ochre; interior dark reddish-brown; adheres to the tongue; large porous or cellular; contains small spangles of mica. Powder of a brownish-yellow color.

Composition, dried at 212° F.—

| | | |
|---|---|---|
| Oxide of iron, | 70.30 | = 49.23 per cent. of *Iron.* |
| Alumina, | 2.15 | |
| Magnesia, | .37 | |
| Oxide of manganese, | .75 | |
| Potash, | .17 | |
| Soda, | .16 | |
| Combined water, | 11.76 | |
| Silica and insoluble silicates, | 13.95 | |
| Loss, | .39 | |
| | 100.00 | |

The air-dried ore lost 1.4 per cent. of *moisture* when dried at 212°.

No. 59—LIMONITE. *Labeled "Rough Sandy Block Ore, on the top of the hill near Little Sandy, Macalister or Buffalo ore bank, Greenup county, Kentucky."*

A dirty yellowish-brown ore; granular; porous; adhering firmly to the tongue; sparkling with small scales of mica. Powder, lighter yellowish-brown.

| | | |
|---|---|---|
| Specific gravity, | | 3.303 |
| Composition, dried at 212° F.— | | |
| Oxide of iron, | 63.20 | = 44.26 per cent. of *Iron.* |
| Alumina, | 1.95 | |
| Oxide of manganese, | 1.15 | |
| Magnesia, | .74 | |
| Combined water, | 10.30 | |
| Silica and insoluble silicates, | 22.35 | |
| Phosphoric acid, a trace. | | |
| Potash, | .58 | |
| | 100.13 | |

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

No. 60—Carbonate of Iron. *Labeled "Grey Block Ore, above Main Block Ore, near top of hills, Buffalo Ore Banks, Greenup county, Kentucky."*

Interior portion dark-grey, resembling a limestone, sparkling with confused crystalline plates; on the exterior portion, to the depth of two inches or more, of a dark reddish-brown color. Some appearance of univalve shells. Powder, of interior portion, light yellowish-grey.

| | | |
|---|---|---|
| Specific gravity, | | 3.106 |
| Composition, dried at 212° F.— | | |
| Carbonate of iron, | 46.40 | = 28.20 per cent. of *Iron.* |
| Oxide of iron, | 8.28 | |
| Carbonate of lime, | 32.15 | |
| Carbonate of magnesia, | 3.26 | |
| Carbonate of manganese, | 1.24 | |
| Alumina, | .35 | |
| Potash, | .23 | |
| Soda, | .17 | |
| Silica and insoluble silicates, | 2.57 | |
| Water, bituminous matter, and loss, | 5.35 | |
| | 100.00 | |

The air-dried ore lost 0.2 per cent. of *moisture* when dried at 212° F.

No. 61—Impure Carbonate of Iron. *Labeled "Impure (bastard) Limestone, under the Main Block ore, high up in the hills, Buffalo Furnace, Greenup county, Ky."*

Of a dark grey color; granular, with spots and infiltrations between

the grains of dark and greenish; sparkling with minute crystalline plates, as of calcareous spar, and the ends of portions of small encrinal stems. Powder of a light buff color.

| | | |
|---|---|---|
| Specific gravity, | | 2.864 |
| Composition, dried at 212°— | | |
| Carbonate of iron, | 23.56 | = 11.35 per cent. of *Iron.* |
| Carbonate of lime, | 67.33 | |
| Carbonate of magnesia, | 4.82 | |
| Carbonate of manganese, | .41 | |
| Alumina, | .48 | |
| Potash, | .23 | |
| Soda, | .10 | |
| Silica and insoluble silicates, | 1.99 | |
| Water and trace of phosphoric acid, | 1.08 | |
| | 100.00 | |

The air-dried ore lost only 0.1 per cent. of *moisture* when dried at 212° F. This would doubtless be very useful to mix with more silicious or aluminous ores, for the purpose of fluxing, instead of the pure limestone.

No. 62—LIMESTONE. *Labeled "Limestone used as a flux, Buffalo Furnace, Greenup county, Ky."*

A fine granular limestone, of a light grey color, containing petrefactions.

| | | |
|---|---|---|
| Specific gravity, | | 2.669 |
| Composition, dried at 212° F.— | | |
| Carbonate of lime, | | 81.55 |
| Carbonate of magnesia, | | 2.44 |
| Alumina, oxide of iron, and phosphates, | | .35 |
| Potash, | | .09 |
| Soda, | | .02 |
| Silica and insoluble silicates, | | 15.56 |
| | | 100.00 |

The air-dried rock lost only 0.1 per cent. of *moisture* when dried at 212°.

No. 63—LIMESTONE. *Labeled "Limestone used as a flux, at Buffalo Furnace, nearly on a level with the Lick Branch of Little Sandy, Greenup county, Ky."*

A greenish-grey, fine granular limestone; between the layers presenting a somewhat marly appearance.

| | |
|---|---|
| Specific gravity, | 2.688 |
| Composition, dried at 212°— F. | |
| Carbonate of lime, | 87.97 |
| Carbonate of magnesia, | 2.72 |
| Alumina, oxide of iron, &c., | 1.85 |
| Potash, | .20 |
| Soda, | .58 |
| Silica and insoluble silicates, | 7.15 |
| | 100.47 |

The air-dried rock lost 0.2 per cent. of *moisture*, when dried at 212° F.

No. 64—IRON FURNACE SLAG. *Labeled "Purple glass cinder, produced at Buffalo Furnace, when making soft iron, Greenup county, Ky."*

A perfectly vitrified slag, of a purple color, transparent in pieces one-fourth of an inch thick; pretty fusible before the blow-pipe; melting into a white globule full of air bubbles.

| Composition— | | | |
|---|---|---|---|
| Silica, | 56.10 | Containing oxygen, | 29.13 |
| Lime, | 24.18 | " | 6.87 |
| Magnesia, | 1.40 | " | .56 |
| Alumina, | 13.90 | " | 6.49 |
| Protoxide of iron, | 2.07 | " | .45 |
| Protoxide of manganese, | .55 | " | .12 |
| Potash, | 2.16 | " | .36 |
| Soda, | .39 | " | .10 |
| | 100.75 | 14.95 | : 29.13 |
| Oxygen as, | | 1. | : 1.96 |

No. 65—IRON FURNACE SLAG. *Labeled "Purple compact cinder, produced when making soft grey iron, Buffalo Furnace, Greenup county, Ky."*

Differs but little from the preceding in appearance and properties.

Composition, dried at 212° F.—

| | | | |
|---|---|---|---|
| Silica, | 55.90 | Containing oxygen, | 29.02 |
| Lime, | 25.42 | " | 7.23 |
| Magnesia, | 1.30 | " | .52 |
| Alumina, | 13.40 | " | 6.26 |
| Protoxide of iron, | 1.01 | " | .22 |
| Protoxide of manganese, | .83 | " | .18 |
| Potash, | 1.27 | " | .16 |
| Soda, | .63 | " | .23 |
| Loss, | .24 | | |
| | 100.00 | | 14.80 : 29.02 |
| Oxygen nearly as | | | 1. : 1.96 |

No. 66—Iron Furnace Slag. *Labeled, "Pea-green cinder, produced when Buffalo Furnace is making much iron, but of a medium closer texture than when purple cinder is formed, Greenup county, Ky."*

A vesicular slag containing fragments of reduced iron; not quite as fusible before the blow-pipe as the two preceding; melting into a compact glass of a rather darker green color.

Composition, dried at 212°—

| | | | |
|---|---|---|---|
| Silica, | 57.90 | Containing oxygen, | 30.06 |
| Lime, | 17.56 | " | 4.89 |
| Magnesia, | 2.30 | " | 1.00 |
| Alumina, | 13.97 | " | 6.53 |
| Protoxide of iron, | 6.03 | " | 2.00 |
| Protoxide of manganese, | 1.02 | " | .22 |
| Potash, | 1.04 | " | .17 |
| Soda, | .18 | " | .05 |
| | 100.00 | | 14.86 : 30.06 |
| Oxygen as, | | | 1. : 2.01 |

Lime being rather deficient in proportion in this slag, its place is supplied by protoxide of iron, causing some loss of this metal, and probably producing a less pure iron than when the two preceding "cinders" are formed.

No. 67—Pig-iron. *Labeled "Medium Textured Pig-iron, produced at Buffalo Furnace when making pea-green cinder, and yielding much iron, Greenup county, Ky."*

A rather fine grained, dark grey iron; flattens a little under the hammer, but soon breaks to pieces; yields easily to the file, rather a strong iron.

| | | | |
|---|---|---|---|
| Specific gravity, | | 7.086 | |
| Composition— | | | |
| Iron, | 93.12 | | |
| Graphite, | 3.10 | Total carbon, | 3.75 |
| Combined carbon, | .65 | | |
| Silicon, | 1.06 | | |
| Slag, | .14 | | |
| Manganese, | .18 | | |
| Aluminium, | .03 | | |
| Potassium, | .15 | | |
| Phosphorus,, | .70 | | |
| Traces of sulphur, magnesia and loss, | .87 | | |
| | 100.00 | | |

No. 68—Pig-iron. *Labeled "High White Iron, Buffalo Furnace, Greenup county, Ky."*

A very strong metal; fragments broken from the large piece with great difficulty; small fragments easily crushed under the hammer; hard enough to wear out the best file, to which it scarcely yields; very light colored and fine grained.

| | | | |
|---|---|---|---|
| Specific gravity, | | 7.322 | |
| Composition— | | | |
| Iron, | 94.70 | | |
| Graphite, | 2.20 | Total carbon, | 2.95 |
| Combined carbon, | .75 | | |
| Silicon, | .60 | | |
| Slag, | .26 | | |
| Aluminium, | .05 | | |
| Potassium, | .14 | | |
| Magnesium, | .02 | | |
| Phosphorus, | .48 | | |
| Traces of manganese, sulphur, and loss, | .80 | | |
| | 100.00 | | |

A pretty pure iron, containing, however, a little too much phosphorus; a great portion of this might possibly be removed by judicious management in its convertion into bar iron.

No. 69—Limonite. *Labeled "Flag Ore, above the limestone, Greenup Furnace, Greenup county, Ky."*

A porous, ochreous looking soft ore, in flat layers, with some portions of reddish and dark reddish brown; adhering firmly to the tongue.

| | | |
|---|---|---|
| Specific gravity, | | 2.681 |
| Composition, dried at 212° F.— | | |
| Oxide of iron, | 38.50 | = 26.96 per cent. of *Iron.* |
| Alumina, | 3.37 | |
| Magnesia, | 1.20 | |
| Oxide of manganese, | .97 | |
| Potash, | .66! | |
| Soda, | .10 | |
| Combined water, | 8.25 | |
| Silica and insoluble silicates, | 46.95 | |
| | 100.00 | |

The air-dried soil lost 1. per cent. of *moisture*, when dried at 212° F. Remarkable for its large proportion of potash. It is *possible*, however, that some fortuitous circumstances caused an over estimate of this ingredient. Our limited time prevented the repetition of the process for the separation of the alkalies.

No. 70—LIMONITE. *Labeled "Big Block Ore, under the limestone, Greenup Furnace, Greenup county, Ky."*

A moderately dense limonite, with irregular layers of rich reddish and yellowish ochreous oxide; the whole containing minute spangles of mica. Powder of a brownish-yellow color.

| | | |
|---|---|---|
| Specific gravity, | | 3.177 |
| Composition, dried at 212° F.— | | |
| Oxide of iron, | 68.10 | = 47.69 per cent. of *Iron.* |
| Alumina, | 2.17 | |
| Magnesia, | .91 | |
| Oxide of manganese, | .37 | |
| Potash, | .48 | |
| Soda, | .07 | |
| Combined water, | 11.51 | |
| Silica and insoluble silicates, | 16.25 | |
| Loss, | .14 | |
| | 100.00 | |

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

No. 71—LIMONITE. *Labeled "Red Ochre, high up in the hills, Greenup Furnace, Greenup county, Ky."*

A porous, friable ore, of a light red and yellow color, with some admixture of grey. Powder of a light red color.

Composition, dried at 212° F.—

| | | |
|---|---|---|
| Oxide of iron, | 26.60 | = 18.62 per cent. of *Iron.* |
| Alumina, | 2.37 | |
| Magnesia, | .77 | |
| Oxide of manganese, | .17 | |
| Potash, | .34 | |
| Soda, | .17 | |
| Combined water, | 5.68 | |
| Silica and insoluble silicates, | 63.90 | |
| Trace of phosphoric acid. | | |
| | 100.00 | |

The air-dried ore lost 1.6 per cent. of *moisture* when dried at 212° F.

No. 72—LIMONITE. *Labeled "Grey Limestone Ore, but no limestone under it, Greenup Furnace, Greenup county, Ky."*

A dull, granular, and porous ore, adhering to the tongue; some grains of a dark color imbedded in a light colored cement, glimmering with a few minute spangles of mica; color, dark reddish-brown, with gray intermixed. Powder, dirty light reddish brown.

| | | |
|---|---|---|
| Specific gravity, | ? | |
| Composition, dried at 212°— F. | | |
| Oxide of iron, | 51.00 | = 35.71 per cent. of *Iron.* |
| Alumina, | 2.27 | |
| Carbonate of lime, | .47 | |
| Magnesia, | 1.48 | |
| Oxide of manganese, | .97 | |
| Potash, | .52 | |
| Soda, | .28 | |
| Combined water, | 9.81 | |
| Silica and insoluble silicates, | 33.65 | |
| Phosphoric acid, a trace. | | |
| | 100.45 | |

The air- dried ore lost 2.2 per cent. of *moisture* when dried at 212°.

No. 73—LIMONITE. *Labeled "Black Bed, Greenup Furnace, Greenup county, Ky."*

A dull looking ore; color, reddish brown, with portions of yellowish and reddish-ochreous. The lens shows dark grains imbedded, and minute spangles of mica; adheres to the tongue. Powder of a dirty yellowish-brown color.

Composition dried at 212°—

| | | |
|---|---|---|
| Oxide of iron, | 67.50 | = 47.27 per cent of *Iron*. |
| Alumina, | 2.97 | |
| Carbonate of lime, | .97 | |
| Magnesia, | 1.62 | |
| Oxide of manganese, | 1.37 | |
| Potash, | .38 | |
| Combined water, | 12.11 | |
| Silica and insoluble silicates, | 14.75 | |
| | 101.67 | |

The air-dried ore lost 1.8 per cent. of *moisture* when dried at 212° F.

No. 74—CARBONATE OF IRON. *Labeled "Limestone Ore, average quality, lies on the limestone, Greenup Furnace, Greenup county, Ky."*

Ore of a variegated appearance; some parts dark reddish-brown, others yellowish-red, others dark grey; infiltrations of calcareous spar evident. Powder of dirty yellow ochre color.

| | | |
|---|---|---|
| Specific gravity, | | 3.582 |
| Composition, dried at 212° F.— | | |
| Carbonate of iron, | 41.98 | 43.65 per cent. of *Iron*. |
| Oxide of iron, | 44.66 | |
| Carbonate of lime, | 4.35 | |
| Carbonate of magnesia, | 1.84 | |
| Carbonate of manganese, | .86 | |
| Alumina, | .55 | |
| Potash, | .27 | |
| Soda, | .67 | |
| Silica and insoluble silicates, | 5.15 | |
| Phosphoric acid, a trace. | | |
| | 100.33 | |

The air-dried ore lost 0.3 per cent. of *moisture* when dried at 212° F.

No. 75—CARBONATE OF IRON. *Labeled, "Limestone Ore, best quality, resting on the limestone, Greenup Furnace, Greenup county, Ky."*

A pretty compact ore; cellular in parts; varying in color, in portions, from dark brown and dark grey, to ochreous yellow; showing fine spangles of mica under the lens. Powder of a reddish-buff, or dirty salmon color.

| | | |
|---|---|---|
| Specific gravity, | | 3.445 |
| Composition, dried at 212° F.— | | |
| Carbonate of iron, | 70.39 | 43.20 per cent. of *Iron.* |
| Oxide of iron, | 13.14 | |
| Carbonate of lime, | 4.75 | |
| Carbonate of magnesia, | 4.68 | |
| Carbonate of manganese, | 1.46 | |
| Alumina, | .37 | |
| Phosphoric acid, | .18 | |
| Potash, | .19 | |
| Soda, | .05 | |
| Silica and insoluble silicates, | 2.45 | |
| Water and loss, | 2.34 | |
| | 100.00 | |

The air-dried ore lost 0.3 per cent. of *moisture,* when dried at 212° F.

No. 76.—LIMESTONE, (IMPURE.) *Labeled "Grey Limestone Ore, lies on the limestone, Greenup Furnace, Greenup county, Ky."*

External appearance like that of a dull grey granular limestone; some calcareous spar in parts; minute dark grains in a whitish cement are evident by the lens; adheres to the tongue.

| | | |
|---|---|---|
| Specific gravity, | | 2.803 |
| Composition, dried at 212° F— | | |
| Carbonate of lime, | 71.45 | |
| Carbonate of iron, | 13.19 | 7.45 per cent. of *Iron.* |
| Oxide of iron, | 1.56 | |
| Carbonate of magnesia, | 3.73 | |
| Carbonate of manganese, | .51 | |
| Potash, | .19 | |
| Soda, | .10 | |
| Alumina, | .47 | |
| Silica and insoluble silicates, | 7.33 | |
| Water and loss, | 1.47 | |
| | 100.00 | |

The air-dried rock lost 0.5 per cent. of *moisture* when dried at 212° F.

No. 77—LIMESTONE. *Labeled, "Limestone used as a Flux, at Greenup Furnace, Greenup county, Ky."*

A dull looking, light grey, fine granular limestone, with organic remains, and small portions of calcareous spar.

| | |
|---|---|
| Specific gravity, | 2.977 |
| Composition, dried at 212° F.— | |
| Carbonate of lime, | 91.60 |
| Carbonate of magnesia, | 2.53 |
| Alumina, oxide of iron, &c., | 1.15 |
| Potash, | .13 |
| Soda, | .10 |
| Silica and insoluble silicates, | 3.97 |
| Loss, | .62 |
| | 100.00 |

The air-dried limestone lost 0.3 per cent. of *moisture* when dried at 212°.

No. 78—Iron Furnace Slag. *Labeled "Cinder produced at the Greenup Furnace, Greenup county, Ky."*

A perfectly vitrified slag, of a smoky-purple color; containing very few bubbles; fusing readily before the blow-pipe into a white blebby globule.

| | | | | |
|---|---|---|---|---|
| Specific gravity, | | | 2.680 | |
| Composition, dried at 212°— | | | | |
| Silica, | 55.54 | Containing oxygen, | | 28.84 |
| Lime, | 19 92 | " | 5.66 | |
| Magnesia, | 2 69 | " | 1.07 | |
| Alumina, | 16 54 | " | 7.73 | |
| Protoxide of iron, | 2 10 | " | .46 | |
| Protoxide of manganese, | .69 | " | .15 | |
| Potash, | 2.30 | " | .39 | |
| Soda, | .14 | " | .092 | |
| Traces of phosphoric acid and loss, | .08 | | | |
| | 100 52 | | 15.49 | : 28 84 |
| Oxygen nearly as | | | 1. | : 1.86 |

No. 79—Pig-iron. *Labeled "Pig-iron produced at Greenup Furnace, Greenup county, Ky."*

A dark grey iron of medium coarse texture; flattens a little under the hammer, but soon breaks to pieces; yields easily to the file.

| | | |
|---|---|---|
| Specific gravity, | | 6.877 |
| Composition— | | |
| Iron, | 91.29 | |
| Graphite, | 3.13 | = Total carbon. |
| Silicon, | 3.57 | |
| Slag, | .22 | |
| Manganese, | .48 | |
| Aluminium, | .30 | |
| Magnesium, | .18 | |
| Potassium, | .05 | |
| Phosphorus, | .67 | |
| Sulphur, | .05 | |
| Loss, | .06 | |
| | 100.00 | |

No. 80—LIMONITE. *Labeled "Soft Limestone Ore over the Ferruginous Limestone, Raccoon ore bank, Greenup county, Ky., (middle bed of ore two-thirds of way up the hill.")*

A friable, porous ore; adhering to the tongue; color from deep reddish-brown, to reddish-grey and light-grey; some portions yellowish. Powder dirty red-brown color.

| | | |
|---|---|---|
| Specific gravity, | | 3.019 |
| Composition, dried at 212° F.— | | |
| Oxide of iron, | 65.30 | = 47.82 per cent of *Iron*. |
| Alumina, | 2.65 | |
| Carbonate of lime, | .47 | |
| Magnesia, | .86 | |
| Oxide of manganese, | 1.55 | |
| Potash, | .22 | |
| Soda, | .10 | |
| Combined water, | 4.93 | |
| Silica and insoluble silicates, | 23.67 | |
| Loss, | .25 | |
| | 100.00 | |

The air-dried ore lost 2.8 per cent. of *moisture*, when dried at 212° F.

No. 81—LIMONITE. *Labeled "Block Ore, Raccoon Ore Banks, Greenup county, Ky."*

A dull looking limonite; dark brownish-red, with shades of lighter; porous; adhering to the tongue. Powder good Spanish brown color.

| | | |
|---|---|---|
| Specific gravity, | | 2.766 |
| Composition, dried at 212° F.— | | |
| Oxide of iron, | 76.20 | = 53.36 per cent. of *Iron*. |
| Alumina, | 2.24 | |
| Magnesia, | 1.86 | |
| Oxide of manganese, | 1.00 | |
| Potash, | .33 | |
| Soda, | .10 | |
| Combined water, | 7.60 | |
| Silica and insoluble silicates, | 11.27 | |
| | 100.60 | |

The air-dried ore lost 3.4 per cent. of *moisture*, when dried at 212° F. Besides its use as a very good iron ore, this mineral, ground to fine powder, could be employed for painting, as Spanish brown or Venetian red, according to its shade of color. These common iron pigments, not very pleasant in color, it is true, are known by experience to be amongst the best preservatives amongst the paints, for exposed wood-work. Several of the ores examined could be employed as pigments.

No. 82—LIMONITE. *Labeled "Block Ore, attached to the ferruginous limestone, under the one foot of sandstone, Raccoon Ore Banks, Green-up county, Ky."*

A dull looking dark reddish-brown ore, with some small interspersed portions of ochreous yellow; porous; adhering to the tongue, but pretty dense; contains minute spangles of mica. Powder, dull Venetian red color.

| | | |
|---|---|---|
| Specific gravity, | | 3.251 |
| Composition, dried at 212° F.— | | |
| Oxide of iron, | 71.90 | = 50.35 per cent. of *Iron*. |
| Alumina, | 1.67 | |
| Magnesia, | 1.13 | |
| Oxide of manganese, | 1.35 | |
| Carbonate of lime, | .27 | |
| Potash, | .24 | |
| Soda, | .06 | |
| Phosphoric acid, | .25 | |
| Combined water, | 9.22 | |
| Silica and insoluble silicates, | 14.17 | |
| | 100.26 | |

The air-dried ore lost 2.4 per cent. of *moisture*, when dried at 212° F.

No. 83—LIMONITE. *Labeled "Main Upper Kidney Ore, in the yellow shales, over the black shales, Raccoon Ore Banks, high up in the hills, Greenup county, Ky."*

In curved layers, sometimes around a nucleus; color from dark reddish-brown to reddish-ochreous-yellow; pretty dense, yet adheres slightly to the tongue. Powder of a dark reddish-brown color.

| | | |
|---|---|---|
| Specific gravity, | | 3.547 |
| Composition, dried at 212° F.— | | |
| Oxide of iron, | 80.60 | = 56.44 per cent. of *Iron*. |
| Alumina, | .87 | |
| Oxide of manganese, | .77 | |
| Magnesia, | .40 | |
| Potash, | .21 | |
| Soda, | .35 | |
| Combined water, | 9.51 | |
| Silica and insoluble silicates, | 6.97 | |
| Loss, | .37 | |
| | 100.00 | |

The air-dried ore lost 1.1 per cent. of moisture, when dried at 212° F.

No. 84—LIMESTONE. *Labeled "Limestone from Old Town creek, used as a flux, Raccoon Furnace, Greenup county, Ky."*

A dull yellowish-greenish, granular limestone; adhering slightly to the tongue. Powder of a light buff color.

| | |
|---|---|
| Specific gravity, | 2.687 |
| Composition, dried at 212° F.— | |
| Carbonate of lime, | 61.95 |
| Carbonate of magnesia, | 2.35 |
| Alumina, oxide of iron, &c., | 4.95 |
| Potash, | .25 |
| Soda, | .24 |
| Silica and insoluble silicates, | 30.17 |
| Loss, | .09 |
| | 100.00 |

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

No. 85—Iron Furnace Slag. *Labeled "Dark Purple Slag, made at Raccoon Furnace, when producing soft grey iron, Greenup co., Ky."*

Perfectly vitrified; color, smoky purple, seen through thin fragments; free from bubbles; before blow-pipe fuses pretty easily into a white blebby globule.

| | | | | |
|---|---|---|---|---|
| Specific gravity, | | | 2.722 | |
| Composition, dried at 212° F.— | | | | |
| Silica, | 56.70 | Containing oxygen, | | 29.44 |
| Lime, | 24.24 | " | 6.89 | |
| Magnesia, | 4.41 | " | 1.76 | |
| Alumina, | 11.48 | " | 5.38 | |
| Protoxide of iron, | 1.02 | " | .22 | |
| Protoxide of manganese, | .53 | " | .12 | |
| Potash, | 1.37 | " | .23 | |
| Soda, | .13 | " | .03 | |
| Loss, | .12 | | | |
| | 100.00 | | 14.63 : | 29.44 |
| Oxygen nearly as | | | 1. : | 2.01 |

A very good slag.

No. 86—Iron Furnace Slag. *Labeled "Green and Purple Porous Light Cinder, produced at Raccoon Furnace when working best, Greenup county, Ky."*

Opaque, and spongy from the presence of myriads of minute air bubbles; general color greenish-grey, some portions purplish; containing some small particles of reduced iron; in some spots it is brownish, from the presence of peroxide of iron; before the blow-pipe it appears not quite as fusible as the preceding, melting into a clear glass.

| | | | | |
|---|---|---|---|---|
| Composition— | | | | |
| Silica, | 61.84 | Containing oxygen, | | 32.11 |
| Lime, | 18.34 | " | 5.21 | |
| Magnesia, | 2.40 | " | 0.96 | |
| Alumina, | 13.00 | " | 6.07 | |
| Protoxide of iron, | 2.97 | " | .66 | |
| Protoxide of manganese, | .31 | " | .07 | |
| Potash, | 1.08 | " | .18 | |
| Soda, | .15 | " | .04 | |
| Trace of phosphoric acid. | | | | |
| | 100.09 | | 13.19 : | 32.11 |
| Oxygen in the proportion of | | | 1. : | 2.43 |

A slag of more difficult fusion than any of the preceding.

No. 87—Pig-iron. *Labeled "Soft Grey Iron, produced at Raccoon Furnace, when making dark purple cinder, Greenup county, Ky."*

A brilliant specimen; of medium fine texture; of a grey color; yields easily to the file, but scarcely flattens under the hammer before it breaks to pieces; more easily powdered than any of the preceding specimens; dissolves sluggishly in diluted hydrochloric acid.

| | | | |
|---|---|---|---|
| Specific gravity, | | | 6.898 |
| Composition— | | | |
| Iron, | 90.18 | | |
| Graphite, | 2.80 | Total carbon, | 3.80 |
| Combined carbon, | 1.00 | | |
| Silicon, | 5.13 | | |
| Slag, | .93 | | |
| Manganese, | .59 | | |
| Aluminium, | .08 | | |
| Potassium, | .05 | | |
| Magnesium, | .07 | | |
| Phosphorus, | .37 | | |
| Sulphur, | .01 | | |
| | 101.21 | | |

Contains quite a large proportion of silicon and slag.

No. 88—Pig-iron. *Labeled "Pig-iron of medium texture, produced when pea-green cinder is formed, Raccoon Furnace, Greenup co., Ky."*

Rather coarser grained, and darker colored, and less brilliant than the preceding; yields easily to the file; flattens a little more under the hammer than 86; is somewhat tougher, yet easily hammered to powder.

| | | | |
|---|---|---|---|
| Specific gravity, | | | 6.798 |
| Composition— | | | |
| Iron, | 91.85 | | |
| Graphite, | 2.40 | Total carbon, | 3.13 |
| Combined carbon, | .73 | | |
| Silicon, | 3.55 | | |
| Slag, | .51 | | |
| Manganese, | .18 | | |
| Aluminium, | .09 | | |
| Potassium, | .06 | | |
| Magnesium, | .08 | | |
| Phosphorus, | .34 | | |
| Sulphur, | .04 | | |
| Loss, | .17 | | |
| | 100.00 | | |

No. 89—Pig-iron. *Labeled "High Iron, produced when furnace is working stiff, especially with grey block ore, Raccoon Furnace, Greenup county, Ky."*

Lighter colored, finer grained, and more compact than the two preceding specimens; yields with difficulty to the file; not sensibly flattened under the hammer, but very easily crushed to powder.

| | | | |
|---|---|---|---|
| Specific gravity, | | | 6.867 |
| Composition— | | | |
| Iron, | 88.57 | | |
| Graphite, | 2.25 | Total carbon, | 4.25 |
| Combined carbon, | 2.00 | | |
| Silicon, | 6.88 | | |
| Slag, | .47 | | |
| Manganese, | .63 | | |
| Aluminium, | .15 | | |
| Potassium, | .03 | | |
| Magnesium, | .15 | | |
| Phosphorus, | .44 | | |
| Sulphur, (not estimated.) | | | |
| | 101.57 | | |

Contains an unusually large proportion of silicon. Is probably produced when the cinder has not the right composition to give it a proper degree of fusibility, and when the furnace has been urged to its greatest heat.

No. 90—Coal. *Labeled "Thirty-Inch Coal, three hundred feet above Raccoon creek, one mile north-east of Raccoon Furnace, Greenup county, Ky.*

A slaty coal; rather tough; of a dull black appearance, except on the cross fracture of the thin layers; these are coated with fibrous coal, which shows vegetable impressions, and is infiltrated with pyrites. Heated over the spirit-lamp it decrepitated strongly; swelled up somewhat, but not sufficient to show that it is a coking coal. It is a splint coal.

| | | | |
|---|---|---|---|
| Specific gravity, | | | 1.320 |
| Composition, dried at the ordinary temperature— | | | |
| Moisture, | 3.90 | Total volatile matters, | 41.20 |
| Volatile combustible matters, | 37.30 | | |
| Carbon in the coke, | 50.20 | Moderately dense coke, | 58.80 |
| Ashes, (purplish-grey.) | 8.60 | | |
| | 100.00 | | 100.00 |

Composition, dried at 212°—

| | |
|---|---|
| Volatile combustible matters, | 38.814 |
| Carbon in the coke, | 52.237 |
| Ashes, | 8.949 |
| | 100.000 |

The per centage of *sulphur* was found to be 1.448. The ashes contained *scarcely* a trace of sulphate of lime.

No. 91—Coal. *Labeled "Under part of eight to ten-inch coal in the bed of Raccoon creek, three hundred and thirty feet under main ore bank of Raccoon Furnace, Greenup county, Ky."*

A dull looking coal of a slaty structure; fibrous coal with vegetable impressions on the layers; cross fracture deep black color, and moderate pitch-like lustre; no appearance of pyrites or other impurities; outside part with an earthy or ochreous incrustation. Over the spirit-lamp, decrepitated slightly; swelled up somewhat, but did not soften much nor agglutinate. A splint coal.

| | | | |
|---|---|---|---|
| Specific gravity, | | 1.393 | |
| Composition, dried at the ordinary temperature— | | | |
| Moisture, | 5.20 | Total volatile matters, | 35.50 |
| Volatile combustible matters, | 30.30 | | |
| Carbon in the coke, | 55.30 | Carbonaceous residue, | 64.50 |
| Ashes, (nearly white,) | 9.20 | | |
| | 100.00 | | 100.00 |

Composition, dried at 212°—

| | |
|---|---|
| Volatile combustible matters, | 31.962 |
| Carbon in the fixed residue, | 58.333 |
| Ashes, | 9.705 |
| | 100.000 |

The proportion of *sulphur* is only 0.453. The ashes contained merely a trace of sulphate of lime. This is quite a dry splint coal, which scarcely swells or agglutinates when exposed to heat; hence it would answer for the smelting of iron without previous coking. With such a coal as this, and the hot blast, the cheaper kinds of iron for common purposes, such as railroad iron, can be most economically made.

No. 92—SANDSTONE. *Labeled "Sandstone under Main Coal, at Raccoon Furnace, used for hearth stones, Greenup county, Ky."*

A fine grained friable sandstone of a light buff color; composed of rounded grains of sand, with a few minute scales of mica; a little oxide of iron, and little or no cementing material.

| | |
|---|---|
| Specific gravity, | 2.151 |
| Composition, dried at 212° F.— | |
| Sand, | 97.80 |
| Alumina, oxide of iron, &c., | .53 |
| Carbonate of lime, | .07 |
| Carbonate of magnesia, | .25 |
| Potash, a trace. | |
| Moisture and loss, | 1.55 |
| | 100.00 |

As it is nearly pure silex, it is well adapted to withstand a high temperature without melting. Pure silex can be fused only by such a very high temperature as is produced by the oxy-hydrogen blow-pipe. The mixture with it of lime, magnesia, potash, oxide of iron, alumina and other bases, as is well known, causes it to melt at a much lower temperature to produce glass, enamel, slag, &c.

No. 93—LIMONITE. *Labeled "Yellow Kidney Ore, Amanda Furnace, above the Main Coal, Greenup county, Ky."*

A pretty dense, dull looking ore; adheres somewhat to the tongue; color from dark reddish-brown to dirty ochre, in concentric veins, and stripes like the colors in some kinds of jasper. Powder of a dark buff, or dark, dirty, salmon color.

| | | |
|---|---|---|
| Specific gravity, | 3.011 | |
| Composition, dried at 212° F.— | | |
| Oxide of iron, | 56.50 | = 39.56 per cent. of *Iron*. |
| Carbonate of lime, | 7.27 | |
| Alumina, | 2.95 | |
| Oxide of manganese, | 1.00 | |
| Magnesia, | 2.30 | |
| Potash, | .26 | |
| Soda, | .11 | |
| Combined water, | 11.34 | |
| Silica and insoluble silicates, and trace of phosphoric acid, | 18.27 | |
| | 100.00 | |

The air-dried ore lost 1.3 per cent. of *moisture*, when dried at 212°.

No. 94—LIMONITE. *Labeled "Red and Blue mixed Block Ore, Amanda Furnace, Greenup county, Ky."*

A dark, reddish-brown, limonite; dull; porous; adhering to the tongue; some portions almost black, others lighter colored; contains a few specks of calcareous spar, and minute scales of mica. Powder, Spanish-brown color.

| | | |
|---|---|---|
| Specific gravity, | | 2.835 |
| Composition, dried at 212° F.— | | |
| Oxide of iron, | 62.90 | = 44.04 per cent. of *Iron*. |
| Alumina, | 3.15 | |
| Carbonate of lime, | .57 | |
| Magnesia, | .68 | |
| Potash, | .32 | |
| Soda, | .04 | |
| Sulphur, | .15 | |
| Manganese, a trace. | | |
| Phosphoric acid, a trace. | | |
| Combined water, | 8.41 | |
| Silica and insoluble silicates, | 24.97 | |
| | 101.19 | |

The air-dried ore lost 2.6 per cent. of *moisture*, when dried at 212° F.

No. 95—LIMONITE. *Labeled "Honey-comb Ore, over the limestone, with limestone ore, Amanda Furnace, Greenup county, Ky."*

Irregular in form, containing cavities; interior, pretty hard, of a dark rust-brown color; exterior, ochreous. Powder, brownish-buff color.

| | | |
|---|---|---|
| Specific gravity, | | 2.914 |
| Composition, dried at 212° F.— | | |
| Oxide of iron, | 81.87 | = 57.33 per cent. of *Iron*. |
| Phosphate of alumina, | .97 | |
| Phosphoric acid, | .23 | |
| Oxide of manganese, | .55 | |
| Magnesia, | .33 | |
| Potash, | .07 | |
| Soda, | .14 | |
| Combined water, | 12.39 | |
| Silica and insoluble silicates, | 3.67 | |
| | 100.22 | |

The air-dried ore lost 1.6 per cent. of *moisture*, when dried at 212° F.

No. 96—LIMONITE. *Labeled "Best Limestone Ore, below Main Coal, Amanda Furnace, Greenup county, Ky."*

A dull looking ore, of a dark reddish-brown color; exterior layers, dull ochreous; structure irregularly laminated; the lens shows minute dark granules, imbedded in a lighter colored substance, and some infiltrations of spar. Powder, rich brownish-yellow ochre color.

| | | |
|---|---|---|
| Specific gravity, | | 3.072 |
| Composition, dried at 212° F.— | | |
| Oxide of iron, | 57.10 | = 40.03 per cent. of *Iron*. |
| Carbonate of lime, | 9.35 | |
| Magnesia, | 1.49 | |
| Alumina, | 1.65 | |
| Oxide of manganese, | .37 | |
| Potash, | .08 | |
| Soda, | .09 | |
| Combined water, | 9.80 | |
| Silica and insoluble silicates, | 20.07 | |
| | 100.00 | |

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

No. 97—CARBONATE OF IRON. *Labeled "Blue Block Ore, with black shale immediately under it; impracticable by itself; lowest bed worked at Amanda Furnace, Greenup county, Ky."*

A dull looking ore, of a dark greenish-grey color mixed with reddish; surfaces of fissures reddish where it has been exposed to the air; adhering to the tongue. Powder, greyish-buff color.

| | | |
|---|---|---|
| Specific gravity, | | 3.391 |
| Composition, dried at 212°— | | |
| Carbonate of iron, | 79.72 | 41.26 per cent of *Iron*. |
| Oxide of iron, | 4.52 | |
| *Alumina and phosphoric acid, | .42 | |
| Carbonate of lime, | .97 | |
| Carbonate of magnesia, | 3.08 | |
| Carbonate of manganese, | 1.23 | |
| Potash, | .24 | |
| Soda, | .18 | |
| Silica and insoluble silicates, | 9.64 | |
| | 100.00 | |

*Phosphoric acid 0.34 per cent.

The air-dried ore lost 0.7 per cent. of *moisture*, when dried at 212° F. "Impracticable by itself," probably because it is a carbonate, which would readily melt on the sudden application of a great heat, and, particularly, because it contains but a small proportion of the materials for the formation of cinder.

No. 98—Iron Furnace Slag. *Labeled "Pea-green Cinder, usually produced when working the blue limestone ore and block ore, at Amanda Furnace, Greenup county, Ky."*

Color, rather olive-green than pea-green; well vitrified, but nearly opaque, from the presence in it of minute air bubbles; translucent on the edges; before the blow-pipe, quite fusible, melting into a blebby globule.

Composition, dried at 212° F.—

| | | | | |
|---|---|---|---|---|
| Silica, | 50.94 | Containing oxygen, | | 26.45 |
| Lime, | 23.77 | " | 5.76 | |
| Magnesia, | 3.19 | " | 1.27 | |
| Alumina, | 15.50 | " | 7.24 | |
| Protoxide of iron, | 2.61 | " | .60 | |
| Protoxide of manganese, | 1.58 | " | .35 | |
| Potash, | 2.24 | " | .38 | |
| Soda, | .77 | " | .20 | |
| Phosphoric acid, a trace. | | | | |
| | 100.00 | | 15.80 : | 26.45 |
| Oxygen nearly as | | | 1. : | 1.67 |

The proportion of lime, &c., to the silica, is rather larger than is absolutely necessary to its proper fusibility; but this excess favors, to some extent, the separation of phosphorus and sulphur from the iron—injurious ingredients, which cause the formation of *white* iron; the former, phosphorus, in too large proportion, makes it brittle in the cold or "*cold short*," and the latter makes it "*hot short*."

No. 99—Pig-Iron. *Labeled "Pig-iron produced from the red and blue block ore, lowest bed, Amanda Furnace, Greenup county, Ky."*

A silver-white iron, very fine-grained, and compact; broken under the hammer and reduced to powder with the greatest difficulty; so very hard as to indent the faces of hammer and anvil; resisting the file like the hardest steel.

| | | |
|---|---|---|
| Specific gravity, | | 7.433 |
| Composition— | | |
| Iron, | 94.89 | |
| Combined carbon, | 3.00 | (No graphite.) |
| Silicon, | 1.55 | |
| Slag, | .11 | |
| Aluminium, a trace. | | |
| Manganese, | .21 | |
| Potassium, | .05 | |
| Magnesium, | .09 | |
| Phosphorus, | .79 | |
| Sulphur, | .20 | |
| | 100.89 | |

This is decidedly the hardest *white* iron of all the specimens examined. We attribute its *high white* condition partly to the phosphorus and sulphur which it contains—more especially to the sulphur—which by favoring the actual *combination* of the carbon with the iron—instead of its separation, as graphite, in the act of cooling, which characterizes soft grey iron—gives it the properties of hardened steel. Its considerable proportion of manganese also aids in producing this condition of things.

The only method for diminishing these injurious ingredients, and producing a grey soft iron, is to increase the proportion of limestone used as a flux, to the greatest extent compatible with the proper fusibility of the cinder.

With good management in the furnace it is probable that a metal might be obtained from these ores which would be admirably adapted to the formation of steel, provided a too great proportion of phosphorus does not remain to injure the tenacity of the iron.

No. 100—Carbonate of Iron. *Labeled "Shot Iron Ore, below Main coal, Ashland, Greenup county, Ky."*

A friable mass, composed of dark brown granules about the size of black mustard seed, united by a soft white cement. Powder, light yellowish-grey color.

Composition, dried at 212° F.—

| | | |
|---|---|---|
| Carbonate of iron, | 60.36 | = 30.46 per cent. of *Iron*. |
| Oxide of iron, | 2.33 | |
| Alumina, | 2.65 | |
| Carbonate of lime, | 3.35 | |
| Carbonate of magnesia, | 3.58 | |
| Carbonate of manganese, | 1.43 | |
| Potash, | .49 | |
| Soda, | .05 | |
| Silica and insoluble silicates, | 24.67 | |
| Water and loss, | 1.09 | |
| Phosphoric acid, a trace. | | |
| | 100.00 | |

The air-dried ore lost 0.7 per cent. of *moisture*, when dried at 212° F. A very good iron ore.

No. 101—Coal. *Labeled "Main Ashland Coal, above clay parting, best for coking? Greenup county, Ky."*

A very pure looking soft bituminous coal, of a deep pitch-black color, and strong lustre; easily broken. Heated over the spirit-lamp it softened and swelled a great deal, and left a bulky coke. It seems to be a "fat" bituminous coal, well adapted to coking.

Specific gravity, 1.288

Composition, dried at the ordinary temperature—

| | | | |
|---|---|---|---|
| Moisture, | 3.40 | Total volatile matters, | 38.30 |
| Volatile combustible matters, | 34.90 | | |
| Carbon in the coke, | 57.90 | Spongy coke, | 61.70 |
| Ashes, (purplish-grey,) | 3.80 | | |
| | 100.00 | | 100.00 |

Composition, dried at 212° F.—

| | |
|---|---|
| Volatile combustible matters, | 36.13 |
| Carbon in the coke, | 59.94 |
| Ashes, | 3.93 |
| | 100.00 |
| The per centage of *sulphur* is, | 0.734 |

The ashes contain 0.093 per cent. of sulphate of lime.

This is not *quite* so soft and *bituminous* as the best Pittsburg coal, but it is sufficiently so, doubtless, to answer all the purposes of the blacksmith and the founder. It is also well suited to production of *gas*, of

which it will probably yield a larger proportion than the Pittsburg or Youghioghany coal.

It is to be remarked, however, that the relative proportion of the *volatile matters* of a coal will not give correct indications of the quantity of good illuminating gas which it will yield; for the reason that this *volatile matter* may consist of larger or smaller proportions of sulphur, nitrogen, and oxygen, as well as of carburets of hydrogen of various composition. *Ultimate* chemical analyses of the coals, (i. e. ascertaining the true proportions of their elementary constituents, the carbon, hydrogen, oxygen, nitrogen, sulphur, and earthy matter,) would give correct data in this relation.

The soft, light, bituminous coals are preferred by the manufacturers of coal gas, in this country, to the hard and dense splint and cannel coals, which really contain a larger proportion of *volatile matters*, not only because the residuary coke has a greater commercial value, but because the relative amount of good gas obtained is greater, in proportion to the cost of production. The true explanation of which fact is, that the *dry* coals, so called, the splint and cannel coals, contain usually a much larger proportion of *oxygen* than the soft, fat, bituminous, and coking coals. This oxygen combines with some of the hydrogen and carbon of the coal during its destructive distillation, in the manufacture of gas, to produce vapor of water and carbonic oxide gas, and thus diminishes the value of the product.

During the burning of these varieties of coal, a marked difference in phenomena results from the relative difference in the proportion of the oxygen which enters into their composition.

The fat, bituminous coal, which contains but little oxygen, softens much, and burns with a very smoky flame—giving off much soot or unburned carbon—like the pure hydrocarbons, oil of turpentine, mineral naphtha, &c., or the bituminous substances, petroleum, asphaltum, &c.; while the *dry* coals, called splint, cherry, and cannel coals, do not soften much, or at all, burn with a clearer flame, and deposit relatively little soot; burning somewhat in the manner of alcohol, ether, and the other combustibles which contain a considerable proportion of oxygen in their elementary composition.

It is obvious, from these facts, that it would have greatly facilitated the knowledge of the relative value of our Kentucky coals, could they have been submitted to *elementary* analyses; but the limited time allot-

ted the chemical investigation, during the past seasons, absolutely precluded attention to this important examination. Should the survey be continued, it is hoped that this field may be fully explored.

No. 102—Coal. *Labeled "Coal with slate roof, first bed above Ashland Main Coal, Greenup county, Ky."*

A pure looking, intensely black coal, with a high lustre, scarcely soiling the fingers; coated on the outside with ochreous oxide of iron; some fibrous coal between the layers; showing vegetable impressions, and somewhat infiltrated with pyrites; heated over the spirit-lamp, it swelled up and softened considerably; probably a coking coal, but not quite so good for this purpose as the preceding.

| | | | |
|---|---|---|---|
| Specific gravity, - - - - - - - - | 1.301 | | |
| Composition, dried at the ordinary temperature— | | | |
| Moisture, - - - - | 5.00 | Total volatile matters, - | 40.70 |
| Volatile combustible matters, - | 35.70 | | |
| Carbon in the coke, - - - | 51.00 | Moderately dense coke, - | 59.30 |
| Ashes, (lilac colored,) - - | 8.30 | | |
| | 100.00 | | 100.00 |
| Composition, dried at 212° F.— | | | |
| Volatile combustible matters, - - - - | 37.579 | | |
| Carbon in the coke, - - - - - - | 53.685 | | |
| Ashes, - - - - - - - - | 8.736 | | |
| | 100.000 | | |
| The per cent. of *sulphur* is, - - - - | 1.818 | | |

The ashes contained about 0.09 per cent. of sulphate of lime. A very good bituminous coal, not quite as pure as the preceding, No. 100. (See Nos. 123 and 124 for other Ashland specimens.)

No. 103—Limonite. *Labeled "Block Ore, principally used at the New Hampshire Furnace, Greenup county, Ky."*

A dull looking limonite, in irregular masses, partly in curved layers; color from dull reddish-brown to dull ochreous; adhering slightly to the tongue; containing minute scales of mica. Powder of brownish-yellow ochre color.

| | | |
|---|---|---|
| Specific gravity, | | 3.111 |
| Composition, dried at 212° F.— | | |
| Oxide of iron, | 57.90 | = 40.53 per cent. of *Iron*. |
| Alumina, | 2.77 | |
| Magnesia, | .72 | |
| Oxide of manganese, | .25 | |
| Potash, | .32 | |
| Soda, | .10 | |
| Combined water, | 10.03 | |
| Silica and insoluble silicates, | 27.67 | |
| Phosphoric acid, a trace. | | |
| Loss, | .24 | |
| | 100.00 | |

The air-dried ore lost 1.3 per cent. of *moisture*, when dried at 212° F.

No. 104—LIMONITE. *Labeled "Variety of Block Ore, New Hampshire Furnace, Greenup county, Ky."*

Resembles the last, but is not in layers; adheres more to the tongue; is more porous, appears rather more granular under the lens, and shows more glimmering specks of mica. Powder, dirty-yellow ochre color.

| | | |
|---|---|---|
| Specific gravity, | | 2.708 |
| Composition, dried at 212° F.— | | |
| Oxide of iron, | 13.25 | = 9.27 per cent. of *Iron*. |
| Alumina, | 4.95 | |
| Carbonate of lime, | 1.67 | |
| Phosphate of lime, | .90 | = Containing 0.5 of phos. acid. |
| Magnesia, | .61 | |
| Combined water, | 4.37 | |
| Silica and insoluble silicates, | 74.36 | |
| | 100.11 | |

This can hardly be called an iron ore; and its considerable proportion of phosphate of lime makes it less valuable for the purpose of fluxing.

No. 105—LIMONITE. *Labeled "Kidney Ore, used occasionally at New Hampshire Furnace, Greenup county, Ky."*

In thin curved layers, the exterior of which is brownish-yellow ochreous; interior, dark reddish-brown. Powder, between umber and yellow ochre color.

Composition, dried at 212° F.—

| | | |
|---|---|---|
| Oxide of iron, | 56.70 | = 39.70 per cent. of *Iron.* |
| Alumina, | 3.75 | |
| Magnesia, | .63 | |
| Oxide of manganese, | .42 | |
| Potash, | .32 | |
| Soda, | .17 | |
| Combined water, | 12.04 | |
| Silica and insoluble silicates, | 25.97 | |
| | 100.00 | |

The air-dried ore lost 2. per cent. of *moisture*, when dried at 212° F.

No. 106—LIMONITE. *Labeled "Dark Red Limestone Ore, New Hampshire Furnace, Greenup county, Ky."*

A very dark, reddish-brown, almost black ore, mottle with dark red; dull; porous; adhering slightly to the tongue; some minute infiltrations of white spar. Powder, dark reddish-brown color.

| | | |
|---|---|---|
| Specific gravity, | | 2.383 |
| Composition dried at 212°— | | |
| Oxide of iron, | 64.70 | = 45.31 per cent of *Iron.* |
| Carbonate of lime, | 16.50 | |
| Oxide of manganese, | 2.15 | |
| Magnesia, | 1.84 | |
| Alumina, | .27 | |
| Potash, | .23 | |
| Soda, | .05 | |
| Combined water, | 7.12 | |
| Silica and insoluble silicates, | 6.47 | |
| Loss, | .67 | |
| | 100.00 | |

The air-dried ore lost 1.7 per cent. of *moisture*, when dried at 212° F.

No. 107—LIMONITE. *Labeled "Poor Sandy Ore, not much used, at New Hampshire Furnace, Greenup county, Ky."*

A dull looking, granular ore, containing a considerable proportion of clear, rounded grains of sand, cemented and mixed with brown oxide of iron, in some places with a pink and yellowish-white cementing material. Powder, brick-red color.

| | | |
|---|---|---|
| Specific gravity, | ? | |
| Composition, dried at 212°— | | |
| Oxide of iron, | 32.10 | = 22.48 per cent. of *Iron.* |
| Alumina, | 1.47 | |
| Magnesia, | .33 | |
| Potash, | .12 | |
| Combined water, | 4.61 | |
| Silica and insoluble silicates, | 61.37 | |
| | 100.00 | |

This might be advantageously used at the New Hampshire Furnace to mix, in proper proportion, with the next preceding ore, No. 105, which is deficient in silicious ingredients. The block ore, principally used there, needs no other addition than limestone.

No. 108—FERRUGINOUS LIMESTONE. *Labeled "Ferruginous Limestone, passing into limestone ore, New Hampshire Furnace, Greenup county, Ky."*

Color, passing from fawn color to dirty ochreous; with some mottlings; dull; scarcely adhering to the tongue. Powder, dirty buff color.

| | | |
|---|---|---|
| Specific gravity, | 2.680 | |
| Composition, dried at 212° F.— | | |
| Carbonate of lime, | | 53.85 |
| Carbonate of magnesia, | | 22.10 |
| Carbonate of iron, | | 7.41 |
| Oxide of iron, | | 4.41 |
| Carbonate of manganese, | | .86 |
| Alumina, | | .37 |
| Potash, | | .21 |
| Soda, | | .19 |
| Phosphoric acid, a trace. | | |
| Silica and insoluble silicates, | | 7.97 |
| Water and loss, | | 2.63 |
| | | 100.00 |

The air-dried limestone lost 0.6 per cent. of *moisture,* when dried at 212° F.

No. 109—LIMESTONE. *Labeled "Limestone used as a flux, from the Brushey fork of Tygert's creek, under the limestone ore, New Hampshire Furnace, Greenup county, Ky."*

A light drab-grey, compact limestone; sparkling with very small portions of imbedded calcareous spar.

| | |
|---|---|
| Specific gravity, | 2.708 |
| Composition, dried at 212°F.— | |
| Carbonate of lime, | 97.85 |
| Magnesia, | 1.30 |
| Alumina, oxide of iron, &c., | .55 |
| Potash, | .15 |
| Soda, | .50 |
| Silicious residue, | 1.27 |
| | 101.62 |

A pretty pure limestone. Dried at 212°, the air-dried limestone lost 0.3 per cent. of *moisture.*

No. 110—Iron Furnace Slag. *Labeled "Dark Purple Glassy Cinder, produced when making soft grey iron, New Hampshire Furnace, Greenup county, Ky."*

Perfectly vitrified; of a more smoky tinge than any of the preceding, with a slight tint of purple or violet; rather clearer, in thin pieces, than those previously examined; rather difficult of fusion; melting, before the blow-pipe, into a white blebby globule.

| | | | |
|---|---|---|---|
| Specific gravity, | | 2.719 | |
| Composition, dried at 212° F.— | | | |
| Silica, | 56.28 | Containing oxygen, | 29.22 |
| Lime, | 19.70 | " | 5.57 |
| Magnesia, | 6.13 | " | 2.45 |
| Alumina, | 13.90 | " | 6.49 |
| Protoxide of iron, | 1.56 | " | .35 |
| Protoxide of manganese, | 1.02 | " | .23 |
| Potash, | 1.26 | " | .21 |
| Loss, | .15 | | |
| | 100.00 | 15.30 | : 29.22 |
| Oxygen nearly as, | | 1. | : 1.91 |

No. 111—Iron Furnace Slag. *Labeled, "White Heavy Cinder, produced at New Hampshire Furnace, Greenup county, Ky."*

A compact, greyish-white slag, of considerable density; nearly opaque, looking like some kinds of hornstone; containing a few small air bubbles, and some small pieces of reduced iron; before the blow-pipe it phosphoresced somewhat like lime or magnesia; proved quite fusible; intermesced greatly, and settled down into a white blebby globule.

| | | | |
|---|---|---|---|
| Specific gravity, | | 2.787 | |
| Composition, dried at 212°— | | | |
| Silica, | 56.34 | Containing oxygen, | 29.25 |
| Lime, | 19.56 | " | 5.57 |
| Magnesia, | 6.59 | " | 2.63 |
| Alumina, | 14.30 | " | 6.68 |
| Protoxide of iron, | 1.36 | " | .30 |
| Protoxide of manganese, | .87 | " | .20 |
| Potash, | 1.00 | " | .17 |
| Soda, | .22 | " | .06 |
| | 100.00 | 15.61 : | 29.25 |
| Oxygen nearly as | | 1. : | 1.87 |

No. 112—Iron Furnace Slag. *Labeled "Pea-green Cinder, produced when making a good run, but iron somewhat close-grained. New Hampshire Furnace, Greenup county, Ky."*

| | | | |
|---|---|---|---|
| Composition, dried at 212°— | | | |
| Silica, | 56.74 | Containing oxygen, | 29.46 |
| Lime, | 16.66 | " | 4.74 |
| Magnesia, | 5.20 | " | 2.08 |
| Alumina, | 15.10 | " | 7.06 |
| Protoxide of iron, | 2.17 | " | .48 |
| Protoxide of manganese, | 2.92 | " | .65 |
| Potash, | 1.66 | " | .28 |
| Soda, | .36 | " | .09 |
| | 100.81 | 15.38 : | 29.46 |
| Oxygen nearly as, | | 1. : | 1.91 |

The first two slags, (110 and 111,) do not differ much in composition—the former is probably formed when there is an accidental excess of carbonaceous matter present; the latter when the oxygen of the blast somewhat prevails. In this last, the smaller proportion of *lime* present throws some light on the simultaneous production of fine-grained iron. The addition of more limestone would probably correct this.

113—Pig-iron. *Labeled "Grey Pig-iron, New Hampshire Furnace, Greenup county, Ky."*

A coarse grained, dark colored iron; flattens somewhat under the hammer, but soon breaks to pieces, and easily pounds to powder; yields easily to the file.

| | |
|---|---|
| Specific gravity, | 6.843 |
| Iron, | 93.12 |
| Graphite, | 2.83 |
| Silicon, | 1.23 |
| Slag, | .13 |
| Manganese, | .34 |
| Aluminium, | .52 |
| Potassium, | .33 |
| Sodium, | .21 |
| Phosphorus, | 1.30 |
| Magnesium, | .06 |
| | 100.00 |

No. 114—Pig-iron. *Labeled "Close textured Pig-iron, New Hampshire Furnace, Greenup county, Ky."*

A very fine grained light-grey iron; flattens considerably under the hammer, but is readily pounded to powder; yields easily to the file; is a soft iron notwithstanding its light color.

| | |
|---|---|
| Specific gravity, | 7.241 |
| Composition— | |
| Iron, | 93.19 |
| Graphite, | 3.13 |
| Silicon, | 1.28 |
| Slag, | .18 |
| Manganese, | .20 |
| Aluminium, | .44 |
| Potassium, | .19 |
| Sodium, | .09 |
| Magnesium, | .06 |
| Phosphorus, | 1.40 |
| Sulphur, a trace. | |
| | 100.16 |

These two specimens of pig-iron are remarkable for their large relative proportion of phosphorus and of aluminium. The former most probably gives to them *cold-short* properties, as they are very easily pounded to powder on the anvil; the presence of the aluminium, with the absence of a notable quantity of sulphur, may be the cause why this iron, although quite light colored, is yet soft; yielding easily to the file.

According to the well known experiments of Faraday and Stodart in England, the celebrated India Steel—the *Wootz*—of which are fab-

ricated the Damascus blades, owes its peculiar excellence to the presence of aluminium, which they found in it in proportions varying from 1.3 to 0.024 per cent. The usually correct Karsten is, however, disposed to doubt their conclusions in this respect, although they are corroborated by the experiments of Mushet. It is probable, from the account which Karsten gives of his mode of investigation, (Band 1, section 484, of his *Handbuch der Eisenhuttenkunde,*) that the aluminium which might have been present in the steel which he submitted to analyses escaped his observation.

The recent interesting experiments of Deville and others, in France, in the production of aluminium in quantity, at a low price, prove that it can easily be alloyed with iron, as well as with many other metals. Its alloy with copper is light, hard and white. From its low specific gravity, only 2.56, it doubtless also reduces the relative weight of iron with which it is combined. Aluminium, the metallic basis of the earth of clay, (alumina,) has been recently introduced into the arts, in France, at a cost of about one-fifth of that of silver. It is a light, malleable metal, nearly as white as silver, of great sonorousness, which may be heated and melted without any loss by oxidation; it does not rust in the moist air.

No. 115—SANDSTONE. *Labeled "Hearth Sandstone, New Hampshire Furnace, Greenup county, Ky."*

A yellowish-grey fine-grained friable sandstone, containing small scales of mica; the grains of sand are rounded, and are cemented by a small amount of ferruginous material; structure somewhat lamellar.

| | |
|---|---|
| Specific gravity, | 2.458 |
| Composition, dried at 212° F.— | |
| Sand, | 94.855 |
| Oxide of iron, alumina, &c., | 2.775 |
| Carbonate of lime, | .197 |
| Carbonate of magnesia, | .837 |
| Potash, | .164 |
| Soda, | .047 |
| Loss, | 1.125 |
| | 100.000 |

No. 116—SANDSTONE. *Labeled "Hearth-stone after two months exposure in New Hampshire Furnace, Greenup county, Ky."*

Much harder, (less friable,) and more compact than the preceding;

scarcely adhering to the tongue; color, bluish-grey with darker thin lines of stratification; no scales of mica visible.

| | |
|---|---|
| Specific gravity, | 2.407 |
| Composition, dried at 212° F.— | |
| Sand, &c., | 98.835 |
| Oxide of iron, alumina, &c., | .325 |
| Carbonate of lime, | .055 |
| Magnesia, | .249 |
| Potash, | .154 |
| Soda, | .029 |
| Loss, | .353 |
| | 100.000 |

If these sandstones were of similar composition at first, the intense heat to which the last specimen was exposed, seems to have removed some of the substances with which the sand composing it was mixed. How this occurred is not easily explained, unless we suppose it took place by sublimation.

No. 117—LIMONITE. *Labeled "Mount Savage Main Ore, Greenup county, Ky."*

A dark, reddish-brown limonite; pretty dense; irregularly cellular; powder, dark Spanish-brown color.

| | | |
|---|---|---|
| Specific gravity, | 3.062 | |
| Composition, dried at 212° F.— | | |
| Oxide of iron, | 85.16 | = 59.63 per cent. of *Iron.* |
| Alumina, | .84 | |
| Oxide of manganese, | .95 | |
| Magnesia, | .59 | |
| Potash, | .25 | |
| Silica and insoluble silicates, | 4.57 | |
| Combined water, | 7.30 | |
| Loss, | .34 | |
| | 100.00 | |

The air-dried ore lost 1.4 per cent. of *moisture*, when dried at 212° F.

No. 118—CARBONATE OF IRON. *Labeled "Mount Savage Iron Ore, under Main Ashland Coal, Greenup county, Ky."*

A dark, umber-grey, fine granular mineral, having the appearance of a dull earthy variety of limestone. Specimen contains a concretionary

cast, as of a portion of a branching coral stem, which is of a light lead color. Powder, light umber color.

| | | |
|---|---|---|
| Specific gravity, | | 3.468 |
| Composition, dried at 212° F— | | |
| Carbonate of iron, | 70.60 | 37.53 per cent. of *Iron*. |
| Oxide of iron, | 5.42 | |
| Carbonate of lime, | 2.15 | |
| Carbonate of magnesia, | 4.91 | |
| Carbonate of manganese, | 1.25 | |
| Alumina, | 1.55 | |
| Potash, | .25 | |
| Soda, | .09 | |
| Silica and insoluble silicates, | 13.37 | |
| Loss, | .41 | |
| | 100.00 | |

The air-dried ore lost 1.4 per cent. of *moisture*, when dried at 212° F.

Both of these are very good iron ores. The first, No. 117, may require the addition of some more silicious ore, or silicious material, with the limestone, to flux it in the furnace.

No. 119—Limonite. *Labeled "Limestone Ore, top of hill, Clinton Furnace, Greenup county, Ky."*

A dull, reddish-brown, and yellowish-brown, pretty compact limonite; adheres firmly to the tongue. Powder, dirty yellowish-brown color.

| | | |
|---|---|---|
| Specific gravity, | | 2.811 |
| Composition, dried at 212° F.— | | |
| Oxide of iron, | 39.90 | = 28.48 per cent. of *Iron*. |
| Alumina, | 3.37 | |
| Carbonate of lime, | 20.87 | |
| Magnesia, | 2.85 | |
| Oxide of manganese, | 2.17 | |
| Phosphoric acid, | .75 | |
| Potash, | .30 | |
| Soda, | .16 | |
| Silica and insoluble silicates, | 20.97 | |
| Combined water, | 8.66 | |
| | 100.00 | |

The air-dried ore lost 1.8 per cent. of *moisture*, when dried at 212° F.

No. 120—Carbonate of Iron. *Labeled "Limestone Ore, two to three feet thick, drifted after at the Clinton Furnace, Greenup county, Ky."*

A dark grey, granular ore; yellowish and reddish-ochreous on the exterior; under the lens presents a confused crystalline appearance. Powder of a dirty buff color.

| | | |
|---|---|---|
| Specific gravity, | | 3.524 |
| Composition, dried at 212° F.— | | |
| Carbonate of iron, | 65.93 | 37.55 per cent. of *Iron*. |
| Oxide of iron, | 8.63 | |
| Carbonate of lime, | 1.97 | |
| Carbonate of magnesia, | 3.34 | |
| Carbonate of manganese, | 5.03 | |
| Alumina, | 2.27 | |
| Potash, | .07 | |
| Soda, | .18 | |
| Silica and insoluble silicates, | 13.17 | |
| | 100.59 | |

No. 121—Carbonate of Iron. *Labeled "Blue Ore, under the coal; average one foot thick; from East fork of Little Sandy river, near Lexington and Big Sandy Railroad, three miles from Clinton Furnace, Greenup county, Ky."*

Dark grey color, mottled with lighter and darker; fine granular; under the lens, dark semi-crystalline grains observed, in a light colored cement; adhering slightly to the tongue. Powder of a mouse-grey color.

| | | |
|---|---|---|
| Specific gravity, | | 3.350 |
| Composition, dried at 212° F.— | | |
| Carbonate of iron, | 42.68 | =32.37 per cent. of *Iron*. |
| Oxide of iron, | 17.02 | |
| Carbonate of lime, | 1.68 | |
| Carbonate of magnesia, | 1.52 | |
| Carbonate of manganese, | .71 | |
| Alumina, | 2.05 | |
| Potash, | .27 | |
| Soda, | .30 | |
| Organic or bituminous matter, | 11.10 | |
| Silica and insoluble silicates, | 20.66 | |
| Water and loss, | 2.01 | |
| | 100.00 | |

The air-dried ore lost 0.7 per cent. of *moisture*, when dried at 212° F.

From the considerable proportion of bituminous matter contained in this ore, it may be called a *black band* ore. It is the only ore of this variety which has been sent to this laboratory from Greenup county.

No. 122—FERRUGINOUS LIMESTONE. *Labeled "Green Carbonate of Iron, Clinton Furnace, Greenup county, Ky."*

Compact; fine granular; with sparkling crystalline grains; scarcely adhering to the tongue; interior, handsome bluish-green color; exterior, rich reddish-brown, mixed with some green particles. Powder of a dirty buff color.

| | | |
|---|---|---|
| Specific gravity, | | 2.934 |
| Composition, (of average specimen,) dried at 212° F.— | | |
| Oxide of iron, | 24.80 | 25.68 per cent. of *Iron.* |
| Carbonate of iron, | 17.42 | |
| Carbonate of lime, | 32.85 | |
| Carbonate of magnesia, | 6.36 | |
| Carbonate of manganese, | 1.81 | |
| Alumina, | 2.79 | |
| Phosphoric acid, | .60 | |
| Potash, | .11 | |
| Soda, | .17 | |
| Silica and insoluble silicates, | 10.47 | |
| Water and loss, | 2.62 | |
| | 100.00 | |

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

No. 123—COAL. *Labeled "Main Coal, with clay parting, Giger's Hill, Catlettsburg, Greenup county, Ky."*

A very pure looking, bituminous coal, of a deep pitch-black color, and strong lustre; a little pyritous matter observed on one of the surfaces; heated over the spirit lamp, it softened and swelled up very much, and the fragments agglutinated into a light spongy coke; seems to be a coking coal.

| | | | |
|---|---|---|---|
| Specific gravity, | | 1.213 | |
| Composition, dried at the ordinary temperature— | | | |
| Moisture, | 4.20 | Total volatile matters, | 40.00 |
| Volatile combustible matters, | 35.80 | | |
| Carbon in the coke, | 57.80 | Coke, | 60.00 |
| Ashes, (yellowish-grey,) | 2.20 | | |
| | 100.00 | | 100.00 |
| Composition, dried at 212°— | | | |
| Volatile combustible matters, | | 37.37 | |
| Carbon in the coke, | | 60.33 | |
| Ashes, | | 2.30 | |
| | | 100.00 | |

The per centage of *sulphur* is .268. The ashes contained about 0.09 per cent. of sulphate of lime. This is evidently a very pure bituminous coal, containing but a small proportion of sulphur, and leaving less than the general average amount of ashes.

No. 124—FIRE-CLAY. *Labeled "No. 1, Fire-clay, below Main Coal, Ashland, Greenup county, Ky."*

A compact light-grey rock, with some discolorations of ochreous, and brown in the crevices and near the surface, from infiltration of oxide of iron; as hard as calcareous spar; not plastic with water until it has been ground to powder; presenting numerous minute spherical cavities, as though it had been full of air-bubbles; adhering to the tongue.

| Composition, dried at 212°— | |
|---|---|
| Silica, | 65.74 |
| Alumina, with trace of oxide of iron, | 26.10 |
| Lime, | .72 |
| Magnesia, | .73 |
| Potash, | .56 |
| Soda, | .14 |
| Water and loss, | 6.01 |
| | 100.00 |

No. 125—FIRE-CLAY. *Labeled "No. 2, Fire-clay, below Main Coal, Ashland, Greenup county, Ky."*

An indurated clay, or soft clay-stone, of a dark grey color; barely yielding to the nail; softens down into a plastic mass when placed in water; burns white.

Composition, dried at 212° F.—

| | |
|---|---|
| Silica, | 51.74 |
| Alumina, with trace of oxide of iron, | 33.90 |
| Lime, | .62 |
| Magnesia, | .73 |
| Potash, | .88 |
| Soda, | .31 |
| Water, organic matter and loss, | 11.82 |
| | 100.00 |

HENDERSON COUNTY.

No. 126—Soil. *Labeled "Soil, four miles south of Henderson, Henderson county, Ky."*

Of a light mouse color, containing some fragments of charcoal; washed very carefully with water it left about 86. per cent. of very fine sand; 1,000 grains, dried at the ordinary temperature, digested in water containing carbonic acid gas, as previously described, gave up more than 7. grains of *solid extract*, dried at 212°. This, treated with pure water, left of *insoluble matter*, 5.582 grains, having the following composition, viz:

| | |
|---|---|
| Silica, | .197 |
| Carbonate of lime, | 3 615 |
| Carbonate of magnesia, | 1.097 |
| Carbonate of manganese, | .556 |
| Alumina, oxide of iron, and trace of phosphates, | .117 |

The matters dissolved in the water, weighed when dried at 212°—1.511 grains; when ignited in a platinum capsule, it lost, with a smell of burnt horn,

| | |
|---|---|
| Organic and volatile matters, | 0.900 |

The residue contained—

| | |
|---|---|
| Carbonate of lime, | .197 |
| Carbonate of magnesia, | .279 |
| Alumina, oxide of iron, and trace of phosphates, | .017 |
| Potash, | .083 |
| Soda, | .035 |

This soil contains a remarkably large proportion of its *essential* ingredients, in a *soluble* condition. One thousand grains of the air-dried soil lost 2.04 per cent. of *moisture*, when dried at 300° F.; and was found to contain the following ingredients, viz:

| | |
|---|---|
| Organic and volatile matters, | 5.080 |
| Carbonate of lime, | 1.254 |
| Carbonate of magnesia, | .447 |
| Carbonate of manganese, a trace. | |
| Alumina, oxide of iron, and a trace of phosphates, | 3.490 |
| Potash, | .085 |
| Soda, | .034 |
| Silica and insoluble silicates, | 89.670 |
| | 100.000 |

This soil contains more than the usual proportion of carbonate of lime, but it is not very rich in the alkalies.

HICKMAN COUNTY.

No. 127—WHITE EARTH. *Labeled "Part of the White Deposit at the Iron Banks, Columbus, Hickman county, Ky."*

A nearly white, (with a slight tint of grey,) fine granular soft mass, easily crushed with the fingers to a fine granular powder.

Composition, dried at 212°—

| | |
|---|---|
| Silica and insoluble silicates, | 90.99 |
| Alumina, oxide of iron, and a trace of phosphate, | 3.60 |
| Carbonate of lime, | .90 |
| Carbonate of magnesia, | 4.35 |
| Potash, | .07 |
| Soda, | .02 |
| Loss, | .07 |
| | 100.00 |

The air-dried earth lost 1.6 per cent. of *moisture*, when dried at 212° F.

No. 128—SOIL. *Labeled "White Soil of Bayou de Chienne, at Moscow, Hickman county, Ky., (quarternary formation.")*

A light grey soil, almost white, containing a proportion of rounded particles of clear quartz, and some irregular concretions containing peroxide of iron.

The air-dried soil lost 2.3 per cent. of *moisture*, when dried at 350°.

One thousand grains of the air-dried soil, treated with water containing carbonic acid, in the manner previously described, gave up in solution only 0.27 grains of *solid extract*, which was found to have the following *composition*, viz:

*See Appendix for the proportion of phosphoric acid in this and the other soils.

| | |
|---|---|
| Organic and volatile matters, | .08 |
| Carbonate and phosphate of lime, and carbonates of magnesia and iron, | .11 |
| Alkaline salts, (containing .005 potash,) | .04 |
| Silica, | .04 |
| | 0.27 |

The *composition* of this soil, dried at 350°, is as follows:

| | |
|---|---|
| Organic and volatile matters, | 2.00 |
| Oxide of iron and alumina, | 6.00 |
| Carbonate of lime, | 1.15 |
| Magnesia, | .16 |
| Oxide of manganese, | .17 |
| Phosphoric acid, (.54 phosphate of lime,) | .19 |
| Potash, | .17 |
| Soda, | .02 |
| Silica and insoluble silicates, | 90.57 |
| | 100.43 |

Washed carefully with water, this soil left about 79. per cent. of very fine, nearly white sand, containing small rounded particles of hyaline and milky quartz, and of a ferruginous mineral.

This soil being rather deficient in alumina and oxide of iron, has but a small power to hold organic matter in combination.

No. 129—White Earth. *Labeled, "Base of Chalk Banks, two miles below Columbus, Hickman county, Ky."*

Appearance like that of a dried clay; color, light grey; rather harsh feel; adheres to the tongue. Dried at 212° it lost 5. per cent. of *moisture.*

Composition, dried at 212°—

| | |
|---|---|
| Organic and volatile matters, | 4.80 |
| Oxide of iron and alumina, | 8.65 |
| Carbonate of lime, | 1.25 |
| Carbonate of magnesia, | .26 |
| Carbonate of manganese, a trace. | |
| Phosphoric acid, a trace. | |
| Potash, | .52 |
| Soda, | .30 |
| Silica and insoluble silicates, | 84.04 |
| Loss, | .18 |
| | 100.00 |

HOPKINS COUNTY.

No. 130—LIMONITE. *Labeled "Red Ochreous Iron Ore, Bunt's Gap, near Alfred Townes', Hopkins county, Ky."*

A soft, porous mass, soiling the fingers, of red, yellow, and brownish ochreous matter. Powder of dirty orange-red color.

Composition, dried at 212° F.—

| | | |
|---|---|---|
| Oxide of iron, | 58.75 | = 41.14 per cent. of *Iron*. |
| Alumina, | 4.10 | |
| Carbonate of lime, | .10 | |
| Sulphur, | .15 | |
| Traces of magnesia, manganese, and phosphoric acid. | | |
| Silica and insoluble silicates, | 26.50 | |
| Combined water and loss, | 10.40 | |
| | 100.00 | |

The air-dried ore lost 3.2 per cent. of *moisture*, when dried at 212° F.

No. 131—LIMONITE. *Labeled "Iron Ore, above the Black Band, head waters of Stewart's creek, Hopkins county, Ky."*

A fragment of a nodular mass, of a lamellar structure; compact; color, yellowish-brown; adheres to the tongue.

| | | |
|---|---|---|
| Specific gravity, | 2.83 | |
| Composition, dried at 212° F. | | |
| Oxide of iron, | 52.16 | = 36.52 per cent. of *Iron*. |
| Alumina, | 7.70 | |
| Magnesia, | .23 | |
| Potash, | .23 | |
| Soda, | .23 | |
| Phosphoric acid, lime, and oxide of manganese, traces. | | |
| Silica and insoluble silicates, | 26.70 | |
| Combined water, | 11.80 | |
| Loss, | .95 | |
| | 100.00 | |

The air-dried ore lost 1.7 per cent. of *moisture*, when dried at 212° F.

No. 132—Impure Bituminous Carbonate of Lime. *Labeled "Black Band Iron Ore, head waters of Stewart's creek, Townes & Kirkwell's, Hopkins county, Ky."*

A dull olive-black, hard mineral; fracture even; earthy.

| | | |
|---|---|---|
| Specific gravity, | | 2.56 |
| Composition, dried at 212° F.— | | |
| Carbonate of lime, | 39.90 | |
| Carbonate of magnesia, | 20.50 | |
| Carbonate of manganese, | 1.02 | |
| Carbonate of iron, | 11.71 | = 6.64 per cent. of *Iron*. |
| Oxide of iron, | 2.22 | |
| Alumina, | .60 | |
| Phosphate of lime, | 5.23 | |
| Potash, | .17 | |
| Soda, | .09 | |
| Bituminous matters, | 6.05 | |
| Silica and insoluble silicates, | 12.41 | |
| Loss, | .10 | |
| | 100.00 | |

The air-dried mineral lost 0.5 per cent. of *moisture*, when dried at 212° F.

Notwithstanding the promising appearance of this mineral, it proves, on analysis, to be worthless as an iron ore—for its considerable proportion of phosphate of lime renders it improper for use, even as a flux to richer ores of iron.

No. 133—Impure Bituminous Carbonate of Iron. *Labeled "Black Band Iron Ore, head waters of Sugar creek, Townes & Kirkwell, Hopkins county, Ky."*

A dull olive-black, hard mineral; not quite so dark in color as the preceding; with an even earthy fracture; weathered exterior surface, yellowish-umber color.

| | | |
|---|---|---|
| Specific gravity, | | 2.613 |
| Composition, dried at 212° F.— | | |
| Carbonate of lime, | 40.09 | |
| Carbonate of magnesia, | 22.17 | |
| Carbonate of manganese, | .28 | |
| Carbonate of iron, | 7.32 | |
| Oxide of iron, | 3.53 | |
| Phosphate of lime, | 2.24 | |
| Alumina, | .17 | |
| Potash, | .21 | |
| Soda, | .14 | |
| Bituminous matter, | 7.25 | |
| Silica and insoluble silicates, | 16.60 | |
| | 100.00 | |

The air-dried powder lost 0.6 per cent. of *moisture*, when dried at 212° F.

This resembles the preceding in composition and properties.

No. 134—Iron Ore. *Labeled "Head waters of Stewart's creek, near the Black Bank, (productive ore?) Hopkins county, Ky."*

A porous, fine granular, light dove-grey colored rock; resembling impure limestone; adheres to the tongue; weathered surface ochreous. Powder, light yellowish-grey color.

| | | |
|---|---|---|
| Specific gravity, | | 2.948 |
| Composition, dried at 212° F.— | | |
| Oxide of iron, | 25.08 | = 25.30 per cent. of *Iron*. |
| Carbonate of iron, | 17.84 | |
| Carbonate of lime, | 5.97 | |
| Carbonate of magnesia, | 7.30 | |
| Carbonate of manganese, | 1.20 | |
| Alumina, | 1.00 | |
| Phosphoric acid, | .36 | |
| Potash, | .20 | |
| Soda, | .09 | |
| Bituminous matters, | 2.51 | |
| Silica and insoluble silicates, | 34.65 | |
| Water and loss, | 3.81 | |
| | 100.00 | |

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

Not a very rich ore, but not too poor to be smelted with advantage —especially to mix with richer mineral.

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

A very pure looking, soft, and friable coal; not soiling the fingers; some portions having a coarse granular fracture, others flat conchoidal; no appearance of pyrites or other impurities. Small fragments heated over the spirit lamp softened, swelled up, and agglutinated, leaving a spongy coke. It appears to be a coking coal.

| | | | |
|---|---|---|---|
| Specific gravity, - - - - - - - | | 1.288 | |
| Composition, dried at the ordinary temperature— | | | |
| Moisture, - - - - | 7.20 | Total volatile matters, - | 41.40 |
| Volatile combustible matters, - | 34.20 | | |
| Carbon in the coke, - - - | 56.30 | Moderately dense coke, - | 58.60 |
| Ashes, (dark grey,) - - | 2.30 | | |
| | 100.00 | | 100.00 |
| Composition, dried at 212° F.— | | | |
| Volatile combustible matters, - - - - | | 36.86 | |
| Carbon in the coke, - - - - - - | | 60.67 | |
| Ashes, - - - - - - - - - | | 2.47 | |
| | | 100.00 | |

The per centage of *sulphur* is 0.106. The ashes contain no appreciable quantity of sulphate of lime.

No. 136—Coal. *Labeled "Robinson's Coal, Clear creek, one-half mile west of railroad, Hopkins county, Ky."*

A soft coal; easily broken; of a pitch-black color; surface and fissure stained with oxide of iron and gypsum; and shows iridescent colors; heated over the spirit-lamp, it softens and swells up; probably a coking coal.

| | | | |
|---|---|---|---|
| Specific gravity, - - - - - - - - | | 1.272 | |
| Composition, dried at the ordinary temperature— | | | |
| Moisture, - - - - | 4.40 | Total volatile matters, - | 45.50 |
| Volatile combustible matters, - | 41.10 | | |
| Carbon in the coke, - - - | 51.10 | Moderately dense coke, - | 54.50 |
| Ashes, (reddish-grey,) - - | 3.40 | | |
| | 100.00 | | 100.00 |

Composition, dried at 212° F.—

| | |
|---|---|
| Volatile combustible matters, | 42.991 |
| Carbon in the coke, | 53.452 |
| Ashes, | 3.557 |
| | 100.000 |
| The per cent. of *sulphur* is, | 1.560 |

The ashes contained a trace of sulphate of lime.

No. 137—Coal. *Labeled "Pond River Coal, under the bridge, near McNary's, Hopkins county, Ky."*

Easily broken; coated in the fissures with ochreous matter; cross fracture, pretty pure pitch-black, and lustrous; heated over the spirit-lamp, it decrepitated considerably; softened and swelled up very much into a spongy coke; probably a coking coal.

Specific gravity, 1.297

Composition, dried at the ordinary temperature—

| | | | |
|---|---|---|---|
| Moisture, | 5.10 | Total volatile matters, | 40.30 |
| Volatile combustible matters, | 35.20 | | |
| Carbon in the coke, | 53.50 | Coke, rather hard, | 59.70 |
| Ashes, (dark brick-red,) | 6 20 | | |
| | 100.00 | | 100.00 |

Composition, dried at 212° F.—

| | |
|---|---|
| Volatile combustible matters, | 37.09 |
| Carbon in the coke, | 56.38 |
| Ashes, | 6.53 |
| | 100.00 |
| The per centage of *sulphur* is, | 1.122 |

The ashes containing 0.13 per cent. of sulphate of lime.

No. 138—Soil. *Labeled "Soil and Sub-soil, Captain Davis' farm, Hopkins county, Ky., (Coal Measures.")*

The dry soil is of a greyish-buff color, (a little more grey than the common post-office paper.) Washed carefully with water it left about 79. per cent. of *very fine sand*, of a dirty-buff color.

Dried at 330° F., the air-dried soil lost 1.86 per cent. of *moisture*.

One thousand grains of the air-dried soil were digested in water containing carbonic acid, like the preceding, but the experiment was lost from the bursting of the cork when it was too late to repeat it.

The composition of this soil, dried at 330° F., is as follows, viz:

| | |
|---|---|
| Organic and volatile matters, | 3.88 |
| Alumina, oxide of iron, and trace of phosphates, | 6.15 |
| Carbonate of lime, | .06 |
| Carbonate of magnesia, | .21 |
| Oxide of manganese, a trace. | |
| Potash, | .10 |
| Soda, | .06 |
| Silica and insoluble silicates, | 89.19 |
| Loss, | .35 |
| | 100.00 |

It cannot be called a very fertile soil.

LIVINGSTON COUNTY.

No. 139—LIMONITE. *Labeled "Sugar Creek Iron Ore, Hopewell Iron Works, Livingston county, Ky."*

A dark brown limonite, reddish ochreous on the surface; hard enough to strike fire with steel, from the presence of infiltrated silex, which gives it, in some pieces, a brecciated appearance. Powder, brownish-yellow ochre.

| | | |
|---|---|---|
| Specific gravity, | | 2.887 |
| Composition, dried at 212° F.— | | |
| Oxide of iron, | 35.97 | = 25.27 per cent. of *Iron*. |
| Alumina, | .80 | |
| Phosphoric acid, | .73 | |
| Carbonate of lime, | .55 | |
| Magnesia, | .13 | |
| Potash, | .21 | |
| Soda, | .34 | |
| Combined water, | 6.60 | |
| Silica and insoluble silicates, | 54.25 | |
| Loss, | .42 | |
| | 100.00 | |

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

No. 140—SOIL. *Labeled "Soil from summit of hill, near Hopewell Furnace, Livingston county, Ky."*

Dry soil, of a buff color. Three pounds of the soil sifted through a seive with two hundred and fifty-six appertures to the inch, left about one ounce of cherty and ferruginous pebbles, of various sizes,

from that of a peach kernel down. One thousand grains, digested in water saturated with water containing carbonic acid, as previously described, yielded only 0.453 grains of solid extract; this, dried at 212° F., heated with pure water, left of *insoluble* matter, dried at 212°, 0.183 grains of the following

Composition—

| | |
|---|---|
| Silica, | 0.076 |
| Carbonate of magnesia, | .076 |
| Carbonate of lime, alumina, oxide of iron, &c., | .031 |

The portion dissolved by the water weighed, when dried at 212°, 0.270 grains Ignited in a platinum capsule it lost, of

| | |
|---|---|
| Organic and volatile matters, | 0.173 |

The fixed residue consisted of—

| | |
|---|---|
| Carbonate of lime, | .027 |
| Carbonate of potash, | .036 |
| Carbonate of soda, | .030 |
| Carbonate of magnesia, &c., &c., | .004 |

The composition of this *soil* was found to be as follows, dried at 300° F.

| | |
|---|---|
| Organic and volatile matters, | 3.240 |
| Carbonate of lime, | .037 |
| Carbonate of magnesia, | .405 |
| Alumina, oxide of iron, and trace of phosphates, | 9.770 |
| Potash, | .108 |
| Soda, | .200 |
| Silica and insoluble silicates, | 85.830 |
| Carbonate of manganese, | .410 |
| | 100.000 |

The air-dried soil lost 3.76 per cent. of *moisture*, when dried at 300° F.

The burnt soil has a handsome dark orange or salmon color. Imperfectly washed, it left fine sand, mixed with small rounded fragments of silicious minerals, like semi-opal, chalcedony, &c., &c.

LOGAN COUNTY.

No. 141—Soil. *Labeled "Soil, southern part of Logan county, Ky., ten miles from Franklin, on the road from Keysburg. (Sub-carboniferous formation.)"*

The dry soil is of a light Scotch snuff color. Carefully washed with water it left about 69. per cent. of very fine sand, of a dirty buff color, containing small beautifully rounded particles of quartz, clear, milky, and reddish, with small particles of a ferruginous mineral.

One thousands grains of the air-dried soil digested in water containing carbonic acid, yielded 1.37 grains of *solid extract*, which had the following composition, viz:

| | |
|---|---|
| Volatile and organic matters, | 0.62 |
| Silica, | .05 |
| Oxide of iron, alumina, and trace of phosphates, | 1.77 |
| Carbonate of lime, | .33 |
| Oxide of manganese, | .18 |
| Potash, | .02 |

The air-dried soil lost 2.3 per cent. of *moisture*, when dried at 300° F., and had the following *composition*, viz:

| | |
|---|---|
| Organic and volatile matters, | 3.500 |
| Oxide of iron and alumina, | 5.160 |
| Carbonate of lime, | .196 |
| Carbonate of magnesia, | .118 |
| Carbonate of manganese, | .119 |
| Phosphate of lime, | .045 |
| Potash, | .181 |
| Soda, | .171 |
| Silica and insoluble silicates, | 90.060 |
| Loss, | ·450 |
| | 100.00 |

LYON COUNTY.

No. 83—LIMONITE. *Labeled "Iron Ore, Chandler Bank, Kelly's, Suwanner Furnace, Lyon county, Ky."*

A hard, dark reddish-brown limonite, hard enough to scratch glass; very compact; in curved layers; exterior surface, reddish and yellowish ochreous; powder of a brownish-yellow ochre color.

| | | |
|---|---|---|
| Specific gravity, | | 3.538 |
| Composition, dried at 212° F.— | | |
| Oxide of iron, | 71.74 | = 50.24 per cent. of *Iron*. |
| Alumina, | 1.40 | |
| Phosphoric acid, | .96 | |
| Potash, | .42 | |
| Soda, | .44 | |
| Combined water, | 9.34 | |
| Silica and insoluble silicates, | 15.70 | |
| Traces of oxide of manganese, magnesia and lime. | | |
| | 100.00 | |

The air-dried ore lost 0.7 per cent. of *moisture*, when dried at 212° F.

A very rich silicious iron ore; probably not as easily reduced as the softer and more porous ores.

No. 143—LIMESTONE. *Labeled "Iron Ore, Backster's Bank, Kelly's Furnace, Lyon county, Ky."*

A hard limonite.

| | | |
|---|---|---|
| Specific gravity, | | 3.37 |
| Composition, dried at 212° F.— | | |
| Oxide of iron, | 71.50 | = 50.07 per cent. of *Iron*. |
| Alumina, | 2.30 | |
| Magnesia, | .15 | |
| Potash, | .05 | |
| Soda, | .09 | |
| Combined water, | 10.40 | |
| Silica and insoluble silicates, | 15.40 | |
| Loss, | .11 | |
| Traces of lime, oxide of manganese, and phosphoric acid. | | |
| | 100.00 | |

The air- dried ore lost 1.1 per cent. of *moisture* when dried at 212°.

No. 144—LIMONITE. *Labeled "Hydrated Brown Oxide of Iron, Alexander's, five miles from Paducah, Blandville road, McCracken county, Ky."*

A hard, fine granular limonite; portion of a large piece in curved layers; color, dark purplish-brown; exterior of layers bright ochreous.

| | | |
|---|---|---|
| Specific gravity, | | 3.65 |
| Composition, dried at 212° F.— | | |
| Oxide of iron, | 83.80 | = 58.68 per cent. of *Iron*. |
| Alumina, | .60 | |
| Oxide of manganese, | .50 | |
| Potash, | .13 | |
| Soda, a trace. | | |
| Magnesia, a trace. | | |
| Phosphoric acid, | 0.07 | |
| Combined water, | 8.30 | |
| Silica and insoluble silicates, | 6.60 | Of which 5. Silica, |
| | 100.00 | |

MUHLENBURG COUNTY.

No. 145—LIMONITE. *Labeled "Iron Ore, Haws' ridge, one and a half miles from Greenville, Muhlenburg county, Ky."*

A portion of a nodular mass, of a greyish-reddish-brown color; rough earthy fracture; adheres to the tongue.

| | | |
|---|---|---|
| Specific gravity, | | 2.571 |
| Composition, dried at 212° F.— | | |
| Oxide of iron, | 48.70 | = 34.10 per cent. of *Iron.* |
| Alumina, | 2.70 | |
| Lime. | .05 | |
| Magnesia, | .58 | |
| Phosphoric acid, | .31 | |
| Oxide of manganese, | .08 | |
| Potash, | .36 | |
| Soda, | .12 | |
| Combined water, | 11.20 | |
| Silica and insoluble silicates, | 35.90 | |
| | 100.00 | |

The air-dried ore lost 2.2 per cent. of *moisture*, when dried at 212° F.

No. 146—LIMONITE. *Labeled "Jenkins' Ore Bank, four miles south-east of Old Furnace, Muhlenburg county, Ky."*

A porous, yellowish-brown ore, with darker layers. Powder, yellow ochreous.

| | | |
|---|---|---|
| Specific gravity. | | 2.83 |
| Composition dried at 212°— | | |
| Oxide of iron, | 62.20 | = 43.56 per cent of *Iron.* |
| Alumina, | 2.52 | |
| Lime, | .39 | |
| Magnesia, | .25 | |
| Brown oxide of manganese, | 1.30 | |
| Phosphoric acid, | 2.65 | |
| Potash, | .21 | |
| Soda, | .03 | |
| Combined water, | 11.50 | |
| Silica and insoluble silicates, | 19.30 | |
| | 100.35 | |

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

Its considerable proportion of phosphoric acid injures the value of this ore.

No. 147—LIMONITE. *Labeled "Iron Ore, with Sandy incrustations, Kincheloe's Bluff, Muhlenburg county, Ky.*

A hard, compact, concretionary limonite; specimen of a curved form, as though it is part of a large reniform nodule; the outside covered with sand cemented with oxide of iron; interior of the curved mass with mamillary and conical projections, rising from a comparatively smooth surface; general color, dark reddish-brown; exterior surfaces, reddish and yellowish ochreous.

| | | |
|---|---|---|
| Specific gravity, | | 3.46 |
| Composition, dried at 212° F.— | | |
| Oxide of iron, | 60.70 | = 42.50 per cent. of *Iron*. |
| Alumina, | 1.87 | |
| Magnesia, | .20 | |
| Lime, | .44 | |
| Oxide of manganese, | .20 | |
| Phosphoric acid, | .63 | |
| Potash and soda, (not estimated.) | | |
| Combined water, | 11.00 | |
| Silica and insoluble silicates, | 25.10 | |
| | 100.14 | |

The air-dried ore lost 1.2 per cent. of *moisture*, when dried at 212° F.

A pretty rich iron ore, notwithstanding the sand which is present.

No. 148—BITUMINOUS CARBONATE OF IRON. *Labeled "Clay Iron-stone, between Turner's and Buckner's Old Iron Works, Muhlenburg county, Ky."*

A nodular mass, of a dark drab color; compact; hard; the exterior layers having an ochreous appearance.

| | | |
|---|---|---|
| Specific gravity, | | 3.11 |
| Composition, dried at 212° F.— | | |
| Carbonate of iron, | 64.87 | =34.18 per cent. of *Iron*. |
| Oxide of iron, | 4.39 | |
| Carbonate of lime, | 3.58 | |
| Carbonate of magnesia, | 4.26 | |
| Carbonate of manganese, | 1.09 | |
| Phosphate of lime, | 2.10 | =0.93 per cent. of phosphoric acid. |
| Alumina, | .67 | |
| Potash, | .23 | |
| Soda, | .28 | |
| Bituminous matter, | 1.40 | |
| Silica and insoluble silicates, | 16.25 | |
| Loss, | .90 | |
| | 100.00 | |

The air-dried powder lost 0.5 per cent. of *moisture*, when dried at 212°.

This very complex ore would, very probably, smelt without the addition of fluxing material; and if the considerable proportion of phosphoric acid present does not injure the quality of the metal, it will yield an iron adapted to the manufacture of steel. It hardly contains enough bituminous matter to entitle it to the name of *Black Band Ore*.

No. 149—Bituminous Carbonate of Iron. *Labeled "Black Band, Williams' Landing, Muhlenburg county, Ky."*

Ore of a slaty structure, with layers of dull black and dark drab-grey; pretty hard; earthy fracture; weathered portions ochreous; powder of dark olive-grey or mouse color.

| | | |
|---|---|---|
| Specific gravity, | | 3.19 |
| Composition, dried at 212° F.— | | |
| Carbonate of iron, | 62.42 | 32.52 per cent of *Iron*. |
| Oxide of iron, | 3.38 | |
| Carbonate of lime, | 3.65 | |
| Carbonate of magnesia, | 7.41 | |
| Carbonate of manganese, | 2.49 | |
| Alumina, | .95 | |
| Phosphoric acid, | .10 | |
| Potash, | .23 | |
| Soda, | .12 | |
| Bituminous matter, | 2.41 | |
| Silica and insoluble silicates, | 15.27 | |
| Water and loss, | 1.57 | |
| | 100.00 | |

The air-dried powder lost 0.6 per cent. of *moisture*, when dried at 212°.

Like the preceding, this would probably require no limestone or other fluxing material for smelting it; and containing less phosphoric acid it is probably a more valuable ore, although its proportion of metallic iron is a little less. Ores of this kind may be more economically worked than any others.

No. 150—Bituminous Carbonate of Iron. *Labeled "Shaly Black Band Iron Ore, waters of Battist creek, Muhlenburg county, Ky."*

A hard slaty mineral, of a very dark grey color in the interior of the layers; exterior of a dark reddish-brown; powder, umber color.

| | | |
|---|---|---|
| Specific gravity, | | 2.94 |
| Composition, dried at 212° F— | | |
| Carbonate of iron, | 64.90 | 36.54 per cent. of *Iron*. |
| Oxide of iron, | 7.41 | |
| Carbonate of lime, | 3.25 | |
| Carbonate of magnesia, | 6.57 | |
| Carbonate of manganese, | 1.18 | |
| Alumina, | .60 | |
| Phosphoric acid, | .35 | |
| Potash, | .17 | |
| Soda, | .52 | |
| Bituminous matter, | 7.87 | |
| Silica and insoluble silicates, | 7.07 | |
| Loss, | .11 | |
| | 100.00 | |

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

This is also a very valuable ore, but in consequence of its small proportion of silica, may require the addition of silicious ore, or other silicious material to flux it in the furnace.

No. 151—Bituminous Carbonate of Iron. *Labeled "Black Band Iron Ore, Ford's Well, Muhlenburg county, Ky."*

Nearly black, with striæ of dark umber color; hard; compact; powder of an umber color.

| | | |
|---|---|---|
| Specific gravity, | | 2.924 |
| Composition, dried at 212°— | | |
| Carbonate of iron, | 74.46 | 36.80 per cent. of *Iron*. |
| Oxide of iron, | 1.15 | |
| Carbonate of lime, | 2.45 | |
| Carbonate of magnesia, | 4.70 | |
| Carbonate of manganese, | 1.03 | |
| Alumina, | .70 | |
| Phosphoric acid, | .38 | |
| Potash, Soda, | Not estimated. | |
| Bituminous matter, | 7.90 | |
| Silica and insoluble silicates, | 5.95 | |
| Water and loss, | 1.28 | |
| | 100.00 | |

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

This ore very much resembles the next preceding; it contains a little less silicious matter than that.

No. 152—Bituminous Carbonate of Iron. *Labeled "Grey Band, (productive iron ore?) Slate Bank between Turner's and Buckner's Old Iron Works, Muhlenburg county, Ky."*

A hard, dark grey mineral, with darker horizontal striæ; fine granular; powder, mouse-grey color.

| | | |
|---|---|---|
| Specific gravity, | | 3.218 |
| Composition, dried at 212°.— | | |
| Carbonate of iron, | 54.32 | 31.17 per cent. of *Iron*. |
| Oxide of iron, | 6.75 | |
| Carbonate of lime, | 3.87 | |
| Carbonate of magnesia, | 2.97 | |
| Carbonate of manganese, | 2.68 | |
| Alumina, | .50 | |
| Phosphoric acid, | .53 | |
| Potash, | .08 | |
| Bituminous matter, | 4.44 | |
| Silica and insoluble silicates, | 21.95 | |
| Water and loss, | 1.91 | |
| | 100.00 | |

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

This would doubtless prove a profitable ore; it would require the addition of a little limestone to flux it in the furnace.

The comparison between the composition of these specimens and that of the *black band* ores of Scotland, will be made in the tabular view to be given at the end of this report.

No. 153—Carbonate of Iron. *Labeled "Carbonate of Iron, from the Slate Ore Bank, between Turner's and the Old Furnace, Muhlenburg county, Ky."*

A pretty compact ore; dark grey in the interior, looking like a dark grey limestone; ochreous and reddish on the exterior; powder of a greyish-buff color.

| | | |
|---|---|---|
| Specific gravity, - - - - - - - | | 3.289 |
| Composition, dried at 212° F.— | | |
| Carbonate of iron, - - - | 62.59 | 40.26 per cent. of *Iron*. |
| Oxide of iron, - - - | 14.79 | |
| Carbonate of lime, - - - | 2.67 | |
| Carbonate of magnesia, - - | 4.69 | |
| Carbonate of manganese, - | 1.42 | |
| Alumina, - - - - - | 1.87 | |
| Phosphoric acid, a trace. | | |
| Potash, - - - - - | .23 | |
| Soda, - - - - - - | .12 | |
| Silica and insoluble silicates, - | 8.19 | |
| Water, bituminous matter, and loss - - - - - - | 3.43 | |
| | 100.00 | |

The air-dried powder lost 0.8 per cent. of *moisture*, when dried at 212°

A very good ore which could probably be smelted without any addition of lime.

No. 154—Bituminous Carbonate of Lime. *Labeled "Black Band Iron Ore, one and a half miles northwest of Greenville, Muhlenburg county, Ky."*

A dark colored, hard rock, with an even earthy fracture; weathered surfaces drab colored.

| | | |
|---|---|---|
| Specific gravity, | | 2.52 |
| Composition, dried at 212° F.— | | |
| Carbonate of lime, | 85.00 | |
| Carbonate of magnesia, | 1.15 | |
| Alumina and oxide of iron, | 1.57 | |
| Oxide of manganese, a trace, | | |
| Phosphoric acid, | .35 | |
| Potash, | .38 | |
| Bituminous matter, | 3.14 | |
| Silica and insoluble silicates, | 7.95 | |
| Loss, | .46 | |
| | 100.00 | |

The dried powder lost 0.6 per cent. of *moisture*, when dried at 212° F.

The specific gravity of this rock is much lower than that of the black band, but its general appearance is very deceptive.

No. 155—Soil. *Labeled "Soil from the Coal region, north slope of hill in the north part of Muhlenburg county, Ky."*

The dry soil is of a light Scotch snuff color; washed carefully with water it left about 70. per cent. of very fine sand of a dirty buff color, containing a few minute quartz crystals, and some rounded particles of hyaline and milky quartz, and of a ferruginous mineral.

One thousand grains digested with water containing carbonic acid, yielded more than six grains of solid extract, out of which the organic matter was burnt, giving a strong ammoniacal or urinous odor, leaving the residuum still black from the presence of oxide of manganese. The composition of this extract is as follows:

| | |
|---|---|
| Organic and volatile matters, | 1.57 |
| Carbonate of lime, | 4.13 |
| Magnesia, | .46 |
| Oxide of manganese, | .83 |
| Oxide of iron, | .08 |
| Potash, | .54 |
| Soda, | .12 |
| Silica, | .05 |
| Phosphoric acid, (not estimated.) | |

The air-dried soil lost 2.85 per cent. of *moisture*, when dried at 350°

The *composition*, dried at this temperature is as follows:

| | |
|---|---|
| Organic and volatile matters, | 5.80 |
| Oxide of iron and alumina, | 5.05 |
| Phosphate of lime, | .08 |
| Oxide of manganese, | .31 |
| Magnesia, | .54 |
| Carbonate of lime, | 1.07 |
| Potash, | .19 |
| Soda, | .03 |
| Silica and insoluble silicates, | 86.64 |
| Loss, | .29 |
| | 100.00 |

Not very rich in phosphates, nor in alumina and oxide of iron.

No. 156—Coal. *Labeled "(McLean,) Airdrie Coal, below the clay parting, six and three-twelfth feet thick, Muhlenburg county, Ky."*

A pure, soft and friable coal, of a shining pitch-black appearance; fibrous coal between the layers; no appearance of pyrites or other impurities; fragments heated over the spirit-lamp, softened, swelled up and agglutinated into a light cellular coke; probably a good coking coal.

| | | | |
|---|---|---|---|
| Specific gravity, | | | 1.221 |
| Composition, dried at the ordinary temperature— | | | |
| Moisture, | 3.10 | Total volatile matters, | 48.40 |
| Volatile combustible matters, | 45.30 | | |
| Carbon in the coke, | 48.50 | Coke, | 51.60 |
| Ashes, (reddish-grey,) | 3.10 | | |
| | 100.00 | | 100.00 |

| | |
|---|---|
| Composition, dried at 212° F.— | |
| Volatile combustible matters, | 46.749 |
| Carbon in the coke, | 50 052 |
| Ashes, | 3.199 |
| | 100.000 |
| The per centage of *sulphur* is, | 1.35 |

The ashes contained no marked amount of sulphate of lime.

No. 157—Coal. *Labeled "Eade's Coal, two miles and a half southwest of Greenville, Muhlenburg county, Ky."*

A soft, pure pitch-black coal, with fibrous coal, exhibiting vegetable impressions, between the layers; no appearance of pyrites or other im-

pureties, heated over the spirit-lamp, it softened and swelled up a good deal, and left a light coke; probably a good coking coal.

| | | | |
|---|---|---|---|
| Specific gravity, - - - - - - - | | 1.260 | |
| Composition, dried at the ordinary temperature— | | | |
| Moisture, - - - - | 2.80 | Total volatile matters, - | 40.40 |
| Volatile combustible matters, - | 37.60 | | |
| Carbon in the coke, - - - | 56.10 | Coke, - - - - | 59.60 |
| Ashes, (purplish,) - - - | 3.50 | | |
| | 100.00 | | 100.00 |
| Composition, dried at 212°— | | | |
| Volatile combustible matters, - - - - | | 38.684 | |
| Carbon in the coke, - - - - - - | | 57.716 | |
| Ashes, - - - - - - - - - | | 3 600 | |
| | | 100.000 | |
| The per centage of *sulphur* is, - - - | | .654 | |

No appreciable amount of sulphate of lime in the ashes.

No. 158--Coal. *Labeled "Clark's Coal, Pond river, on Princeton and Greenville road, Muhlenburg county, Ky."*

A very friable, dull looking coal; not soiling the fingers; breaking into small fragments; heated over the spirit-lamp it burnt only for a short time with a flame; did not soften nor swell up; and the residuum burnt on the hot iron, after removal from the lamp, like rotten wood.

| | | | |
|---|---|---|---|
| Specific gravity, - - - - - - - - | | 1.348 | |
| Composition, dried at the ordinary temperature— | | | |
| Moisture, - - - - | 8.70 | Total volatile matters, - | 33.30 |
| Volatile combustible matters, - | 24.60 | | |
| Carbon in the fixed residuum, - | 59.20 | Fixed residue, - - | 66.70 |
| Ashes, (nearly white,) - - | 7.50 | | |
| | 100.00 | | 100.00 |
| Composition, dried at 212° F.— | | | |
| Volatile combustible matters, - - - - | | 26.944 | |
| Carbon in the fixed residue, - - - - | | 64.840 | |
| Ashes, - - - - - - - - | | 8.216 | |
| | | 100.00 | |
| The per centage of *sulphur* is, - - - | | .550 | |

OWSLEY COUNTY.

No. 159—Coal. *Labeled "Todd & Crittenden's Coal, from the Three Forks of the Kentucky river, Owsley county, Ky."*

A good specimen of Kentucky river coal; of a pitch-black color, and considerable lustre; fibrous coal, with vegetable impressions between the layers; over the spirit-lamp it swells up somewhat, but does not agglutinate as much as the Pittsburg coal; a somewhat *dry* bituminous coal, or soft variety of splint coal.

| | | | |
|---|---|---|---|
| Specific gravity, - - - - - - - | | 1.295 | |
| Composition, dried at the ordinary temperature— | | | |
| Moisture, - - - - | 3.40 | Total volatile matters, - | 36.80 |
| Volatile combustible matters, - | 33.16 | | |
| Carbon in the coke, - - - | 57.10 | Coke, - - - - | 63.20 |
| Ashes, (nearly white,) - - | 6.43 | | |
| | 100.00 | | 100.00 |
| Composition, dried at 212° F.— | | | |
| Volatile combustible matters, - - - - | | 34.575 | |
| Carbon in the coke, - - - - - - | | 58.765 | |
| Ashes, - - - - - - - - | | 6.660 | |
| | | 100.000 | |
| The per centage of *sulphur* is, - - - - | | .337 | |

From want of sufficient time, this was the only one of the Kentucky coals which was submitted to ultimate or elementary analysis. Burnt in the usual way, in the combustion tube with fused chromate of lead, there were obtained from 5 grains, 12.85 of *carbonic acid*, and 2.48 of water. Deducting the sulphur and ashes, as stated above, the statement of the ultimate composition of this coal is as follows:

Ultimate analysis, dried at 212°, average of six operations—

| *A*—Calculated with the ashes: | | *B*—Calculated without the ashes: | |
|---|---|---|---|
| Carbon, - - - - - | 69.160 | Carbon, - - - - - | 74.094 |
| Hydrogen, - - - - | 5.360 | Hydrogen, - - - - | 5.742 |
| Oxygen, nitrogen, and loss, | 18.483 | Oxygen, nitrogen, and loss, | 19.802 |
| Sulphur, - - - - - | .337 | Sulphur, - - - - - | .362 |
| Ashes, - - - - - | 6.660 | | |
| | 100.000 | | 100.000 |

No. 160—Coal. *Labeled "Cannel Coal from Haddock's Mine, between South and Middle Forks of Kentucky river, Owsley county, Ky."*

A very tough, pitch-black coal; fracture large conchoidal; not soiling the fingers; powder nearly black, with a very slight brownish

tinge, like lamp-black; heated over the spirit-lamp, swelled a little and became somewhat porous; burning with a very large clear flame; but did not soften as much as the preceding specimen; burns on the open fire without coking; gives out a great deal of flame.

| | | | |
|---|---|---|---|
| Specific gravity, - - - - - - - | | 1.211 | |
| Composition, dried at the ordinary temperature— | | | |
| Moisture, - - - - | 1.10 | Total volatile matters, - | 50.00 |
| Volatile combustible matter, - | 48.90 | | |
| Carbon in the coke, - - - | 47.00 | Coke, - - - - | 50.00 |
| Ashes, (buff colored,) - - | 3.00 | | |
| | 100.00 | | 100.00 |
| Composition, dried at 212° F.— | | | |
| Volatile combustible matters, - - - - | | 49.444 | |
| Carbon in the coke, - - - - - - | | 47.523 | |
| Ashes, - - - - - - - - - | | 3.033 | |
| | | 100.000 | |
| The per centage of *sulphur* is only, - - - | | 0.241 | |

The ashes contain about 0.236 per cent. of *sulphate of lime.*

One of the best specimens of cannel coal. We hope to be able at a future time to examine these coals more thoroughly, as well as to pass in review the rich variety of coals to be found in the eastern coal fields of Kentucky.

### SIMPSON COUNTY.

No. 161—Soil. *Labeled "Soil, north part of Simpson county, Ky., three-quarters of a mile from the Warren county line."*

The dry soil is of a snuff color, with a tinge of reddish or lilac; rather darker colored than usual.

Washed with water, about 25. per cent. of fine sand was obtained, the grains of which, under the lens, appeared rounded; some pellucid, others yellow, red and brown.

One thousand grains digested in water containing carbonic acid gave up nearly 3. grains of *solid extract*, dried at 212°.

This treated with pure water left rather more than one-half its weight of *insoluble matter*, which had been dissolved by the carbonic acid; having the following composition, viz:

| | | |
|---|---|---|
| Silica, | 0.120 | |
| Carbonate of lime, | .377 | |
| Carbonate of magnesia, | .916 | |
| Carbonate of manganese, | .025 | |
| Sulphate of lime, | .010 | |
| Alumina, oxide of iron, and a trace of phosphate, | .027 | = 1.475 |

The portion dissolved by the water was dried and the

| | | |
|---|---|---|
| Organic and volatile matters, removed by heat, weighed, | 0.780 | |

The residue contained,

| | | |
|---|---|---|
| Carbonate of lime, | .257 | |
| Carbonate of magnesia, | .132 | |
| Potash, | .064 | |
| Soda, | .037 | = 1.270 |

Alumina and oxide of manganese, traces.

The air-dried soil lost 2.8 per cent. of *moisture*, when dried at 320°.

The *composition* of the soil is as follows, dried at 320°:

| | |
|---|---|
| Organic and volatile matters, | 5.100 |
| Carbonate of lime, | .194 |
| Carbonate of magnesia, | .307 |
| Carbonate of manganese, | .235 |
| Alumina, oxide of iron, and trace of phosphates, | 6.510 |
| Potash, | .131 |
| Soda, | .070 |
| Silica and insoluble silicates, | 87.470 |
| | 100.017 |

TODD COUNTY.

No. 162—Sub-soil. *Labeled "Red Clay Sub-soil, Todd county, Ky.; the same prevalent through a large district of the sub-carboniferous limestone formation. How much oxide of iron?"*

Color, dull reddish-yellow. The *composition* is as follows:

| | |
|---|---|
| Organic and volatile matters, | 4.10 |
| Oxide of iron, alumina, and trace of phosphates, | 5.60 |
| Carbonate of lime, | 1.42 |
| Carbonate of magnesia, | .24 |
| Potash, | .11 |
| Soda, | .03 |
| Silica and insoluble silicates, | 88.30 |
| | 100.00 |

The air-dried soil lost 2. per cent. of *moisture*, when dried at 212°.

No. 163—Soil. *Labeled "Soil, with admixture of sub-soil, taken opposite a large plantation amongst oak timber, about 2 miles from the crossing of the Elk fork of Red River, between Haydensville and Hollingsworth Mill, Todd county, Ky."*

Dry soil of a greyish-brown color, with a tinge of red. Washed with water it left only *very fine sand*. One thousand grains digested in water containing carbonic acid as before described, yielded 1.093 grs. of *solid extract*, dried at 212°. This, treated with pure water, left of *insoluble matter*, which had been dissolved by the carbonic acid, the following ingredients:

| | | |
|---|---|---|
| Silica, | 0.160 | |
| Carbonate of lime, | .257 | |
| Carbonate of magnesia, | .151 | |
| Carbonate of manganese, | .341 | |
| Alumina, oxide of iron, and trace of phosphates, | .037 | |
| Sulphate of lime and loss, | .167 | = 1.113 |

The *soluble portion*, ignited in a platinum capsule, lost of,

| | |
|---|---|
| Organic and volatile matters, | 0.280 |

And the fixed residue consisted of,

| | | |
|---|---|---|
| Carbonate of lime, | .037 | |
| Carbonate of magnesia, | .007 | |
| Potash, | .067 | |
| Soda, | .033 | |
| Alumina, oxide of iron, trace of phosphates, and loss, | .156 | = 580 |

The air-dried soil lost 2.8 per cent. of *moisture*, when dried at 212°.

Its *composition* is as follows:

| | |
|---|---|
| Organic and volatile matters, | 4.180 |
| Carbonate of lime, | .194 |
| Carbonate of magnesia, | .475 |
| Carbonate of manganese, | .114 |
| Alumina, oxide of iron, and trace of phosphates, | 6.830 |
| Potash, | .178 |
| Soda, | .095 |
| Silica and insoluble silicates, | 87.830 |
| Sulphate of lime and loss, | .104 |
| | 100.00 |

TRIMBLE COUNTY.

No. 164—LIMESTONE. *Labeled "Marble, Corn Creek, on the Ohio river opposite to Marble Hill, the quarry of Conchitie Marble of Messrs. Wm. W. Dean and Co., in Jefferson county, Indiana, thirty miles above Louisville; supposed to be of the same kind. Quarry of Dr. Hopson."*

This rock is of a warm, or drab-grey color, presenting a granular crystalline structure, containing many fragments of shells, especially of *Murchisonia bellicincta;* and very small portions of coral—probably *Chaetetes lycoperdon*—cemented by pure minute crystals of calcareous spar, which form the principal mass of the rock. Some of the fragments of fossils have a pink color; the cavities of some of the shells are filled with beautifully clear, colorless calcareous spar; in others the spar filling them is colored of a pinkish-brown, or flesh color by oxide or carbonate of iron; which appears occasionally in the stone in small spots and patches. On one of the specimens there is the fragment of a bi-valve shell, and in another two portions of Orthoceræ. The weathered surfaces are remarkably even, and free from fissures, and indicate great durability. A piece of the rock, rubbed down with sand, &c., received a very good polish; a few fine cracks only traverse the surface, in appearance like the sutures on a skull, which doubtless are the results of the long exposure to the atmospheric influences of this outside portion of the bed, and will not, probably, be found in the interior of the stratum, where moisture and a uniform temperature have been preserved.

Compared with two slabs of the *Conchitic marble*, from the quarry of the Messrs. Deans, at the marble-yard of Mr. Pruden, of this city, it was found, by all appearances, to be identical. (The face of one of these slabs, however, which seemed to be course grained, was studded with branching specimens of the *Chaetetes lycoperdon.*)

*Specific gravity* of this marble was found to be 2.704; that of the Dean's as reported by Dr. Owen, 2.683.

A fragment of an irregular tetrahedral form, weighing 314.8 grains, (nearly 20.38 grammes,) was allowed to remain in water for about an hour, when having been wiped dry with blotting paper, and weighed, it was found to have gained, by imbition of water, 1.5 grains,=0.47 per cent. At the end of an hours exposure, in a dry room, at the temper-

ature of 71.5° F., it had lost one-third of this water; next morning it retained only 0.1 grains of the water.

Its *composition* was found to be as follows, viz: (For comparison, the results of the analyses of two varieties of Dean's *Conchitic marble*, by Dr. D. D. Owen, are placed in adjoining columns.)

| | | Dean's marble, two varieties. | |
|---|---|---|---|
| Carbonate of lime, - - - - - | 96.03 | 89.68 | 81.60 |
| Carbonate of magnesia, - - - - | .74 | 3.80 | 10.50 |
| Carbonate of iron, - - - - - | 1.09 | 2.30 | 5.28 |
| Phosphate of lime, - - - - - | 1.19 | .85 | .90 |
| Alumina, - - - - - - | .16 | 1.00 | .52 |
| Insoluble earthy matter, (silica, &c.,) - | .66 | 2.00 | .20 |
| Moisture, - - - - - - - | .06 | .10 | .10 |
| Oxide of manganese, - - - - | a trace, | a trace, | a trace. |
| Loss, - - - - - - - - | .07 | .27 | .90 |
| | 100.00 | 100.00 | 100.00 |

It would appear from the above comparison of the composition of this specimen, with that of those analyzed by Dr. Owen, from the Indiana quarry, that this is even purer than those. It has also a slightly higher specific gravity. There can be no doubt that it will prove an equally good and handsome building material.

The following remarks by Dr. Owen, on the Conchitic marble of Indiana, will doubtless apply with a perfect fitness to this marble also: "Taking into consideration the properties and chemical composition of the rock of Marble Hill, as ascertained by the preceding investigations, and a careful inspection of the quarries, as well as the rock in its natural position along the face of the bluff, I have no hesitation in pronouncing it the *best* and *most beautiful* material for constructions and ornamental purposes that has come within my notice from any western locality." (A *Geological* report on the Marble Hall Quarry, &c., &c., by David Dale Owen, M. D., 1853.)

Whether the more recent geological explorations in Kentucky, of its worthy Principal Geologist, will enable him to modify his opinion, in the above relation, will be seen in his forthcoming report on the geology of this State.

TRIGG COUNTY.

No. 165—Soil. *Labeled "Soil, for seven inches, in cherty bed of sub-carboniferous limestone system, Barren oak land, four miles south of Cadiz, Trigg county, Ky."*

Color of the dried soil, dark greyish-buff; washed with water it left a large proportion of *very fine sand* of a dirty buff color.

One thousand grains of the air-dried soil digested, as before described, in water containing carbonic acid, yielded rather more than one grain of *solid extract*, dried at 212°. This, treated with water, left of *insoluble matters* which had been dissolved by the carbonic acid, as follows:

| | | |
|---|---|---|
| Silica, | 0.147 | |
| Carbonate of lime, a trace. | | |
| Carbonate of magnesia, | .195 | |
| Carbonate of manganese, | .054 | |
| Alumina, oxide of iron, and a trace of phosphates, | .017 | = .413 |

The *soluble* portion dried and ignited, lost of

| | | |
|---|---|---|
| Organic and volatile matters, | 0.400 | |

The fixed residue consisted of—

| | | |
|---|---|---|
| Carbonate of lime, | .047 | |
| Carbonate of magnesia, | .069 | |
| Carbonate of manganese, | .022 | |
| Alumina, oxide of iron, and a trace of phosphates, | .017 | |
| Potash and soda, | .031 | |
| Loss, | .044 | = .630 |

The air-dried soil lost 1.74 per cent. of *moisture*, when dried at 300°.

Its *composition* is as follows:

| | |
|---|---|
| Organic and volatile matters, | 3.28 |
| Carbonate of lime, | .034 |
| Carbonate of magnesia, | .195 |
| Carbonate of manganese, | .195 |
| Alumina, oxide of iron, and trace of phosphates, | 3.690 |
| Potash, | .096 |
| Soda, | .022 |
| Silica and insoluble silicates, | 92.310 |
| Loss, | ·178 |
| | 100.00 |

UNION COUNTY.

No. 166—Coal. *Labeled "Coal from Casey's Mine, near Caseyville, Union county, Ky."*

A pure looking, glossy black, soft bituminous coal, of a lamellar structure; no appearance of pyrites or other impurities. Heated over the spirit-lamp it softened and swelled up very much, and agglutinated into a light spongy coke. Seems a good coking coal.

| | | | |
|---|---|---|---|
| Specific gravity, | | | 1.312 |
| Composition, dried at 212° F.— | | | |
| Volatile combustible matters, | 40.70 | | |
| Carbon in the coke, | 52.30 | Coke, | 59.30 |
| Ashes, (purplish-grey,) | 7.00 | | |
| | 100.00 | | |
| The per centage of sulphur is, | | | 0.88 |

The air-dried coal lost only 0.4 per cent. of *moisture*, when dried at 212°.

No. 167—Fire Clay. *Labeled "Fire-clay from Casey's Mines, Union county, Ky."*

A soft clay-stone, or indurated clay; what is sometimes called "horse-back" by the coal-diggers; irregularly lamellar, of a dark grey color, with some black vegetable impressions; exhibits a few minute scales of mica.

| | |
|---|---|
| Composition, dried at 212°— | |
| Silica, | 73 00 |
| Alumina, | 17.60 |
| Oxide of iron, | 3.00 |
| Carbonate of lime, | .60 |
| Potash and soda, | .10 |
| Water, organic matter and loss, | 5.70 |
| | 100.00 |

A very good fire-clay.

WARREN COUNTY.

No. 168—Soil. *Labeled "Soil west part of Warren county, Ky."*

Dry soil of a dirty powdered cinnamon color; contained a few fragments of radiated and milky quartz, (too large to go through the seive of 256 apertures to square inch.) By washing with water obtained about 60. per cent. of very fine sand, of a cinnamon color, containing

a few small scales of mica. One thousand grains of the air-dried soil, digested in water containing carbonic acid, as already described, yielded a little more than one grain of *solid extract*, dried at 212°. This, treated with pure water, left of *insoluble matter*, which had been dissolved by the carbonic acid, rather more than half a grain; having the following composition, viz:

| | | |
|---|---|---|
| Silica, | 0.170 | |
| Carbonate of lime, | .137 | |
| Carbonate of magnesia, | .131 | |
| Alumina, oxide of iron, and a trace of phosphates, | .067 | |
| Sulphate of lime, | .010 | 0.515 |

The *soluble matter*, dried and ignited in a platinum capsule lost of

| | | |
|---|---|---|
| Organic and volatile matters, | 0.300 | |

And the fixed residue contained

| | | |
|---|---|---|
| Carbonate of lime, | .077 | |
| Carbonate of magnesia, | .097 | |
| Potash, | .038 | |
| Soda, | .021 | |
| Alumina, &c., a trace. | | .533 |
| In all, | | 1.048 |

The air-dried soil lost 2.18 per cent. of *moisture*, when dried at 212°.

Its *composition* is as follows:

| | |
|---|---|
| Organic and volatile matters, | 2.900 |
| Carbonate of lime, | .094 |
| Carbonate of magnesia, | .350 |
| Carbonate of manganese, | .054 |
| Phosphate of lime, | .221 |
| Alumina and oxide of iron, | 5.129 |
| Potash, | .150 |
| Soda, | .043 |
| Silica and insoluble silicates. | 90.890 |
| Sulphate of lime and loss, | .069 |
| | 100.000 |

It would be improved by a larger proportion of alumina and oxide of iron, which would increase its power of absorbing and retaining the products of animal and vegetable decomposition, gases and vapors.

PITTSBURG COAL.

For the purposes of comparison with the coals of Kentucky, a specimen of this coal was submitted to examination.

No. 169—Coal. *Labeled "Pittsburg Coal," sent to me from Louisville some years since, and kept in a dry place, (in my cabinet,) ever since.*

A pure looking coal of a pitch-black color and considerable lustre. Heated over the spirit-lamp it softened and swelled up very much, and agglutinated into a very light coke.

| | | | |
|---|---|---|---|
| Specific gravity, - - - - - - - - - | | 1.291 | |
| Composition, dried at the ordinary temperature— | | | |
| Moisture, - - - - - | 2.00 | Total volatile matters, - | 31.70 |
| Volatile combustible matters, - | 29.70 | | |
| Carbon in the coke, - - - | 65.30 | Coke, - - - - | 68.30 |
| Ashes, (yellowish-grey,) - - | 3.00 | | |
| | 100.00 | | 100.00 |
| Composition, dried at 212° F.— | | | |
| Volatile combustible matters, - - - - | | 30.003 | |
| Carbon in the coke, - - - - - - | | 66.636 | |
| Ashes, - - - - - - - - - | | 3.061 | |
| | | 100.000 | |

The per centage of *sulphur* is only 0.055 in the specimen examined, which is probably a selected specimen.

# I. IRON ORES.

## (*a*) LIMONITES.

*(Showing the per centage of each ingredient.)*

| Number in report. | Peroxide of iron | Carbonate of iron | Per centage of iron. | Alumina. | Lime and carbonate. | Magnesia and carbonate. | Brown oxide of manganese. | Phosphoric acid. | Potash. | Soda. | Silica, &c. | Water. | Sulphur, &c. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 5 | 79.90 | – | 55.95 | 1.10 | 0.10 | 1.53 | 1.80 | – | not es | timt'd | 9.00 | 6.57 | – |
| 11 | 24 20 | 6.28 | 19.24 | 1.95 | 51.35 | 1.53 | 3 41 | 0.24 | 0 23 | 0.18 | 9.67 | 1.96 | – |
| 12 | 71.50 | – | 50.07 | 2.45 | – | 1.03 | 1.37 | – | .34 | .12 | 11.97 | 11.57 | – |
| 13 | 67.40 | – | 47.20 | .87 | .57 | 1.81 | .95 | – | .50 | .16 | 17.57 | 11.55 | – |
| 23 | 39.60 | – | 27.73 | 1.00 | .58 | – | .20 | .67 | not es | tim'td | 51.30 | 6.40 | – |
| 31 | 41.70 | – | 29.20 | 1.25 | – | .20 | .58 | 2.30 | .13 | – | 45.05 | 8.01 | – |
| 32 | 49.69 | – | 34.79 | 2.53 | – | .33 | .45 | .22 | .38 | .11 | 38.35 | 7.68 | – |
| 33 | 60.00 | – | 42.00 | .68 | 20.67 | 3.84 | – | – | .17 | .06 | 4.07 | 10.70 | – |
| 34 | 72.70 | – | 50.90 | 2 00 | – | .37 | .57 | – | .42 | .17 | 13.17 | 11.48 | – |
| | | | | Phos. | | | | | | | | | |
| 35 | 54 60 | – | 38.23 | 4.55 | 13.85 | – | – | .74 | .36 | .32 | 13.37 | 9.28 | – |
| 36 | 87.00 | – | 60.09 | .60 | – | .82 | .65 | .67 | .30 | .21 | 3.47 | 6.59 | – |
| | | | | | | carb. | carb. | | | | | | |
| 44 | 61.18 | 7.48 | 46.51 | 2.27 | 2.15 | 2.02 | 2.92 | – | .45 | – | 11.23 | 10.29 | – |
| 45 | 68.10 | – | 47.69 | 2.93 | – | .67 | 1.64 | .43 | .54 | .13 | 13.05 | 11.67 | – |
| 46 | 58.90 | – | 41.24 | 4.15 | 3.15 | 2.40 | 97 | – | .58 | .47 | 17.87 | 11 26 | – |
| 54 | 49 45 | – | 34.63 | .45 | 7.35 | 2.58 | 1.15 | 1.53 | .67 | .19 | 25.65 | 10.96 | – |
| 55 | 66.90 | – | 46.85 | 2.65 | – | .33 | .65 | .25 | .27 | .31 | 19.75 | 8.75 | – |
| 56 | 63 50 | – | 44 54 | 3.55 | – | .40 | 1 95 | – | .34 | .17 | 17.95 | 12.05 | – |
| 57 | 60.50 | – | 42.35 | 2.95 | – | .40 | 3.15 | .14 | .19 | .37 | 25.25 | 6.95 | – |
| 58 | 70.30 | – | 49.23 | 2 15 | – | .37 | .75 | – | .17 | .16 | 13.95 | 11.76 | – |
| 59 | 63.20 | – | 44 26 | 1 95 | – | .74 | 1.15 | – | .44 | – | 22.35 | 10.30 | – |
| 69 | 38.50 | – | 26.96 | 3.37 | – | 1.20 | .97 | – | .66 | .10 | 46.95 | 8.25 | – |
| 70 | 68.10 | – | 47.69 | 2.17 | – | .91 | .31 | – | .48 | .07 | 16.25 | 11.51 | – |
| 71 | 26 60 | – | 18.62 | 2.37 | – | .77 | .17 | – | .34 | .17 | 63.90 | 5.68 | – |
| 72 | 51 00 | – | 35.71 | 2.27 | .47 | 1.48 | .97 | – | .52 | .28 | 33 65 | 9.81 | – |
| 73 | 67.50 | – | 47.27 | 2.97 | .97 | 1.62 | 1.32 | – | .38 | – | 14.75 | 12.11 | – |
| 80 | 65 30 | – | 47 82 | 2.65 | 47 | .86 | 1.55 | – | .22 | .10 | 23.67 | 4.93 | – |
| 81 | 76.20 | – | 53.36 | 2.25 | – | 1.86 | 1.00 | – | .33 | .10 | 11 27 | 7.60 | – |
| 82 | 71.90 | – | 50 35 | 1.67 | .27 | 1.13 | 1.35 | .25 | .24 | .06 | 14.17 | 9.22 | – |
| 83 | 80 60 | – | 56 44 | .87 | – | .40 | .77 | – | .21 | .35 | 6.97 | 9 51 | – |
| 93 | 56 50 | – | 39.56 | 2 95 | 7.27 | 2.30 | 1 00 | trace. | 0.26 | 0.11 | 18 27 | 11.34 | – |
| 94 | 62.90 | – | 44.04 | 3.15 | .57 | .68 | trace. | trace. | .32 | .04 | 24 97 | 8.41 | 0.15 |
| 95 | 81.87 | – | 57.33 | .97 | – | .33 | .55 | .23 | .07 | .14 | 3.67 | 12.39 | – |
| 96 | 57.10 | – | 40.03 | 1.65 | 9.37 | 1.49 | .37 | – | .08 | .09 | 20.07 | 9.80 | – |
| 103 | 57.90 | – | 40.53 | 2.77 | – | .72 | 25 | trace | .32 | .10 | 27.67 | 10.03 | – |
| | | | | | | | | phos l. | | | | | |
| 104 | 13.25 | – | 9.27 | 4.95 | 1 67 | .61 | – | .90 | not es | tim'td | 74.37 | 4.36 | – |
| 105 | 56 70 | – | 39.70 | 3.75 | – | .63 | .42 | – | .32 | .17 | 25.97 | 12.04 | – |
| 106 | 64.70 | – | 45.31 | .27 | 16 50 | 1.84 | 2 15 | – | .23 | .05 | 6.47 | 7.12 | – |
| 107 | 32 10 | – | 22 48 | 1.47 | – | .33 | – | – | .12 | – | 61.37 | 4.62 | – |
| 117 | 85.16 | – | 59.63 | .84 | – | .59 | .95 | – | .25 | – | 4.57 | 7.64 | – |
| 119 | 39 90 | – | 27.48 | 3.37 | 20.87 | 2.85 | 2.17 | .75 | .30 | .16 | 20.97 | 8.66 | – |
| 130 | 58 75 | – | 41.14 | 4.10 | .10 | – | – | trace. | not es | tim'td | 26.50 | 10.40 | .15 |
| 131 | 52.16 | – | 36.52 | 7.70 | trace. | .23 | trace. | trace | .23 | .23 | 26.70 | 11.80 | – |
| 139 | 35.97 | – | 25.27 | .80 | .55 | .13 | – | .73 | .21 | .34 | 54.25 | 6.60 | – |
| 142 | 71.74 | – | 50.24 | 1.40 | trace. | trace | trace | .96 | .42 | .44 | 15.70 | 9.34 | – |
| 143 | 71 50 | – | 50.07 | 2 30 | trace. | .15 | trace. | trace. | .05 | .09 | 15.40 | 10.40 | – |
| 144 | 83.80 | – | 58.68 | .60 | – | trace. | .50 | .07 | .13 | trace. | 6 60 | 8.30 | – |
| 145 | 48 70 | – | 34.10 | 2.70 | .05 | .55 | trace. | .31 | .36 | .12 | 35.90 | 11.20 | – |
| 146 | 62 20 | – | 43.20 | 2 52 | .39 | .25 | 1.30 | 2.65 | .21 | .03 | 19.30 | 11.50 | – |
| 147 | 60.70 | – | 42.50 | 1.87 | .44 | .20 | 20 | .63 | not es | tim'td | 25.10 | 11.00 | – |

## IRON ORES—Continued.

### (*b.*) Carbonates of Iron

| Number in report. | Carbonate of iron. | Peroxide of iron. | Per centage of iron. | Alumina. | Carbonate of lime. | Carbonate of magnesia. | Carbonate of manganese. | Phosphoric acid and phosphate of lime. | Potash. | Soda. | Bituminous matter. | Silica, &c. | Water and loss. | Sulphur. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 7 | 65.96 | 7.19 | 36.90 | – | 5.90 | 6.03 | 1.57 | 2.64 | 0.23 | 0.06 | 1.03 | 8.70 | 0.67 | – |
| 14 | 14.26 | 16.77 | 18.55 | 5.83 | 35.15 | 6.54 | .84 | – | .29 | .08 | – | 19.17 | 1.05 | – |
| | | | | | | | | phos. l. | | | | | | |
| 24 | 12.42 | 14.07 | 15.86 | 2.91 | 18.48 | 1.49 | trace. | 29.49 | .57 | .15 | 1.32 | 16.07 | 3.03 | – |
| 37 | 72.86 | 7.42 | 39.42 | 1.97 | 3.17 | 2.80 | 1.18 | .04 | .32 | .10 | – | 9.47 | .52 | .15 |
| 38 | 78.51 | 5.57 | 41.80 | 1.77 | 2.36 | 2.81 | 1.11 | .04 | .17 | .64 | – | 4.87 | 2.15 | – |
| 49 | 62.24 | 2.68 | 31.93 | 5.15 | 2.75 | 3.43 | 1.12 | .54 | .44 | .15 | not est | 18.17 | 3.33 | – |
| 50 | 56.58 | 4.86 | 30.70 | .25 | 2.95 | 2.17 | 1.68 | trace. | .44 | .38 | – | 30.10 | .59 | – |
| 60 | 46.40 | 8.28 | 28.20 | .35 | 32.15 | 3.26 | 1.24 | – | .23 | .17 | – | 2.57 | 5.35 | – |
| 61 | 23.56 | – | 11.35 | .48 | 67.33 | 4.82 | .41 | – | .23 | .10 | – | 1.99 | 1.08 | – |
| 74 | 41.98 | 44.66 | 43.65 | .55 | 4.35 | 1.84 | .86 | – | .27 | .67 | – | 5.15 | – | – |
| 75 | 70.39 | 13.14 | 43.20 | .37 | 4.75 | 4.68 | 1.46 | .18 | .19 | .05 | – | 2.45 | 2.34 | – |
| 97 | 79.72 | 4.52 | 41.26 | .08 | 97 | 3.08 | 1.23 | .34 | .24 | .18 | – | 9.64 | – | – |
| 100 | 60.36 | 2.33 | 30.46 | 2.65 | 3.35 | 3.58 | 1.43 | – | .47 | .05 | – | 24.67 | 1.09 | – |
| 118 | 70.60 | 5.42 | 37.53 | 1.55 | 2.15 | 4.91 | 1.25 | – | .25 | .09 | – | 13.37 | .41 | – |
| 120 | 65.93 | 8.63 | 37.55 | 2.27 | 1.97 | 3.34 | 5.03 | – | .07 | .18 | – | 13.17 | – | – |
| 121 | 42.68 | 17.02 | 32.37 | 2.05 | 1.68 | 1.52 | .71 | – | .27 | .30 | 11.10 | 20.66 | 2.01 | – |
| 122 | 17.42 | 24.80 | 25.68 | 2.79 | 32.85 | 6.36 | 1.81 | .60 | .11 | .17 | – | 10.47 | 2.62 | – |
| 134 | 17.84 | 25.08 | 25.30 | 1.00 | 5.97 | 7.30 | 1.20 | .36 | .20 | .09 | 2.50 | 34.65 | 3.81 | – |
| | | | | | | | | phos. l. | | | | | | |
| 148 | 64.87 | 4.39 | 34.18 | .67 | 3.56 | 4.26 | 1.09 | 2.10 | .23 | .28 | 1.40 | 16.25 | .90 | – |
| 149 | 62.42 | 3.38 | 32.52 | .95 | 3.65 | 7.41 | 2.49 | .10 | .23 | .12 | 2.41 | 15.27 | 1.57 | – |
| 150 | 64.90 | 7.41 | 36.54 | .60 | 3.25 | 6.57 | 1.18 | .35 | .17 | .52 | 7.87 | 7.07 | .11 | – |
| 151 | 74.46 | 1.15 | 36.80 | .70 | 2.45 | 4.70 | 1.03 | .38 | notes ti'ed. | | 7.90 | 5.95 | 1.28 | – |
| 152 | 54.32 | 6.75 | 31.17 | .50 | 3.87 | 2.97 | 2.68 | .53 | .08 | – | 4.40 | 21.95 | 1.91 | – |
| 153 | 62.59 | 14.79 | 40.26 | 1.87 | 2.65 | 4.69 | 1.42 | trace. | .23 | .12 | not est | 8.19 | 3.41 | – |
| a. | 86.10 | .23 | 41.42 | .63 | 5.41 | 1.77 | – | – | – | – | 3.03 | 1.40 | 1.41 | – |
| b. | 85.44 | .23 | 41. | .63 | 5.94 | 3.77 | – | – | – | – | 3.03 | 1.40 | – | – |

Those which contain a notable proportion of bituminous matters are such as have received the name of Black Band Iron Ores, in Scotland, England and Wales.

For the purposes of comparison I have added to the table two analyses of one of the best of the European Black Band Ores, viz:

a. *Called "Mushet's Black Band," from its discoverer; from near Airdrie; analyzed by Dr. Colquohoun.*

b. *Same ore analyzed by Dr. Thompson.*

In different specimens of this variety of ore, as analyzed by Dr. Colquohoun, *bituminous matters* were found in proportions from 1.86 to 17.38 per cent.

| | |
|---|---|
| Alumina, from - - - - - - - | 1. to 5. per cent. |
| Silica, from - - - - - - - | 1.4 to 19.9 per cent. |
| Iron, from - - - - - - - | 25. to 40. per cent. |

Results which agree very well with those above shown in relation to the Kentucky ores.

# II. COALS, &c.

| Number in the report. | Specific gravity. | Per centage of moisture. | Volatile combustible matters. | Carbon in the coke. | Ashes. | Total volatile matters. | Coke. | Per centage of sulphur. | |
|---|---|---|---|---|---|---|---|---|---|
| 3 | 1 219 | 13.20 | 37.40 | 38.10 | 11.30 | 50 60 | 49.40 | not est. | Lignite |
| 6 | 1.321 | not est'md | 38.00 | 53 90 | 8.10 | 38.00 | 62.00 | 0.085 | |
| 8 | 1.291 | 7.20 | 31.40 | 56.90 | 4.50 | 38.60 | 61.40 | .290 | |
| 9 | 1.247 | 4.00 | 34.70 | 60.70 | .60 | 38.70 | 61.30 | .268 | |
| 15 | 1.313 | 5.40 | 35.60 | 55 00 | 4.00 | 41.00 | 59.00 | .710 | |
| 16 | 1.443 | 4.00 | 33.50 | 42.70 | 19.80 | 37.50 | 62.50 | 7 905 | |
| 17 | 1.312 | 5.00 | 40.80 | 49.50 | 4.70 | 45.80 | 54.20 | 2.410 | |
| 18 | 1.307 | 2.80 | 41.10 | 48.90 | 7.20 | 43.90 | 56.10 | 2.160 | |
| 19 | 1.278 | 4.00 | 37.70 | 53.30 | 5.00 | 41.70 | 58.30 | 1.363 | |
| 25 | 1.316 | 2 00 | 35.00 | 55.40 | 7.60 | 37.00 | 63.00 | 1.040 | |
| 43 | 1.287 | 6.00 | 34.20 | 56.20 | 3.60 | 40.20 | 59.80 | 1.694 | |
| 90 | 1.320 | 3.90 | 37.30 | 50.20 | 8 60 | 41.20 | 58.80 | 1.448 | |
| 91 | 1.393 | 5.20 | 30.30 | 55.30 | 9.20 | 35.50 | 64.50 | 0.433 | |
| 101 | 1.288 | 3.40 | 34.90 | 57.90 | 3.80 | 38.30 | 61.70 | .734 | |
| 102 | 1.301 | 5.00 | 35.70 | 51.00 | 8.30 | 40.70 | 59.30 | 1.818 | |
| 123 | 1.213 | 4 20 | 35.80 | 57.80 | 2.20 | 40.00 | 60 00 | .268 | |
| 135 | 1.288 | 7.20 | 34.20 | 56.30 | 2.30 | 41.40 | 58 60 | 1.060 | |
| 136 | 1.272 | 4.40 | 41.10 | 51.10 | 3.40 | 45.50 | 54.50 | 1.560 | |
| 137 | 1.297 | 5.10 | 35.20 | 53.50 | 6.20 | 40.30 | 59.70 | 1.122 | |
| 156 | 1 221 | 3.10 | 45.30 | 48 50 | 3.10 | 48.40 | 51.60 | 1.350 | |
| 157 | 1.260 | 2.80 | 37.60 | 56.10 | 3.50 | 40.40 | 59 60 | .654 | |
| 158 | 1.34- | 8.70 | 24.60 | 59.20 | 7.50 | 33.30 | 66.70 | .550 | |
| 159 | 1.295 | 3.40 | 33.40 | 58.50 | 4.70 | 36 80 | 63 20 | .337 | |
| 160 | 1.211 | 1.10 | 48.90 | 47.00 | 3.00 | 50.00 | 50.00 | .241 | |
| 166 | not ascertained. | | 40.70 | 52.30 | 7.00 | 40.70 | 59.30 | .880 | |
| 169 | 1.291 | 2.00 | 29.70 | 65.30 | 3.00 | 31.70 | 68.30 | .055 | |

## III. IRON FURNACE SLAGS.

| Number in the report | Silica. | Lime. | Magnesia. | Alumina. | Protoxide of iron. | Protoxide of manganese. | Potash. | Soda. | Oxygen in the silica | Oxygen in the bases | Proportion of the O. in the bases, to the O. in the silica. | Furnace. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 40 | 55.00 | 27.10 | 1.95 | 12.30 | 1 57 | 0.27 | 1.73 | 0.08 | 28.55 | 14.95 | 1:1.91 | Pennsylvania. |
| 41 | 60.64 | 14.65 | 2.55 | 13.30 | 4.62 | .88 | 2.55 | .81 | 31.85 | 13.13 | 1:2.42 | Pennsylvania. |
| 47 | 56.90 | 13.20 | 3.46 | 20.50 | 2.43 | .51 | 3.16 | .36 | 29.55 | 16.00 | 1:1.85 | Buena Vista. |
| 52 | 52.20 | 17.25 | 3.25 | 23.30 | .16 | .27 | 2.20 | .91 | 27.10 | 16 00 | 1:1.69 | Bellefonte. |
| 64 | 56 10 | 24.18 | 1.40 | 13.90 | 2.07 | .55 | 2 16 | .39 | 29 13 | 14.95 | 1:1.96 | Buffalo. |
| 65 | 55.90 | 25.42 | 1.30 | 13.40 | 1 01 | .83 | 1.27 | .63 | 29.02 | 14.89 | 1:1.96 | Buffalo. |
| 66 | 57.90 | 17.56 | 2.30 | 13.97 | 6.03 | 1.02 | 1.04 | .18 | 30.06 | 14.86 | 1:2.01 | Buffalo. |
| 78 | 55.54 | 19.92 | 2.69 | 16.54 | 2.10 | .69 | 2.30 | .14 | 28.84 | 15.49 | 1:1 84 | Greenup. |
| 85 | 56.70 | 24 24 | 4.41 | 11.84 | 1.02 | .53 | 1.37 | .13 | 29.44 | 14.63 | 1:2 01 | Raccoon. |
| 86 | 61.80 | 18.34 | 2.40 | 13.00 | 2.97 | .31 | 1.08 | .15 | 32.11 | 13.19 | 1:2.43 | Raccoon. |
| 98 | 50.94 | 23 77 | 3.19 | 15.50 | 2.61 | 1.58 | 2.24 | .77 | 26 45 | 15.80 | 1:1.67 | Amanda. |
| 110 | 56.28 | 19.70 | 6 13 | 13.90 | 1.56 | 1.02 | 1.26 | – | 29 22 | 15.30 | 1:1 91 | N. Hampshire. |
| 111 | 56.34 | 19.58 | 6.59 | 14.30 | 1.36 | .87 | 1.60 | .22 | 29.25 | 15.61 | 1:1.87 | N. Hampshire. |
| 112 | 56.74 | 16.66 | 5.20 | 15.10 | 2.17 | 2.92 | 1.66 | .36 | 29.46 | 15.38 | 1:1.91 | N Hampshire. |

## IV. PIG-IRON.

| Number in the report | Specific gravity. | Iron. | Graphite. | Combined carbon. | Manganese. | Silicon. | Slag. | Aluminium. | Magnesium. | Potassium. | Sodium. | Phosphorus. | Sulphur. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 42 | 6.770 | 92 08 | 3.03 | 0 36 | trace. | 2.91 | 0.16 | 0.07 | 0.24 | 0.12 | – | trace. | trace. |
| 48 | 6.903 | 91.88 | 1 65 | 3.15 | 0.35 | 3.27 | .30 | .07 | trace. | – | – | " | " |
| 53 | 6.915 | 94.54 | 2.25 | 1.08 | .35 | 1.26 | .18 | .08 | .17 | .21 | 0.03 | " | " |
| 67 | 7.066 | 93 12 | 3 10 | .65 | .18 | 1 06 | .14 | .03 | trace. | .15 | – | 0.75 | " |
| 6[illegible] | 7.322 | 94.70 | 2 20 | .75 | trace. | .60 | 26 | .05 | .02 | .14 | – | .48 | " |
| 79 | 6 877 | 91.21 | 3.13 | – | .48 | 3.57 | .22 | .30 | .18 | .05 | – | .67 | 0.05 |
| 87 | 6 898 | 90.18 | 2.80 | 1.00 | .59 | 5.13 | .93 | .08 | .07 | .05 | – | .37 | .01 |
| 88 | 6.798 | 91.85 | 2 40 | .73 | .18 | 3.55 | .51 | .09 | .08 | .06 | – | .34 | .04 |
| 89 | 6.867 | 88 57 | 2.25 | 2.00 | .63 | 6.88 | .47 | .15 | .15 | .03 | – | .44 | trace. |
| 99 | 7.433 | 94.89 | 3.00 | – | trace. | 1.55 | .11 | trace. | .09 | .05 | – | .79 | .20 |
| 113 | 6 841 | 93 12 | 2.83 | – | .34 | 1.21 | .13 | .52 | .06 | .33 | .21 | 1.30 | trace. |
| 114 | 7.241 | 93.19 | 3.13 | – | .20 | 1.28 | .18 | .44 | .06 | .19 | .09 | 1.40 | " |

## V. LIMESTONES.

| Number in report. | Specific gravity. | Carbonate of lime. | Carbonate of magnesia. | Carbonate of iron. | Carbonate of manganese. | Oxide of iron. | Phosphate of lime. | Bituminous matters. | Silica, &c. | Potash. | Soda. | Alumina, &c. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 21 | – | 52.20 | 37.95 | – | – | – | – | – | 6.38 | 0.28 | – | 2.27 |
| 22 | 2.786 | 65.69 | 1.57 | 8.00 | 0.34 | – | – | – | 11.37 | – | – | 13.23 |
| 39 | 2.776 | 95.25 | 2.74 | – | – | – | – | – | .57 | .09 | 0.08 | 1.27 |
| 51 | 2.687 | 97.17 | 1.39 | – | – | – | – | – | .55 | .11 | .09 | 1.17 |
| 62 | 2.669 | 81.55 | 2.44 | – | – | – | – | – | 15.56 | .09 | .02 | .35 |
| 63 | 2.688 | 87.97 | 2.72 | – | – | – | – | – | 7.15 | .20 | .58 | 1.85 |
| 76 | 2.803 | 71.45 | 3.73 | 13.19 | .51 | 1.56 | – | – | 7.33 | .19 | .10 | .47 |
| 77 | 2.977 | 91.50 | 2.53 | – | – | – | – | – | 3.97 | .13 | .10 | 1.15 |
| 84 | 2.687 | 61.95 | 2.35 | – | – | – | – | – | 30.17 | .25 | .24 | 4.95 |
| 108 | – | 53.85 | 22.10 | 7.41 | .86 | 4.41 | – | – | 7.97 | .21 | .19 | .37 |
| 109 | 2.708 | 97.85 | 1.30 | – | – | – | – | – | 1.27 | .15 | .50 | .55 |
| 132 | 2.560 | 39.90 | 20.50 | 11.71 | 1.02 | 2.22 | 5.23 | 6.05 | 12.41 | .17 | .09 | .60 |
| 133 | 2.613 | 40.09 | 22.17 | 7.32 | .28 | 3.53 | 2.24 | 7.25 | 16.60 | .21 | .14 | .17 |
| 154 | 2.520 | 85.00 | 1.15 | – | – | – | .63 | 3.14 | 7.95 | .38 | – | 1.57 |
| 164 | 2.704 | 96.03 | .74 | 1.09 | – | – | 1.19 | – | .66 | – | – | .16 |

REMARKS. No. 21 was sent as a *hydraulic limestone.* It contains much less than the quantity of silica and alumina usually present in good water limes. If it is found by experience to form a good water cement, its *hydraulic* character must be mainly due to the magnesia which it contains in large quantity.

No. 22, which was supposed to be an *iron-ore*, deserves trial as a water lime.

Nos 132, 133, and 14, resemble very much the Black Band iron-ores; but the small proportion of iron which they contain renders them of no value in this relation, especially as they generally contain injurious quantities of phosphate of lime, which will prevent their use as fluxes for the richer ores.

# VI. CLAYS.

| Number in the report. | Silica. | Alumina. | Oxide of iron. | Lime. | Magnesia. | Potash. | Soda. | Water. | Locality. |
|---|---|---|---|---|---|---|---|---|---|
| 4 | 71.94 | 20.70 | trace. | 0.37 | 0.35 | 0.63 | – | 6.20 | Ballard co., Ky. |
| 124 | 65.74 | 26.10 | trace. | .72 | .73 | .56 | 0.14 | 6.01 | Greenup co., Ky. |
| 125 | 51.74 | 33.98 | trace. | .62 | .73 | .88 | .31 | 11.82 | Greenup co., Ky. |
| 167 | 73.00 | 17.60 | 3.00 | .60 | – | .10 | – | 5.70 | Union co., Ky. |
| a | 61.01 | 23.60 | 5.66 | .82 | .51 | .56 | 1.41 | 6.15 | England. |
| b | 63.30 | 23.30 | 1.80 | not estimated. | | | not est. | 10.30 | England. |
| c | 72.96 | 24.78 | – | 1.04 | trace. | alkalies, 1.22 | | – | Germany. |
| d | 71.04 | 22.46 | – | 3.82 | – | alkalies, 2.68 | | – | England. |

REMARKS. For comparison, the composition of four foreign clays is given above.

a. From the white bed, plastic clay formation, used in pottery, near Farnham. Analyzed by Mr. Way.

b. Best Stourbridge fire-clay.

c. Berlin porcelain ware, (burnt?)

d. Superior porcelain clay.

# VII. SOILS.

| Number in report. | Dissolved by water containing carbonic acid from 1000 gr. | Moisture. | Organic matters. | Carbonate of lime. | Carbonate of magnesia. | Carbonate and oxide of manganese. | Phosphoric acid and phosphates. | Potash. | Soda. | Alumina and oxide of iron. | Silica, &c. | Sulphate of lime. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 530 | 1.84 | 3.04 | 0.034 | 0 461 | 0.411 | trace | 0.108 | 0 037 | 3 93 | 92.01 | – |
| 2 | 1 943 | 2.44 | 4.12 | .134 | .260 | .081 | trace. | .159 | .063 | 4 85 | 89.65 | – |
| 19 | 1.884 | 1.86 | 3.46 | .097 | .305 | .025 | trace. | .204 | .074 | 5.01 | 90.59 | – |
| 20 | 3.822 | 2.60 | 5.68 | .223 | .280 | .415 | trace. phos l | .154 | .061 | 5.47 | 87.43 | 0.19 |
| 27 | – | 4 41 | 8.00 | .494 | .429 | – | .26 | .205 | .062 | 4.181 6 170 | 79.91 | – |
| 28 | – | 4 58 | 5 98 | .540 | 527 | .204 | .45 | .139 | .051 | 4.528 7.190 | 80.43 | – |
| 29 | 1 115 | 1 72 | 1 72 | 1.547 | .517 | .036 | trace. | .198 | .052 | 4 47 | 92.25 | – |
| 30 | 1.275 | 3.80 | 2.60 | .393 | .593 | – | trace | .170 | .082 | 9 51 | 87.03 | – |
| 126 | 7.043 | 2 04 | 5.08 | 1 254 | .447 | – | trace. | .085 | .024 | 3.49 | 89.67 | – |
| 127 | – | 1 60 | – | .900 | 4.750 | – | trace. | .070 | .020 | 3 60 | 90 99 | – |
| 128 | 0.270 | 2.30 | 2 00 | 1 150 | .160 | 170 | .19 | .170 | .120 | 6.00 | 90 57 | – |
| 129 | – | 5.00 | 4.80 | 1 250 | .260 | trace. | trace. | .520 | .300 | 8 65 | 84.04 | – |
| 138 | – | 1.88 | 3.88 | 060 | .210 | trace. | trace | .100 | .060 | 6.15 | 89.19 | – |
| 140 | 0.453 | 3.76 | 3.24 | 0.370 | .405 | .400 | race phos l | .108 | .200 | 9.77 | 86.23 | – |
| 141 | 1 390 | 2.30 | 3 50 | .196 | .118 | .119 | .045 | .181 | .171 | 5.16 | 90.06 | – |
| 155 | 7.780 | 2.85 | 5.80 | 1.070 | 540 | .310 | .68 | .190 | 030 | 5 05 | 86.64 | – |
| 161 | 2.946 | 2.80 | 5 10 | 1 940 | .307 | .235 | trace. | .131 | .070 | 6.51 | 87.47 | – |
| 162 | – | 2 00 | 4 10 | 1.420 | .240 | – | trace | .110 | .030 | 4.10 | 88 30 | – |
| 164 | 1.693 | 2.80 | 4.18 | .194 | .475 | .114 | trace. | .178 | .095 | 6.83 | 87.83 | .04 |
| 165 | 1.043 | 1.74 | 3.28 | .034 | .195 | .195 | trace. phos l | .096 | .022 | 3.69 | 92.31 | – |
| 168 | 1.042 | 2.18 | 2.90 | .094 | .350 | .054 | .22 | .150 | .043 | 5.129 | 90.99 | – |

# SUPPLEMENT TO FAYETTE COUNTY, KENTUCKY.

## MINERAL WATERS.

In the summer, 1852, Mr. John S. Wilson, boring for water in the cellar of his store, on Cheapside, Lexington, (opposite the court-house,) obtained a pretty strong saline *chalybeate water*—a kind of mineral water which is somewhat rare in our blue limestone (lower silurian,) formation.

This water first appeared forty feet below the level of the street, after boring through twenty-six and a half feet of solid limestone containing hard masses of pyrites.

The water effervesces slightly; has a marked saline and chalybeate taste, and speedily deposits a red ochreous sediment when allowed to stand exposed to the atmosphere. It has been much employed, since its discovery, as a remedial agent. Its strength is found to vary at different times—being often greater just before a rain. It appears to have become slightly weaker, but has not materially altered since it was first obtained.

An average proportion of its saline contents was obtained by slowly evaporating, in a beaker glass, on the water bath, two hundred and forty ounces Troy, supplied to the glass as the water evaporated during the course of nine months.

The proportion of *free carbonic acid*, as ascertained by a separate process, in which it was precipitated by ammoniated chloride of barium, is as follows:

| Free carbonic acid, | in 20 lbs Troy, | in 1 lb Troy. |
|---|---|---|
| | 39.0428 grains, | 1.9521 |
| | 82.6000 cubic inches, | 4.1300 |

Composition of saline contents—

| | In 20 lbs Troy. | In 1 lb Troy. | |
|---|---|---|---|
| Carbonate of iron, | 6.3003 | 0.3150 | In the insoluble portion, on evaporation. |
| Carbonate of lime, | 36.5871 | 1.8293 | |
| Carbonate of magnesia, | 2.5610 | .1280 | |
| Sulphate of lime, | 4.9109 | .2455 | |
| Silica, | 1.3748 | .0687 | |

| | | |
|---|---|---|
| Chloride of sodium, - - - | 133.2590 | 6.6620 |
| Chloride of potassium, - - - | 5.6604 | .2880 |
| Chloride of calcium, - - - | 83.7314 | 4.1865 |
| Chloride of magnesium, - - | 44.1349 | 2.2067 |
| Sulphate of magnesia, - - - | 4.2359 | .2117 |
| Bromide of magnesium, - - | 1.9801 | .0990 |
| Silica, - - - - - - | 2.3200 | .1160 |
| | 327.0558 | 16.3525 |

The mineral waters usually found in this formation contain sulphuretted hydrogen, with chloride of sodium, &c., &c., as exemplified in the composition of the celebrated Blue Lick water.

The waters of almost every deep bored well in this neighborhood exhibit more or less evidences of the presence of the saline and gaseous ingredients which characterize the Blue Lick water; some in so small amount as to have a mere trace of sulphuretted hydrogen, others so strongly as to entitle them to be classed as mineral waters. In some the common salt predominates, and sulphuretted hydrogen is almost entirely absent; all bearing evidence to the sub-marine origin of our limestone strata. The full examination of the various mineral waters of this and the other formations must be reserved for future investigations.

# APPENDIX TO THE CHEMICAL REPORT OF THE GEOLOGICAL SURVEY.

Most of the time allotted to this part of the survey having been devoted to the laboratory work, less in space is given to theoretical views and general applications than perhaps would have been satisfactory to some of the readers of the report. The writer was, however, impressed with the importance of the fact that the careful ascertainment of truth should be the basis of all reasoning, and that, especially in the study of natural objects and processes, nothing can supercede, in the commencement, the patient labor of observation and experiment; that, moreover, when the composition of our Kentucky ores, soils, and minerals in general is once accurately established, their applications to our wants and uses would be obvious to all well informed persons. He has therefore consumed the time mainly in the analyses, and made up his report principally of their results.

It would have been easy to have filled many pages of the report with *general considerations, applications,* or *theoretical views* in regard to the soils and minerals of our State, in relation to the cultivation of the soil, the manufacture of iron, or to other manufactures in which they are employed; to have made the report an elementary work on agriculture and the mechanical arts; but there are many good works, easily accessible to persons interested in these pursuits, in which these matters are fully developed; and the writer has thought it to be his first duty, at this stage of the business, to endeavor to make out the composition of as many of the soils and minerals of Kentucky as would be possible in the time which he had at his disposal, leaving for the future the general considerations and applications which might naturally present themselves.

The study of the *science* of agriculture is becoming more and more important as the good lands of our country become gradually deteriorated by a thriftless husbandry, or as the poorer lands are brought into cultivation. Whilst the country is new, and the soil so rich that successive cropping for a number of years causes no very sensible diminu-

tion of its products, it cannot be expected that the farmer will care much or know much of those essential elements, resident in the soil, without which no plant can grow or mature its seed; but the time will inevitably come when this subject will be forced upon the attention of the agriculturist and the political economist, and the study of the *science* of the cultivation of the soil will become a first necessity.

It is the part of a wise and provident man, or nation, to look at and provide for future contingencies, and it is not too soon now to begin the work of the ascertainment and diffusion of this kind of knowledge. Already some of our richest soil, in the blue-grass region, shows, by chemical analysis, evident signs of partial loss of the indispensable ingredients of its fertility; as may be seen by comparing the analysis of No. 27 with that of No. 28; the one virgin blue limestone soil from Fayette county, Kentucky; the other, soil from the same tract, taken from a spot in close proximity, which has been for many years in cultivation, (see also page 100 of Dr. Owen's general report;) and there can be no doubt that similar comparative examinations, of the uncultivated and long cultivated soils from other districts, would show precisely analagous results.

The idea that the soil is inexhaustible—a bank on which we may draw forever without precaution—is held at present by very few, theoretically, although *practically* the great majority of our farmers seem to entertain it, and act upon it without scruple. The positive facts, which have been ascertained by chemical analysis, in relation to the elements of plants and of organic beings generally, are gradually becoming known to the masses, and by the improvement of the common education of the people, we may hope that this knowledge, so important to agriculture and the arts in general, will be more widely diffused.

It is demonstrated, by general experience in the laboratory, that no vegetable, the most minute, can grow, no microscopic vegetable cell, in short, can be formed without the assistance of certain mineral substances, always to be found in fertile soils; and that whilst the greatest proportion of the weight of vegetable and other organic bodies, composed of carbon, hydrogen, nitrogen and oxygen, may be derived from the gases of the atmosphere and from water, the *fixed materials*, always found in their ashes, drawn from the soil by the living plant, are equally essential to vegetable growth. In the absence of these, whatever may be the abundance of the atmospheric elements,

vegetable developement would be impossible; even the absence of one or more of them would prove an insuperable obstacle to growth.

As the atmospheric elements are everywhere abundant, these *fixed elements*, existing in the soil and in the surface water, are more especially worthy of the attention of agriculturists in all parts of the world. It was the removal of these, or of some of them, by successive exhausting crops of tobacco, corn, &c., which caused the reduction of much of the soil of Virginia from a state of high fertility to one of almost hopeless sterility; as, on another continent, the constant exportation of grain has rendered worthless countries which formerly were the granaries of Europe; a spendthrift system which, if long continued, will, in the course of time, bring even the rich prairies of the West to the condition of sun-burnt deserts.

In order justly to appreciate the value of the mineral ingredients of vegetables, the reader, having acquired some knowledge of elementary chemistry, may consult some of the recent valuable publications on the chemistry of agriculture; none, perhaps, would be more satisfactory than the "*Lectures on the Applications of Chemistry and Geology to Agriculture.* By Jas. F. Johnston;" re-published in this country by Wiley and Putnam; and there are other good works on these subjects, of more recent publication, easily accessible.

The examination, by chemical analysis, of the ashes of plants in which these mineral ingredients are always found in their natural proportions, enables us to appreciate fully their value in the economy of organic nature. In no plant or part of vegetable tissue are they absent. Usually all present in every plant, they vary in their relative proportions in different vegetables, and even in different parts of the same vegetable—some plants requiring for their healthy growth more potash, some more soda, lime, oxide of iron, silica, or phosphates than others. A soil which contains them all in sufficient abundance is a fertile soil; and one from which they are entirely absent is hopelessly sterile until they are supplied.

These important elements of vegetable nourishment are potash, soda, lime, magnesia, oxide of iron, oxide of manganese, phosphorus or phosphoric acid, sulphur or sulphuric acid, chlorine, silica, and a few others found in minuter proportion. These exist in various states of combination in the fertile soil, and in relatively small proportion, except the silica, in particular, which forms the greatest weight of all

soils, but in the insoluble state of sand, in various degrees of fineness. They are all dissolved, in notable quantity, by the water which falls from the atmosphere, principally by the aid of the carbonic acid which it always contains, and partly by the organic acids resulting from the decomposition of animal and vegetable substances in the soil. The operation employed in the analyses of the soils, given in the present report, by digesting them in water containing carbonic acid, always showed the solution of a considerable quantity of these nutritious mineral ingredients, and exemplified the mode in which these substances, generally little soluble in pure water, are naturally dissolved and made available for vegetable nourishment.

To give an idea of the quantity of these substances removed from the land in the usual course of cropping, the following table is appended. It has been collated from the second volume of *Dr. Emmons' Agriculture of New York*, prepared and published at the expense of that State, as a part of the great work, "on the *Natural History of New York.*"

| Inorganic matter removed from the soil in the following vegetable products. | Potash. | Soda. | Lime. | Carbonate of lime. | Magnesia. | Phosphate of lime and magnesia. | Phosphate of potash and soda. | Sulphuric acid. | Chlorine. | Chloride of sodium. | Silica. | Total. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | lb | lb | lb | lb | lb | lb | lb | lb | lb | lb | lb | lb |
| One ton of potatoes, (tubers,) | 8.40 | 3.00 | 1.00 | – | 1.61 | 3.57 | – | 1.70 | 0.21 | – | 0.51 | 20.00 |
| One ton of parsnips, (roots,) | 32.59 | 12.04 | – | 0.83 | .60 | 33.56 | not | giv- | en. | – | 11.90 | 91.52 |
| One ton of timothy hay, | 18.46 | .61 | – | .12 | .30 | 10.15 | – | 2.48 | – | – | 26.40 | 60.01 |
| One ton of clover hay, | 32.15 | 18.40 | – | 38.39 | 4.87 | 25.54 | – | .62 | 2.29 | 1.49 | 1.05 | 123.30 |
| One ton of oat straw, | 98.16 | 5.92 | – | 11.87 | .73 | 14.55 | – | 9.41 | .95 | – | 21.91 | 163.49 |
| One ton of wheat straw, | 8.06 | 2.35 | – | 1.17 | .28 | 9.19 | – | 2.47 | .26 | – | 84.84 | 108.62 |
| Fifty bushels of oats, | 16.07 | 4.89 | – | .06 | .07 | 25.00 | 8.75 | 1.81 | .02 | – | 28.15 | 84.82 |
| Twenty bushels of rye, | 2.19 | 1.07 | .03 | – | .05 | 5.82 | .73 | .57 | – | .09 | .42 | 10.97 |
| An acre of summer wheat (the grain,) | 3.84 | .87 | – | .005 | | 12.53 | 5.07 | .14 | – | – | .69 | 23.145 |
| An acre (white flint) indian corn, 14,700 plants, (the grain,) | 14.95 | 14.12 | .10 | – | 1.51 | 22.19 | – | 2.74 | .31 | – | 5.94 | 61.85 |
| An acre (white flint) indian corn, 14,700 plants, (the cob,) | 12.31 | 2.03 | .10 | – | .31 | 8.23 | – | .12 | .04 | – | 4.68 | 27.83 |

Collated from the 2d volume of Dr. Emmon's Agriculture of New York.

## TECHNICAL TERMS.

Complaints are sometimes made, by practical farmers, that the reports of agricultural chemists, and works on agricultural chemistry are too technical for their comprehensions. The use of technical or scientific terms is deprecated, even by some well educated persons, as tending to darken the subject. A little reflection, however, will enable them to see that they are just as indispensable as the different names used to designate different persons, and that instead of obscuring they render the language lucid and definite; and for this purpose, as well as to designate substances and properties which are not usually mentioned in *common parlance*, they are necessarily employed. In the present age of scientific advancement and application it should be part of every system of common education to give a knowledge of the general principles and ordinary terms of modern science, and especially those of natural science; and when our educational systems are better adapted to the progress of science and improvement, these terms will be no more difficult to the educated man than the names in the Heathen Mythology are to the classical scholar.

In the present report it is believed that no terms are used which are not defined in Webster's folio or octavo dictionary.

## RE-EXAMINATION OF THE SOILS FOR PHOSPHORIC ACID.

The correct estimation of minute quantities of phosphoric acid in complex mixtures, especially when, as in soils, it is associated with lime, magnesia, oxide of iron, and alumina, is a matter of considerable difficulty. The various processes which have been hitherto proposed are generally either inaccurate or exceedingly tedious; hence perhaps

the reason why, in soil analyses, the phosphates are not as frequently estimated as their very great importance to agriculture renders desirable.

Having procured some molybdate of ammonia, and repeated the process of Sonnenschein for the estimation of phosphoric acid by means of this re-agent, the writer was convinced that this is at once the easiest, most generally applicable, and most reliable, with certain precautions, of all the methods for the estimation of this acid. He has, therefore, while this report was going through the press, submitted all the soils described in it to a new examination by this process. The results are as follows:

*Per centage of Phosphoric Acid in the soils described in the preceding pages, each dried as there stated.*

| | | PER CENT. |
|---|---|---|
| No. 1. | Soil from southern part of Ballard county. Phosphoric acid, | 0.116 |
| No. 2. | Soil from north-west part of Ballard county. Phosphoric acid, | .155 |
| No. 10. | Soil from southern part of Butler county. Phosphoric acid, | .076 |
| No. 20. | Soil from southern part of Christian county. Phosphoric acid, | .129 |
| No. 27. | Soil from Fayette county. Virgin soil. Phosphoric acid, | .466 |
| No. 28. | Soil from Fayette county. Soil of old field. Phosphoric acid, | .379 |
| No. 29. | Soil from Hickman, Fulton county, (bluff.) Phosphoric acid | .102 |
| No. 30. | Soil from Hickman, Fulton county, (under the gravel bed.) Phosphoric acid, | .157 |
| No. 126. | Soil from Henderson county. Phosphoric acid, | .129 |
| No. 128. | Soil from Hickman county, white soil. Phosphoric acid, | .129 |
| No. 138. | Soil from Hopkins county, soil and sub-soil. Phosphoric acid | .089 |
| No. 140. | Soil from Livingston county. Phosphoric acid, | .064 |
| No. 141. | Soil from southern part of Logan county. Phosphoric acid, | .076 |
| No. 155. | Soil from northern part of Muhlenburg county. Phosphoric acid, | .090 |
| No. 161. | Soil from northern part of Simpson county. Phosphoric acid, | .129 |
| No. 162. | Soil from Todd county, red clay sub-soil. Phosphoric acid, | .062 |
| No. 163. | Soil from Todd county, soil and sub-soil. Phosphoric acid, | .156 |
| No. 165. | Soil from Trigg county, barren oak land. Phosphoric acid, | .063 |
| No. 168. | Soil from western part of Warren county. Phosphoric acid, | .076 |

The soils which have been analyzed since the preparation of the body of this report have all been submitted to this same process for the estimation of their phosphoric acid.

ROB. PETER.