# GEOLOGICAL SURVEY OF KENTUCKY.

N. S. SHALER, Director.

## CHEMICAL REPORT

OF THE

# SOILS, COALS, ORES,

## IRON FURNACE PRODUCTS, CLAYS, MARLS, MINERAL WATERS, ROCKS, ETC.,

## OF KENTUCKY.

BY ROBERT PETER, M. D., Etc., Etc.,

CHEMIST TO THE SURVEY.

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# INTRODUCTORY LETTER.

CHEMICAL LABORATORY,
KENTUCKY GEOLOGICAL SURVEY,
LEXINGTON, KY., April, 1878.

Professor N. S. SHALER, *Director Kentucky Geological Survey:*

DEAR SIR: I have the honor to make herewith a report of the results of the chemical work performed for the Kentucky Geological Survey from February of last year up to the present time.

Very respectfully,
ROBERT PETER.

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# CHEMICAL REPORT OF THE SOILS, COALS, ORES, PIG IRONS, CLAYS, MARLS, MINERAL WATERS, ROCKS, &c., OF KENTUCKY.

Of the chemical analyses herewith reported, more than one hundred and thirty in number, seventy-four are of soils, subsoils, and under-clays; of which three, reported in the Appendix, are from Texas. These latter were examined for the purpose of comparison with our Kentucky soils.

The limits of variation, in the proportions of the essential ingredients of the seventy-one Kentucky soils, are shown in the following table, viz:

| | Per ct. | Number. | County. | Per cent. | Number. | County. |
|---|---|---|---|---|---|---|
| Organic and volatile matters vary from . . . | 9.185 | in 2,037 | in Hardin | to 2.045 | in 1,986 | in Allen |
| Alumina and iron and manganese oxides vary from . . . . . . . . . . . . . . . . | 24.465 | in 2,015 | in Grant | to 3.096 | in 2,029 | in Grayson |
| Lime carbonate varies from . . . . . . . . . | 9.425 | in 2,015 | in Grant | to .030 | in 1,968 | in Allen |
| Magnesia varies from. . . . . . . . . . . . | .824 | in 2,022 | in Grant | to .025 | in 2,042 | in Hardin |
| Phosphoric acid varies from. . . . . . . . . | .823 | in 2,014 | in Grant | to .013 | in 1,968 | in Allen |
| Potash extracted by acids varies from . . . . | 1.778 | in 2,022 | in Grant | to .035 | in 2,041 | in Hardin |
| Soda extracted by acids varies from . . . . . | .617 | in 2,009 | in Grant | to traces | in several | |
| Sand and insoluble silicates vary from . . . . | 59.940 | in 2,015 | in Grant | to 92.980 | in 1,967 | in Allen |
| Water, expelled at 380° F., varies from . . . | 2.715 | in 2,037 | in Hardin | to .483 | in 2,030 | in Grayson |
| Water, expelled at 212° F., varies from . . . | 6.575 | in 2,013 | in Grant | to .950 | in 1,967 | in Allen |
| Potash, in the insoluble silicates, varies from . | 2.910 | in 2,037 | in Hardin | to .722 | in 1,979 | in Barren |
| Soda, in the insoluble silicates, varies from . . | 1.214 | in 2,009 | in Grant | to .022 | in 2,080 | in Oldham |

In the sample of cretaceous soil from Collins county, Texas, called "black waxy" soil, there were 17.085 per cent. of lime carbonate, 0.497 of potash extracted by acids, while the 61.840 per cent. of sand and insoluble silicates contained only 0.443 per cent. of potash in the insoluble silicates.

The specimens from Grant county, which appear to such advantage in this comparative table, are of heavy, tough under-clays, excavated from some of the cuts on the Cincinnati Southern Railroad, some of which were called by the doubtful name of "hard pan" by the contractors. From the too large proportion of clay which they contain, as well as their resulting physical constitution, they would by no means prove as productive, under culture, as might be inferred from their chemical composition alone. The fact that favorable physical conditions are as necessary to the fertility of the soil as the chemical conditions, has long been known; but both the chemical and physical are equally indispensable.

These heavy under-clays, which are so rich in some of the mineral elements of plant nourishment, might doubtless be used with advantage, in the manner of marl, as a top-dressing on light or sandy, poor or exhausted soils. They would also answer for common pottery or bricks.

The five samples of *coals* examined, from Butler, Greenup, and Madison counties, presented the usual characteristics of our good Kentucky coals, some of them being better than the average, because of their small proportions of ash and sulphur, especially the sample from Big Hill, in Madison county.

The *limonite iron ores*, from Lyon and Trigg counties, proved to be rich, containing from 46.320 to 50.195 per cent. of iron; they are also remarkably free from sulphur, and contain less than the average of phosphorus, which latter ingredient was found in them only in the proportions of from 0.079 to 0.220 per cent. of the ore. The pig irons smelted from these ores were found also to be generally of very good quality.

Amongst the *clays* which were analyzed, that from Bald Knob Church, Ohio county—No. 2076—was found to be quite refractory, and it may very probably be made available for fire-clay if in sufficient abundance.

Seventeen different samples of *limestone* were examined, many of which were from the phosphatic layers in the blue limestone of Fayette county, mentioned in the preceding Report. In fourteen samples, mostly from the same quarry, and all from the same neighborhood, the proportions of phosphoric acid were found to vary from 1.462 per cent. in No. 2002 up to 21.940 per cent. in sample four of No. 2004. (See Fayette county.)

While these interesting phosphatic layers, in the Lower Silurian limestone of this county, have not as yet been found regular and continuous enough, perhaps, to justify working for the manufacture of superphosphate, they are yet quite interesting, as throwing much light on the superior fertility of our Lower Silurian, or so-called "Blue-grass soil." As will be seen, the analyses of some of the most abundant of the fossils of this limestone did not develop in these any unusual proportion of phosphoric acid.

One of the limestones analyzed—No. 2073—a ferruginous limestone from Rough creek, Ohio county, was found, when calcined, to possess the properties of hydraulic cement.

The lead ore found in our limestone, usually associated with zinc sulphide in veins of baryta sulphate, examined for silver, was found to give the usual negative result. Indeed, general experience, hitherto, seems to show that very little silver is associated with the galena found in undisturbed limestone layers; that ore being most generally argentiferous which is in veins in the rocks which have been much disturbed by volcanic action.

The re-examination of the *mineral waters* of the Olympian Springs, in Bath county, and of the Lower Blue Lick Springs, in Nicholas county, has developed several interesting facts. Not only is it shown that the general composition of these celebrated waters has not been altered, or the waters weakened sensibly, during the considerable period intervening between the analyses, but also several new ingredients, in small quantities, have been discovered in them. Not the least interesting of these are boracic acid and lithium compounds. Compounds of barium and strotium found in these, also in minute proportions, are believed to be, like the above substances, more generally prevalent than was formerly supposed.

Several other mineral waters, deserving of a more complete examination, were qualitatively examined. Kentucky is quite rich in these waters, and a more systematic study of them than has, as yet, been possible, is desirable.

The chemical analyses of the *ashes* of the *Hungarian grass, German millet*, &c., together with the microscopic photographs of parts of their silicious skeletons by Mr. Alex. T. Parker and Mr. J. Mullen, and the experiments to discover the nature of the peculiar "root action" of these plants in their decomposition of the silicates of the soil, as well as to determine the nature of the special acid solvents exuded from the plants for this purpose, detailed in the Appendix, throw some light on the mysterious selective power of vegetables, by which materials, very different in kind and quantity, are appropriated by different plants from a soil common to all. Some, because probably of superior decomposing power which they exert over the silicates of the soil, being able to extract essential mineral ingredients and thrive, where others die of inanition, for want of the proper solvent or digestive agent.

To produce the silicious cell-casts and skeleton of the Hungarian grass and German millet, the silicious material must have been dissolved in water, in unusually large proportion, in the vicinity of the roots of these plants. Unless in solution, it could not penetrate the cell walls.

It is well known to chemists that when silicates are decomposed, by acids or other agents, in the presence of water, that the silicic acid thus produced is soluble to a large amount in that fluid; but that it may again be easily brought to an insoluble condition, as it exists in flint or sand, by the subsequent separation of the water; and this fact, with the demonstration of the exudation from the rootlets of these plants of an acid fluid containing oxalic, phosphoric, and other acids, probably in greater quantity than is produced by many other vegetables, enables us to guess how these may decompose more of the silicates of the soil than other plants and absorb more dissolved silicic acid.

Plants, like animals, vary greatly in their natural power of appropriating essential elements of food. Some live and thrive on food of most difficult digestion; others, like the young of most animals, require nourishment in the most soluble and available condition. Some, like the Hungarian grass and other plants which grow on sterile soils, can extract their essential mineral food from the hardest stony particles; others, like our ordinary grain-producing plants, depend more on the natural soil solution, which brings their food to their roots already in a condition to be most readily absorbed. Peculiar root action on the soil is no doubt common, in a greater or less degree, to all plants; yet, that the common soil solution, produced by the solvent action of the atmospheric waters upon the soil ingredients, is also a common source of plant food, is equally demonstrable.

ALLEN COUNTY.

No. 1967—SOIL, *labeled "Virgin soil, from the surface of the tract of land of about fifty square miles in extent, in the eastern part of Allen county, called the 'Buncombe tract.' A very poor district. Forest growth: scrub oak, black oak, poplar, chestnut, hickory, &c. Produces about three to five barrels of corn to the acre (equal to fifteen to twenty-five bushels). Sub-stratum arenaceous, clayey, and calcareo-silicious rocks; decayed to the depth of fifteen feet." Collected by Rev. Herman Hertzer.*

The dried soil is of a light dirty-buff color. The coarse sieve removed from it only a few small ferruginous concretions. The silicious residue, after digestion in acids, all passed through fine bolting-cloth, except a small proportion of small rounded grains of quartz and undecomposed silicates, and a few very small silicified entrochi.

No. 1968—"SUBSOIL *of the next preceding soil," &c., &c. Collected by Rev. Herman Hertzer.*

Of a lighter and more yellowish buff color than the preceding; containing fewer small ferruginous concretions. The fine bolting-cloth separated from the silicious residue only a few small rounded grains of quartz and of undecomposed silicates of various tints.

No. 1969—"SURFACE SOIL, *one year in cultivation. Upland. Land of William H. H. Mitchell, one mile west of Scottsville, Allen county. Forest growth: a maple grove. Product: fifty to sixty bushels of corn to the acre." Collected by Rev. Herman Hertzer.*

The dried soil is of a light greyish-umber color. The coarse sieve removed from it a few angular fragments of ferrugihous quartzose rock. The fine bolting-cloth separated from silicious residue a small quantity of fine rounded particles of quartz and undecomposed silicates of a reddish-grey color.

No. 1970—"SUBSOIL *of the next preceding,*" *&c., &c. Collected by Rev. Herman Hertzer.*

The dried subsoil is very much in color like the surface soil, being only slightly lighter. The coarse sieve and bolting-cloth removed similar fragments and particles from the soil and the silicious residue. The rounded particles of undecomposed silicates and quartz amounted to about four and a half per cent. of the subsoil.

No. 1971—"SURFACE SOIL. *Upland, from the farm of Wm. H. H. Mitchell (same locality as the preceding), which has been in cultivation for sixty years. Yields twenty-five bushels of corn per acre; eight to ten bushels of wheat; or fifteen to twenty of oats. Original forest growth: chestnut, maple, oaks, poplar, &c. Geological formation: the Keokuk Group—calcareo-silicious and argillaceous rocks and shales; decayed to the depth of twenty feet below the soil.*" *Collected by Rev. Herman Hertzer.*

The dried soil is of a buff color. The coarse sieve separated from it some small quartzose concretions, silicified entrochi, and iron gravel. The silicious residue, from the digestion in acid, all passed the fine bolting-cloth except a few rounded grains of milky quartz and of dark-colored undecomposed silicates, with some minute silicified entrochi.

No. 1972—"SUBSOIL *of the next preceding.*" *&c. Collected by Rev. Herman Hertzer.*

The subsoil is lighter and brighter colored than the surface soil. The coarse sieve removed from it fewer quartzose and ferruginous concretions than from that, and the bolting-cloth separated fewer silicious particles.

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

| | No. 1967. | No. 1968. | No. 1969. | No. 1970. | No. 1971. | No. 1972. |
|---|---|---|---|---|---|---|
| Organic and volatile matters | 2.215 | 2.045 | 5.475 | 4.000 | 2.745 | 2.450 |
| Alumina and iron and manganese oxides | 3.616 | 5.872 | 5.609 | 7.394 | 5.452 | 8.090 |
| Lime carbonate | .110 | .030 | .520 | .470 | .070 | .080 |
| Magnesia | .106 | .097 | .124 | .097 | .079 | .140 |
| Phosphoric acid | .019 | .013 | .156 | .141 | .083 | .045 |
| Sulphuric acid | Not esti | mated. | | | | |
| Potash | .144 | 160 | .148 | .380 | .221 | .219 |
| Soda | .489 | .312 | .210 | .175 | .143 | .115 |
| Sand and insoluble silicates | 92.980 | 90.840 | 85.740 | 85.090 | 90.440 | 88.040 |
| Water, expelled at 380° F. | .650 | .615 | 2.200 | 1.625 | .865 | .890 |
| Total | 100.329 | 99 984 | 100.202 | 99.372 | 100.098 | 100.029 |
| Hygroscopic moisture | 0.950 | 1.250 | 2.425 | 2.215 | 1.175 | 1.550 |
| Potash in the insoluble silicates | .992 | .958 | .958 | .853 | 1.081 | 1.188 |
| Soda in the insoluble silicates | .253 | .209 | .314 | .242 | .354 | .258 |
| Character of the soil | Virgin soil | Subsoil. | New soil | Subsoil. | Old field. | Subsoil. |

The unproductiveness of the soils Nos. 1967 and 1968, from the so-called Buncombe tract, finds an explanation in their chemical composition as detailed above. Both surface soil and subsoil show a very marked deficiency of phosphoric acid, the proportions of which, 0.019 and 0.013 per cent. only, are smaller than have been found in any other Kentucky soils. This deficiency alone would cause sterility; but it fortunately can be remedied quite easily by means of top dressings of fertilizers containing phosphates, such as commercial superphosphate of lime, bone-dust, or good guano. These soils are also somewhat deficient in organic matters (humus), lime, &c., and may no doubt be greatly improved by the cultivation of clover, with top dressings of plaster of Paris or slaked lime, and the plowing under of the green crop after one year's grazing with hogs or cattle. The relative small proportion of alumina, &c., to the sand and silicates, which makes them what are called a "hungry soil," may be measurably remedied by the judicious use of such clay marls as may be accessible. The alkalies, potash, and soda are not greatly deficient in these soils, yet the use of wood ashes, or some other alkaline fertilizer, would doubtless increase their fertility.

The soils Nos. 1969–1970 and 1971–1972, differing so greatly in productiveness—soil 1969 producing fifty to sixty bushels of corn to the acre, and the others only twenty-five bushels—also exhibit very significant differences in their chemical composition. Taking the surface soils for comparison, we find the more productive soil, No. 1969, contains nearly twice as much organic matters and phosphoric acid as the less fertile one, No. 1971, and that this latter essential ingredient, phosphoric acid, is notably deficient in the less productive soils. Another marked difference is found in the relative proportions of lime and magnesia, the great deficiency of which in the old field soils seems to indicate that their present inferiority is probably as much owing to an original difference of composition as to the deteriorating influence of the sixty years of cultivation. This supposition is strengthened by the relatively higher proportion of potash in the old field soil.

The remarks on the improvement of the soil of the Buncombe tract apply also to this old field soil.

### BARREN COUNTY.

#### SOILS AND SUBSOILS, &C.

No. 1973—"VIRGIN SOIL, *from the farm of Major J. S. Barlow, in the 'Barrens,' four miles east of Cave City, Barren county.*" *Collected by Rev. Herman Hertzer.*

"Geological formation: St. Louis limestone, the partly decomposed rock six feet beneath the surface. Very rich soil generally in the 'Barrens.' The 'Barrens,' so-called because of the absence of forest growth in early times, extend from Hardin county through Barren, Warren, and Simpson counties. Formerly 'prairie' land, now overgrown with a young forest of black oak, scrub oak, walnut, beech, and hickory."

The dried soil is of a light umber color. Clods friable. The coarse sieve removed from it only a small quantity of small fragments of decomposing chert and iron gravel. The silicious residue, after digestion in acids, all passed through fine bolting-cloth, except a small quantity of particles of partly decomposed silicates, and some few clear quartz grains.

No. 1974—"SOIL, *sixty years in cultivation, from the same locality as the last. Average crops: of tobacco, one thousand* *two hundred pounds; wheat, fifteen bushels; corn, forty to fifty bushels." Collected by Rev. Herman Hertzer.*

The dried soil is of an umber color, slightly darker than that of the preceding soil. The clods are friable. The coarse sieve separated from it about forty per cent. in weight of angular fragments of decomposing chert. The silicious residue all passed through the fine bolting-cloth, with the exception of some small angular particles of partly decomposed silicates.

[From the comparative color and chemical composition of these two soils, it is probable that their labels were accidentally interchanged.]

No. 1975—"SUBSOIL *of the two preceding soils," &c., &c.*

The dried subsoil is of a light grey-brown color; is somewhat cloddy, the clods being firm. The coarse sieve removed from it only a few small fragments of decomposing chert. The silicious residue, after digestion in acids, all passed through fine bolting-cloth, except some small particles of partly decomposed silicates, and a few small rounded quartz grains.

No. 1976—"VIRGIN SOIL, *from the farm of Daniel Davasher, southern part of Barren county. Geological formation: silicious grit, decomposed fifteen feet deep. Forest growth: beech, hickory, oaks, poplar, and chestnut." Collected by Rev. Herman Hertzer.*

The dried soil is of a light brownish-grey color. The coarse sieve removed from it about twenty-two per cent. of coarse angular fragments of ferruginous sandstone and silicious concretions. The bolting-cloth separated from the silicious residue some silicious particles, grey, white, and flesh-colored, with a few of partly decomposed silicates.

No. 1977—"SURFACE SOIL; *in cultivation for thirty years; from the same farm as the next preceding. Yield: of corn, forty bushels; of wheat, ten to fifteen bushels; of tobacco, eight hundred pounds." Collected by Rev. Herman Hertzer.*

The dried soil is of a light dirty-buff color. The coarse sieve removed from it about seven per cent. of coarse silicious fragments, and the silicious residue left on the fine bolting-cloth a few particles similar in character to those of the virgin soil.

No. 1978—"SUBSOIL *of the next preceding,*" *&c., &c. Collected by Rev. Herman Hertzer.*

The dried subsoil is of a grey-buff color. It contains about eleven per cent. of coarse angular silicious fragments and concretions, and its silicious residue gave fewer silicious particles by the fine bolting-cloth than the preceding.

No. 1979—"VIRGIN SOIL, *from the farm of Mrs. M. E. Davis, eight miles south of Glasgow, Barren county. Geological formation: silicious or Kekokuk Group. Forest growth: black walnut, beech, sugar-tree, &c., &c.*" *Collected by Rev. Herman Hertzer.*

The dried soil is of a light grey-umber color. The coarse sieve removed from it less than five per cent. of coarse angular silicious fragments and concretions. The silicious residue, from digestion in acids, all passed through the fine bolting-cloth, except small greyish, reddish, and white particles of quartz and partly decomposed silicates.

No. 1980—"SURFACE SOIL, *sixty years in cultivation; from the same farm as the preceding. Geological formation: silicious or Keokuk Group, rocks decayed to depth of twelve to fifteen feet. Average crops: of tobacco, one thousand to eleven hundred pounds; of corn, twenty-five to forty bushels.*" *Collected by Rev. Herman Hertzer.*

The dried soil is a little lighter colored and more yellowish than the preceding. The coarse sieve removed from it but a very small proportion of small angular silicious and ferruginous fragments, and the silicious residue contained fewer small silicious grains than the preceding.

No. 1981—"SUBSOIL *of the next preceding,*" *&c., &c. Collected by Rev. Herman Hertzer.*

The dried subsoil is of a brownish-buff color. The coarse sieve separated from it only a very small proportion of small silicious and ferruginous gravel. The fine bolting-cloth removed from the silicious residue a considerable proportion of soft, partly decomposed silicate grains, and but few hard silicious particles.

No. 1982—"SURFACE SOIL, *sixty years in cultivation; from the same farm as the preceding. Bottom land. Inexhaustible because of annual inundation. Average crop: fifty bushels of corn." Collected by Rev. Herman Hertzer.*

The dried soil is of a light brownish-umber color. The coarse sieve separated only a very small proportion of small silicio-ferruginous fragments, and the silicious residue, from digestion in acids, all passed through the fine bolting-cloth.

No. 1983—"SUBSOIL *of the next preceding." &c., &c. Collected by Rev. Herman Hertzer.*

The dried subsoil is slightly more brownish in tint than the preceding. The coarse sieve removed from it but a very small proportion of silicio-ferruginous gravel. Like that of the preceding, the silicious residue all passed through the fine bolting-cloth, leaving upon it no small silicious particles.

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

| | No. 1973 | No. 1974 | No. 1975 | No. 1976 | No. 1977 | No. 1978 | No. 1979 | No. 1980 | No. 1981 | No. 1982 | No. 1983 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Organic and volatile matters. | 4.175 | 5.475 | 2.615 | 5.465 | 3.065 | 2.300 | 4.700 | 3.450 | 2.415 | 4.150 | 3.725 |
| Alumina and iron and manganese oxides, | 7.365 | 7.740 | 8.323 | 4.310 | 4.942 | 6.142 | 4.632 | 4.622 | 6.186 | 5.967 | 6.034 |
| Lime carbonate | .215 | .465 | .090 | .340 | .225 | .125 | .425 | .190 | .190 | .475 | .475 |
| Magnesia | .197 | .250 | .197 | .047 | .065 | .080 | .061 | .061 | .065 | .017 | .115 |
| Phosphoric acid | .125 | .275 | .092 | .125 | .093 | .093 | .108 | .198 | .124 | .093 | .131 |
| Sulphuric acid | Not esti | mated. | | | | | | | | | |
| Potash | .209 | .126 | .308 | .184 | .158 | .092 | .069 | .126 | .225 | .105 | .161 |
| Soda | . . . . | .004 | . . . . | .029 | .053 | .055 | .060 | .024 | .086 | . . . . | . . . . |
| Sand and insoluble silicates | 86.065 | 82.990 | 86.665 | 87.470 | 90.185 | 89.985 | 87.985 | 89.685 | 89.650 | 87.710 | 87.835 |
| Water, expelled at 380° F. | 1.575 | 2.275 | .935 | 1.800 | 1.015 | .800 | 1.650 | 1.300 | 1.000 | 1.325 | 1.375 |
| Total | 99.926 | 99.600 | 99.225 | 99.770 | 99.801 | 99.672 | 99.690 | 99.656 | 99.941 | 99.842 | 99.851 |
| Hygroscopic moisture. | 1.865 | 2.500 | 1.775 | 2.150 | 1.500 | 1.700 | 2.100 | 1.650 | 1.735 | 1.800 | 1.900 |
| Potash in the insoluble silicates | 1.227 | 1.074 | 1.253 | .934 | 1.102 | 1.179 | .722 | 1.223 | 1.151 | 1.156 | 1.127 |
| Soda in the insoluble silicates | .394 | .334 | .373 | .300 | .318 | .256 | .234 | .381 | .318 | .372 | .446 |
| Character of the soil | Virgin. | Old field | Subsoil. | Virgin. | Old field | Subsoil. | Virgin. | Old field | Subsoil. | Old field | Subsoil. |

The reasons for believing that the labels of soils Nos. 1973 and 1974 have been accidentally interchanged, is the greater proportions of organic matters, lime, magnesia, and phosphoric acid, and the smaller quantity of sand and insoluble silicates in 1974 than in 1973. The greater proportion of potash in the latter is also corroborative of this supposition because the subsoil is richer in this alkali than the surface soils.

These Barren county soils are above the average in native fertility, and would require only skillful management, with a judicious rotation of crops and the occasional use of special fertilizers, as may be indicated, to keep them up to a high degree of productiveness.

## BATH COUNTY.

### Mineral Waters, &c., of the Olympian Springs.

The principal waters of these celebrated springs were qualitatively examined by the writer about the year 1848–'9, and the results were published in volume III of the first series of Reports of the Geological Survey of Kentucky, pages 208–210. About ten years thereafter (in 1858–'9) more extended quantitative analyses were made by him of samples of these waters, sent to his laboratory in bottles by Mr. H. Gill, the proprietor. As such analyses of the waters forwarded in bottles could not include the gases, and, moreover, were liable to accidental errors, the writer visited these springs in August last (1877), accompanied by his son, Alfred M. Peter, in order to quantitatively estimate the gases in the recent waters; to evaporate a sufficient quantity on the spot to enable him to estimate their minuter saline ingredients, and to collect with care, in very clean glass-stoppered bottles, enough of the waters of the several springs for complete quantitative analyses in his laboratory in Lexington.

The hydrogen sulphide was estimated in the recent waters at the springs, by the volumetric process, with the use of a deci-normal iodine solution, &c., and the carbonic acid, thrown down in a measured quantity of the waters, by an ammoniacal solution of barium chloride, was separated and weighed at the laboratory.

THE SULPHUR WATERS OF THE OLYMPIAN SPRINGS.

No. 1984—"SALT SULPHUR WATER." *Well at the saloon, near the main house or hotel. The water is raised by a pump in the well, which is eight to ten feet deep. The spring is said to yield about two hundred and seventy gallons per hour. The temperature of the water was found to be 56° F., when that of the atmosphere was 75° F. The water forms a slight yellowish or ochreous incrustation on the glass tumblers used at the well. It exhibits a slightly alkaline reaction.*

No. 1985—"BLACK SULPHUR WATER." *From an open well, about a quarter of a mile nearly south of the main house, in the bottom ground just at the foot of the hill. The water is confined in a barrel without heads, sunk into the ground. The temperature of the water in the barrel was 57° F. Its sediment is nearly black, and it exhibits a slightly alkaline reaction.*

No. 1986—"WHITE SULPHUR WATER." *From a rather feeble spring about three miles from the Olympian Springs.*

This spring was not visited by the writer, but a demijohn of the water was sent to the "Springs" by John D. Young, Esq. The hydrogen sulphide, therefore, was not estimated.

## COMPOSITION OF THESE BATH COUNTY SULPHUR WATERS.

In 1000 parts of the water.

| | No. 1984. | No. 1985. | No. 1986. | |
|---|---|---|---|---|
| Hydrogen sulphide gas | 0.0011 | 0.0012 | not est. | |
| Carbonic acid gas ($CO_2$) | 0.2400 | .2781 | not est. | |
| Lime carbonate | 0.1975 | 0.0158 | 0.0744 | |
| Magnesia carbonate | .0506 | .0046 | .0316 | |
| Baryta carbonate | .0128 | . . . . . | . . . . . | |
| Strontia carbonate | .0045 | . . . . . | . . . . . | Held in solution by the carbonic acid. |
| Iron carbonate | .0025 | .0024 | | |
| Alumina | .0006 | . . . . . | .0021 | |
| Manganese carbonate and phosphoric acid | traces. | traces. | | |
| Lime sulphate | .0083 | .0061 | .0039 | |
| Potash sulphate | . . . . . | .0031 | .0133 | |
| Soda sulphate | . . . . . | .0025 | .0408 | |
| Soda carbonate. . . . . . traces | not est. | .3247 | .3113 | |
| Calcium chloride | .0213 | . . . . . | . . . . | |
| Magnesium chloride | .1089 | . . . . . | .0071 | |
| Sodium chloride | 4.8997 | .1208 | .1326 | |
| Potassium chloride | .0355 | . . . . . | . . . . . | |
| Lithium chloride | .0008 | trace. | trace. | |
| Sodium bromide | .0166 | . . . . . | . . . . . | |
| Sodium iodide and sulphide | trace. | trace. | trace. | |
| Boracic acid | trace. | trace. | trace. | |
| Silica | .0232 | .0124 | .0115 | |
| Traces of organic matter and loss, | .0340 | .0164 | . . . . . | |
| Total saline matters in 1000 parts | 5.4168 | 0.5088 | 0.6286 | |
| Specific gravity of the water | 1.004 | not est. | not est. | |

These interesting sulphur waters present considerable differences in their chemical composition. The salt sulphur of the saloon contains greatly more chlorides than the others, and especially much more sodium chloride (common salt) than they, while the black and white sulphurs are much more alkaline from the presence of a considerable quantity of carbonate of soda. They also contain more alkaline sulphates. All of them have a notable quantity of iron carbonate, of which chalybeate ingredient the salt sulphur and the black sulphur contain the largest proportions. The quantity in the white sulphur was not separately determined, but is doubtless quite minute.

These waters, and particularly those of the salt sulphur well, are applicable to the treatment of a great variety of chronic diseases, under judicious medical advice, combining, as they do, saline, alkaline, and chalybeate properties, with those of the hydrogen sulphide, and the bromides and iodides. They are found to be diuretic, diaphoretic, tonic, and alterative, when used internally, not usually exerting much aperient action; and when employed in the bath, for which purpose the salt sulphur is used exclusively, they are valuable in the treatment of cutaneous affections, &c.

The very small proportions of barium, strontium, aluminum, and lithium compounds, together with those of boracic and phosphoric acids, which were detected in this recent re-examination of these waters, interesting as their discovery may be to the philosopher, cannot be supposed to exert much influence in their medicinal action, yet, doubtless, they are not without effect.

Since the detection of barium and strontium compounds in these waters containing sulphates, the attention of the writer was drawn to a recent communication of M. Dieulafait to the Academy of Science of Paris, as to the very general presence of strontium carbonate or sulphate in the sea waters, as well as in limestone, gypsum, and the fossil remains of the mollusca, and saline mineral waters generally. According to his statement, only forty-four out of eight hundred of such waters, &c., failed to show distinct evidence of the presence of strontium.

On examining Liebig's analysis of the celebrated *Keiserquelle* (Emperor well), at Aix-la-Chapelle, in Rhenish Prussia, one of the most noted waters of Europe, and an early resort of the Romans, a remarkable resemblance in general composition may be seen between this and the salt sulphur water of the Olympian Springs, as the following comparative table shows:

| | Salt sulphur water of Olympian Springs. | Water of Emperor Well, Aix-la-Chapelle. |
|---|---|---|
| Lime carbonate | 0.1975 | 0.1580 |
| Magnesia carbonate | .0506 | .0510 |
| Baryta carbonate | .0128 | . . . . . . . . . |
| Strontia carbonate | .0045 | .0002 |
| Iron carbonate | .0025 | .0096 |
| Alumina | .0006 } | traces. |
| Manganese, phosphoric acid | traces. } | |
| Lime sulphate | .0083 | traces. |
| Potash sulphate | . . . . . . . . . | .1540 |
| Soda sulphate | . . . . . . . . . | .2830 |
| Soda carbonate | traces. | .6500 |
| Lithia carbonate | . . . . . . . . . | .0003 |
| Lithium chloride | .0008 | . . . . . . . . . |
| Calcium chloride | .0213 | . . . . . . . . . |
| Magnesium chloride | .1089 | . . . . . . . . . |
| Sodium chloride | 4.8997 | 2.6390 |
| Potassium chloride | .0355 | . . . . . . . . . |
| Sodium bromide | .0166 | .0036 |
| Magnesium bromide | . . . . . . . . . | .0006 |
| Sodium sulphide | traces. | .0195 |
| Sodium iodide | traces. | traces. |
| Boracic acid | traces. | . . . . . . . . . |
| Silica | .0232 | .0661 |
| Organic matters, &c. | .0340 | .0752 |
| Total saline matters in 1000 parts | 5.4168 | 4.1020 |
| Temperature | 56° F. | 131° F. |

The Aix-la-Chapelle are hot springs, and the water contains more alkaline sulphates and carbonates, with less of chlorides and bromides, than our salt sulphur water; but the general resemblance of their chemical composition is close, especially as they contain nearly the same gaseous ingredients.

One object in view in the re-examination of the Olympian Spring waters was to ascertain whether their proportion of saline matters had been diminished in the lapse of nearly twenty years since the first analyses were made by the writer. It is interesting to see that no notable change in this respect has occurred. (*See vol. 4, p. 69, Reports Geological Survey of Kentucky, first series*). The slight apparent difference being probably due to less perfect drying of the total saline matters in the former analyses.

CHALYBEATE MINERAL WATERS OF THE OLYMPIAN SPRINGS

No. 1987—"MAIN CHALYBEATE SPRING; *in a valley, about half a mile north of the main building, Olympian Springs.*"

The water runs, over a wooden gutter, out of the ferruginous magnesian limestone, which lies under the Devonian shale, at the base of the hill, about four feet above the bed of the so-called "Chalybeate Branch," which runs into Mud Lick. The spring yields about three litres of water per minute (*i. e.*, somewhat more than three quarts). The temperature of the water is 54° Fahrenheit. It deposits a sediment in its channel of outflow, which is of a ferruginous-brown color. The water, as it flows out of its source, is remarkably clear, but exposure to the air, by the removal of carbonic acid and the substitution of oxygen, converts the dissolved iron carbonate into the hydrated peroxide, which is insoluble in water.

The dried *ferruginous sediment*, on analysis, was found to contain about 65 per cent. of *iron peroxide*, about 20 per cent. of *soluble silica*, with notable proportions of *lime* and *magnesia carbonates*, and traces of *manganese*, *phosphoric* and *apocrenic acids*. Hydrosulphuric acid did not detect the presence of arsenic or any metal of that group.

No. 1988—"CHALYBEATE SPRING, *flowing out of a crevice in the ferruginous magnesian limestone in the bed of the Chalybeate Branch, about sixty yards above the main chalybeate spring above described.*"

It deposits a ferruginous sediment in the bed of the branch of a light brownish-orange color.

COMPOSITION OF THESE OLYMPIAN SPRING CHALYBEATE WATERS.

In the 1000 parts

| | No. 1987 | No. 1988. | |
|---|---|---|---|
| Free carbonic acid gas | 0.1214 | 0.1269 | |
| Iron carbonate | 0.0242 | 0.0100 | Held in solution by the free carbonic acid. |
| Lime carbonate | .0998 | .0890 | |
| Magnesia carbonate | .0143 | .0103 | |
| Manganese carbonate | trace | trace. | |
| Phosphoric acid | trace. | trace. | |
| Lime sulphate | .0554 | .0366 | |
| Magnesia sulphate | .1170 | .0693 | |
| Potash sulphate | .0125 | 0117 | |
| Soda sulphate | . . . . | .0238 | |
| Sodium chloride | .0308 | .0060 | |
| Magnesium chloride | .0031 | . . . | |
| Lithium chloride | trace. | trace. | |
| Apocrenic acid | trace. | trace. | |
| Silica | .0332 | .0198 | |
| Loss | .0194 | .0168 | |
| Total saline matters in 1000 parts of the waters | 0.4097 | 0.2935 | |

The main chalybeate spring water is in every respect very good of its kind, and may be used in all cases in which chalybeate remedies are indicated. The principal difference in composition between the two springs is, that the main spring is more than twice as strong in iron carbonate, making it a better chalybeate remedy than the other. It also contains more sulphate of magnesia, but less sulphate of soda. They form a valuable addition to the Olympian Springs.

As the chalybeate and other saline ingredients of these waters seem evidently to have been derived mainly from the ferruginous magnesian limestone out of which they flow, and which the waters have worn and perforated in a remarkable manner, the writer collected some of the limestone and submitted it to analysis, with the following result:

No. 1989—FERRUGINOUS MAGNESIAN LIMESTONE, *out of which flow the chalybeate springs above described, as well as many others in this region, and which forms the bed of the Chalybeate Branch, at and near those chalybeate springs. It lies immediately under Black Devonian Shale. Collected by Robert Peter.*

A crystalline granular limestone; grey, of various tints, in the interior—generally light grey; light ferruginous or brownish-ochreous on the exterior. Adheres slightly to the tongue, and is more or less porous. The water has worn it irregularly, and in some places perforated it by enlarging the small crevices or cavities in it.

COMPOSITION, DRIED AT 212° F.

| | |
|---|---|
| Lime carbonate | 54.000 |
| Magnesia carbonate | 34.027 |
| Iron carbonate | 11.532 |
| Phosphoric acid | .006 |
| Potash | .143 |
| Soda | .040 |
| Silica | .280 |
| Total | 100.028 |

The main agent in the solution of this ferruginous limestone is, undoubtedly, the carbonic acid dissolved in the water which flows over or percolates it. The greater part of this carbonic acid is no doubt derived from the gradual decomposition of the vegetable matters on the surface of the hill at the base of which the springs and this rock are located. At present this and the neighboring hills are covered with the primeval pine forest, which keeps the surface continually covered with its vegetable *débris*, which, by slow decomposition and oxidation, yields an abundance of carbonic acid to the atmospheric water which falls upon it, thus making it, what the pure water itself is not, a good solvent of the iron and other carbonates of the ferruginous magnesian limestone beneath. It appears, therefore, that the character or strength of these springs is greatly dependent on the forest growth on the surface of the hill or hills above them; and that if these woods on the hills above should be at any time cleared off, and the surface of the land deprived of its present carpet of decaying vegetable matters, the springs would measurably lose their strength and value. Another deplorable result from clearing off these woods and bringing the soil into arable culture would be, that more of the atmospheric water would run off from the surface of the hills, and less of it would sink into the depth of the soil and subsoil to feed springs; so that, if the springs were not entirely dried up, except in a rainy season, their outflow would be greatly diminished. Moreover, the beauty, salubrity, and attractiveness of this favorite sylvan watering-place depend greatly on the native pine forest which clothes the neighboring hills.

In addition to the sulphur, salt sulphur, and chalybeate waters of this locality, there are others, saline and alkaline, of various qualities, deriving their dissolved ingredients, some from the salts of the primeval ocean under which the rocks were deposited, some from the action of the atmospheric waters and gases on the Devonian and other strata. One of the oldest known, which formerly was called a salt lick, to which the wild denizens of the forests resorted, and around which the buffaloes made their wallows, may be described as follows:

No. 1990—"SALT WATER *from the old well at the original Salt Lick, near the remains of the old barracks of the volunteers of* 1812, *about one hundred to one hundred and fifty yards south from the main house.*"

The water flows out in a small stream, running into Mud Lick creek. The ground about is covered with an efflorescence of salt. The water tastes like that of the salt sulphur well, but it has only a slight odor of hydrogen sulphide.

COMPOSITION OF THIS SALT WATER.

*Carbonic acid gas, not estimated; hydrogen sulphide, a trace.* In 1000 parts of the water.

| | | |
|---|---|---|
| Lime carbonate | 0.1844 | Held in solution by the carbonic acid. |
| Magnesia carbonate | .0458 | |
| Baryta carbonate | .0099 | |
| Strontia carbonate | .0045 | |
| Iron and manganese carbonate, and phosphate | .0019 | |
| Lime sulphate | .0036 | |
| Soda carbonate | .2241 | |
| Calcium chloride | .0152 | |
| Magnesium chloride | .1188 | |
| Sodium chloride | 4.7121 | |
| Potassium chloride | .0375 | |
| Lithium chloride | trace. | |
| Bromine, boracic acid | trace. | |
| Silica | .0232 | |
| Loss | .0130 | |
| Total saline contents in 1000 parts of the water | 5.3940 | |

This water resembles that of the salt sulphur well in the relative proportions of its common salt and other chlorides; but it is more decidedly alkaline, because of its larger proportion of carbonate of soda, and contains less of bromine and lithium compounds. Moreover, it is almost destitute of hydrogen and sodium sulphides, which give a distinctive character to the salt sulphur water. On examining volume IV of the Reports of the Geological Survey of Kentucky, first series, for the former analysis of this water, the writer finds that a transposition of the labels on the bottles in which the waters were sent to the laboratory by Mr. Gill must have occurred (see pages 71, 72), so that the label "salt water," &c., &c., was placed on the bottle which contained the so-called "cooking water," and *vice versa*. The analysis No. 803, page 72, agrees pretty well with the present in the principal ingredients and the total saline contents. This now published is of course more complete and accurate.

### THE ALKALINE SALINE WATERS OF THE OLYMPIAN SPRINGS.

No. 1991—WATER *from the well at the kitchen door of the main house; about eight feet deep; yields about one hundred and thirty-five gallons per minute. The water is raised with a wooden pump.*

It is slightly alkaline in reaction, and deposits a slight ochreous sediment in the bottle. Tastes somewhat chalybeate, and smells and tastes faintly sulphurous. This water is used for all ordinary purposes of the kitchen and household, as well as for drinking.

No. 1992—WATER, *called "Tea Water," from a spring or open shallow well, on the border of Mud Lick creek, about half a mile south of the main house, and above it on the stream.*

The spring is inclosed in two no-headed barrels, placed the one on top of the other, and is about four feet deep. The water was not overflowing. Temperature of the water, 62°. Reaction slightly alkaline. As there had been rain shortly before the sample of the water was obtained for analysis, it may possibly be weaker than usual.

COMPOSITION OF THESE WATERS.

In 1000 parts of the water.

| | No. 1991. | No. 1992. | |
|---|---|---|---|
| Carbonic acid gas | not est. | not est. | |
| Hydrogen sulphide gas | a trace. | none. | |
| Lime carbonate | 0.0556 | 0.0241 | Held in solution by carbonic acid. |
| Magnesia carbonate | .0277 | .0059 | |
| Strontia carbonate or sulphate | trace. | trace. | |
| Iron and manganese carbonates and phosphates | .0054 | .0022 | |
| Lime sulphate | .0065 | . . . . . | |
| Soda sulphate | .0208 | . . . . . | |
| Potash sulphate | .0285 | . . . . . | |
| Sodium chloride | .1483 | .0377 | |
| Potassium chloride | . . . . . | .0039 | |
| Magnesium chloride | .0047 | . . . . . | |
| Soda carbonate | .5431 | .4479 | |
| Sodium sulphide | trace. | . . . . . | |
| Lithia, boracic acid | trace. | trace. | |
| Silica and loss | .0280 | .0315 | |
| Total saline contents in 1000 parts | 0.8686 | 0.5532 | |

Although these waters do not contain a very large proportion of saline matters, yet their alkaline and slightly chalybeate properties may make them available as diuretic, depurative, tonic, and alterative remedial agents. Many celebrated alkaline waters are not stronger in saline and gaseous contents than these. These examinations and analyses were made in August, 1877; on reexamining the water from the well at the kitchen door, No. 1991, in February, 1878, after rather a wet season, the water was found to be at least one third weaker in saline contents.

No. 1993—"WATER, *from an 'Epsom Well,' about three quarters of a mile northeast of Olympian Springs, on the farm of Mr. Robinson.*"

The well is about twenty feet deep, walled up with stone. The water is used by the family for drinking and all domestic purposes, and they have become accustomed to it, so that it produces no sensible effect upon them. Mr. Robinson had turned the rain water from the roofs of his houses into the well, so that the water obtained for examination had been much weakened by the result of a recent rain; hence a quantitative analysis was not made of it. It tasted strongly of Epsom salt, and gave decided evidence, by the usual tests, of the presence in it of much *magnesia* and *sulphuric acid*, considerable *lime* and *chlorine*, and traces of *iron*, &c., &c.

The old "Epsom Well," the water of which had been analyzed and reported by the writer in volume IV, page 70, of Reports of the Geological Survey of Kentucky, first series, had been filled up; but Mr. Robinson will probably reopen it. This aperient water would be a valuable addition to the considerable variety of the mineral waters of the Olympian Springs, especially as the other waters do not generally exert a laxative action.

### BRECKINRIDGE COUNTY.

No. 1994—"MARLY SHALE, *from Tar Creek Hill; Bowling Green road, near Cloverport, Breckinridge county.*" *Collected by P. N. Moore.*

A friable shale; of a yellowish olive-grey color; containing many minute specks of mica. Before the blow-pipe it fuses into a dark colored slag. Burns of a handsome bright brick color.

COMPOSITION, DRIED AT 212° F.

| | |
|---|---|
| Silica | 66.960 |
| Alumina | 15.626 |
| Iron oxide | 8.380 |
| Lime | .493 |
| Magnesia | .677 |
| Phosphoric acid | .154 |
| Potash | 3.295 |
| Soda | .628 |
| Water, carbonic acid, and loss | 3.787 |
| Total | 100.000 |

This marly shale would no doubt be useful as a fertilizer on old exhausted soils of a light and sandy nature. Exposed to the frosts on the surface of the ground, it would very probably undergo complete disintegration. Its considerable proportion of potash would gradually become available for vegetable nourishment under the influence of the atmospheric agencies, but might perhaps be brought more quickly into use by the simultaneous application of slacked lime on a clover crop. It might be used for *terra cotta*.

BUTLER COUNTY.

No. 1995.—"COAL *from 'Mining City Coal Bank,' recently opened; owned by the Green and Barren River Navigation Company. Mouth of Mud Creek. Bed thirty-six to thirty-nine inches thick. Average sample." Sent from Frankfort by John R. Procter.*

A pure-looking coal, breaking into thin laminæ, with fibrous coal and very little fine-granular pyrites between. Specific gravity not determined.

COMPOSITION, AIR-DRIED.

| | |
|---|---|
| Hygroscopic moisture | 3.28 |
| Volatile combustible matters | 44.20 |
| Spongy coke | 52.52 |
| Total | 100.00 |
| Total volatile matters | 47.48 |
| Fixed carbon in the coke | 48.56 |
| Dark lilac-grey ash | 3.96 |
| Total | 100.00 |
| Percentage of sulphur | 3.060 |

A very good splint coal, resembling the "block coal" of Indiana, yielding quite a small proportion of ash, and containing no inordinate quantity of sulphur.

No. 1996.—"MARLY CLAY SHALE OR INDURATED CLAY. (*Fire-clay?*) *Below the coal at the Mud Creek Mines. Collected by John R. Procter.*"

Of a dark-grey or lead color, imperfectly and irregularly laminated. Contains many minute specks of mica, and some imperfect impressions, apparently of marine shells. It is quite plastic when powdered. Burns of a light yellowish-grey color, nearly white, hence might be made available in *terra cotta*. Fuses before the blow-pipe.

COMPOSITION, DRIED AT 212° F.

| | |
|---|---|
| Silica | 51.660 |
| Alumina | 15.560 |
| Iron oxide | 7.680 |
| Lime | 7.269 |
| Magnesia | .817 |
| Phosphoric acid | not est. |
| Potash | 3.276 |
| Soda | .293 |
| Water, carbonic acid, organic matters, and loss | 13.445 |
| Total | 100.00 |

Its large proportions of iron oxide, lime, and alkalies render it easily fusible at a high temperature.

FAYETTE COUNTY.

No. 1997.—"WATER *from a bored well about* 80 *to* 90 *feet deep, on the site of the Lexington Depot of the Cincinnati Southern Railroad, about three quarters of a mile from the Court-house.*" *Collected by Mr. C. J. Norwood and Mr. ——— Totten, Civil Engineer.*

The water is perfectly limpid and colorless, has a slight petroleum-like odor, but contains no hydrogen sulphide.

No. 1998.—"WATER *from the same well after it had been deepened to one hundred and fifty-three feet and a half. Sent by Chas. A. Tasker, Resident Engineer on the C. S. R. R., at Lexington.*"

The water is yet clear, inodorous, and tasteless; like the former sample, it gave a slightly alkaline reaction.

The object of the analyses was to ascertain the availability of this water for use in boilers of the locomotives of the railroad.

COMPOSITION IN 1000 PARTS OF THE WATER.

| | No. 1997. | No. 1998. | |
|---|---|---|---|
| Lime carbonate | 0.0404 | 0.0358 | Held in solution in the water by carbonic acid, the proportion of which was not estimated. |
| Magnesia carbonate | .0066 | .0189 | |
| Silica | .0138 | .0058 | |
| Iron oxide, phosphoric acid, strontia carbonate | trace. | ..... | |
| Lime sulphate | .0126 | .0240 | |
| Potash sulphate | .0118 | .0205 | |
| Soda sulphate | .0385 | .0058 | |
| Magnesium chloride | .0097 | .0501 | |
| Sodium chloride | .0514 | .0612 | |
| Soda carbonate | .1252 | .1530 | |
| Silica | .0218 | .0036 | |
| Lithia / Organic matters | trace. | ..... | |
| Total saline matters in 1000 parts | 0.3318 | 0.3787 | |

The water became very slightly stronger in saline matters by deepening the well, but its character was not materially altered. From its alkaline nature, owing to the presence in it of a certain proportion of carbonate of soda, the writer predicted that it would prove eminently fit for use in the steam-boiler, and that any sediment which might be deposited would not be likely to form a hard incrustation. Subsequent practical experience has verified this prediction. The material in the supply water which causes the hardest and worst crust in the steam-boiler is the lime sulphate or gypsum; as this is only slightly soluble in water, and is much less soluble in the very hot water of the high-pressure boiler than it is in cold water, its presence in the feed-water is greatly feared by the locomotive engineer. This injurious substance dissolves in about five hundred parts of cold water; but when subjected to the heat corresponding with four atmospheres of pressure in the steam-boiler, or one hundred and twenty pounds to the square inch, it deposits a crust, although contained in 1000 parts of water.

In the stronger of these waters the sulphate of lime is only in the proportion of about one part to forty thousand of the water; and, consequently, it would not probably form any crust until the water was evaporated to one fortieth its original volume, even if unaccompanied by any decomposing agent. But in this water, as soon as the free carbonic acid is separated by the heat, the excess of carbonate of soda present decomposes the sulphate of lime, producing a powdery precipitate of carbonate of lime, and an equivalent amount of sulphate of soda, which remains dissolved in the water. Perfect immunity from boiler-crust may generally be secured by blowing off the residual water of the boiler at proper intervals, varying in length according to the character of the water used.

In this connection, it may be of interest to give the elevation of this well above sea level, as communicated by Geo. B. Nicholson and Chas. A. Tasker, civil engineers on the Cincinnati Southern Railroad, as follows:

Elevation of the top of this well above sea level, 964 feet.

Elevation of the bottom of the bore which furnished the water for the first analysis, 876 feet.

Elevation of the bottom of the bore which furnished that for the second analysis, 802 feet.

Elevation of the top of the well at the Lexington fair grounds above sea level, 974 feet 3 inches.

### SOILS OF FAYETTE COUNTY.

No. 1999—"SURFACE SOIL, *from the lawn at Ashland, near Lexington, homestead of the late Henry Clay, near Lexington, Kentucky.*" *Collected by John H. Talbutt.*

The dried soil is of a dark brownish-umber-grey color. It all passed through the coarse sieve except numerous rootlets and some small, friable, shot iron ore. It appears to contain no sand. The silicious residue from two grammes, left after digestion in acids, all passed through fine bolting-cloth except a single small grain of clear quartz, and some small, soft, rounded particles of partly decomposed silicates.

No. 2000—"SUBSOIL *of the next preceding,*" *&c., &c.*

The air-dried subsoil is a little lighter colored and more brownish than the surface soil. The clods are somewhat more adhesive. It contains a considerable proportion of friable shot iron ore. The silicious residue gave a single minute grain of transparent quartz only, when passed through the fine bolting-cloth.

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

| | No. 1999. | No. 2000. |
|---|---|---|
| Organic and volatile matters | 4.325 | 3.535 |
| Alumina and iron and manganese oxides | 12.168 | 15.666 |
| Lime carbonate | .295 | .345 |
| Magnesia | .214 | .331 |
| Phosphoric acid | .492 | .604 |
| Sulphuric acid | not est. | not est. |
| Potash | .268 | .372 |
| Soda | .038 | ..... |
| Sand and insoluble silicates | 80.090 | 77.715 |
| Water, expelled at 380° F. | 1.800 | 1.300 |
| Total | 99.690 | 99.868 |
| Hygroscopic moisture | 2.850 | 3.375 |
| Potash in the insoluble silicates | 1.343 | 1.273 |
| Soda in the insoluble silicates | .359 | .332 |
| Character of the soil | Surface soil. | Subsoil. |

These present all the characteristics of our rich "blue-grass" or blue limestone soils. In the first place, they contain no gravel, pebbles, coarse sand, or even what might generally pass for fine sand, the whole being in such a state of fine division that, when the soft clods are disintegrated, by the action of water or otherwise, it will pass through fine bolting-cloth; yet, because of the presence of more than three fourths of its weight of exceedingly fine silicious material, water does not lodge on it, but readily passes through it, so that it is easily drained; and, because of the clefts and crevices in the limestone sub-stratum, it is usually naturally drained through the numerous subterraneous caverns and channels of the rock on which it rests.

These soils, moreover, present more than the usual proportion of phosphoric acid, and large proportions of the alkalies, potash, and soda, which aid in giving to them a very durable fertility. The proportions of alumina and iron oxide, of humus, &c., are such as characterize our richest soils.

PHOSPHATIC LAYERS IN THE LOWER SILURIAN LIMESTONE OF FAYETTE COUNTY.

In volume IV, new series, of Reports of the Geological Survey of Kentucky, on pages 65 and 66, mention is made and the analysis given, of a specimen of phosphatic limestone extraordinarily rich in phosphoric acid. As the quarry from which it came was not then in use, and the face of it had been covered by fallen earth, the correctness of the statement of the quarryman, to the effect that a layer of similar material was sometimes as much as a foot in thickness in this quarry, could not at that time be easily tested.

Other specimens of rock of similar external qualities, from the neighborhood of this quarry, were examined; and when the quarry was again opened and worked for turnpike material, in the autumn of 1877, a more complete examination was made by the writer, the results of which are given below.

No. 2001—"PHOSPHATIC LIMESTONE, *a layer in the Lower Silurian 'Blue Limestone' formation; taken from a shallow well at the Wine House at Winton, farm of Robert Peter, about six and a half miles north from Lexington, on the Newtown Turnpike. Collected by R. Peter.*"

In thin fissile layers, of a dark olive-slate color, between the harder, greyish-blue, more crystalline limestone layers. It contains many minute fossils, especially spiral shells.

No. 2002—"PHOSPHATIC LIMESTONE, *from a quarry on the farm of John Keiser, on the north side of the Newtown Turnpike, about six miles from Lexington. Collected by R. Peter.*"

Sample taken from the roadside, where it had been placed for turnpike purposes. It is of a dull, bluish-slate color, and is quite fissile. It does not contain so many small fossils as the next preceding.

COMPOSITION OF THESE PHOSPHATIC LIMESTONES, DRIED AT 212° F.

| | No. 2001. | No. 2002. |
|---|---|---|
| Lime carbonate | 78.040 | 57.440 |
| Magnesia carbonate | 2.332 | 7.327 |
| Alumina and iron and manganese oxides | 4.017 | 8.716 |
| Phosphoric acid | 2.623 | 1.462 |
| Silicious residue | 9.891 | 21.784 |
| Alkalies, sulphuric acid, water, &c., &c. | 3.097 | 3.271 |
| Total | 100.000 | 100.000 |

No. 2003—"PHOSPHATIC LIMESTONE, *from the same quarry, on the northwest side of the Newtown Turnpike, about three miles north of Lexington, from which the very rich specimen was taken described on pages* 65 *and* 66 *of the* 4*th volume, new series, of Kentucky Geological Reports. Collected by Robert Peter.*"

Taken from irregular layers, about one foot in thickness, near the base of the quarry, say from four to six feet below the surface of the rock, which is covered with about four feet of earth, on the ridge or hill in which the quarry is located. These layers are of a dark-grey color, of various thickness, mixed more or less with lighter-grey crystalline layers. The dark-grey portion adheres strongly to the tongue, absorbs water freely; it is quite tough in the mass, but somewhat friable in the small fragments, and contains small organic remains, principally fragments of brachiopod shells, some small gasteropods, and occasionally fragments of trilobite crusts.

COMPOSITION, DRIED AT 212° F.

| | | |
|---|---|---|
| Lime carbonate | 49.160 | |
| Magnesia carbonate | .090 | |
| Phosphates, with alumina, iron oxide, &c. | 46.540 | Containing 21.018 phosphoric acid. |
| Silicious residue | 2.820 | |
| Organic matters and loss | 1.390 | |
| Total | 100.000 | |

As it was evident, from the analyses already made, that the phosphoric acid was quite irregularly diffused throughout these irregular layers, eleven several samples were selected from portions of this phosphatic layer which had been quarried and hauled out to be broken up for the turnpike, described as follows, viz:

No. 2004—SPECIMEN 1*a*.—A somewhat crystalline layer, about one and three quarters inch thick, of a dull bluish-grey color; attached to layer 1*b*, which was darker colored (lead colored), more dull, and less crystalline than 1*a*.

SPECIMEN 2 is probably a continuation of 1.

SPECIMEN 3, probably a continuation of the same combined layer, contained a portion of a trilobite shield, which was not included in the portion analyzed.

SPECIMEN 4.—A thin layer, weathered of a light buff color.

SPECIMEN 5.—A dark bluish-grey or lead-colored layer; like 1*b*, coarse granular, and dull.

SPECIMEN 6*a*.—The dark grey unweathered portion of a layer which was weathered on one surface to a grey-buff color, showing the minute whorled univalve fossil shells very distinctly.

SPECIMEN 6*b*.—The buff, weathered portion of this layer.

SPECIMEN 7.—A thin layer weathered on the two surfaces; moderately dark grey in the interior; more dense than specimen 1; contains the minute univalve fossils.

8.—A thin crystalline layer, of a light grey color, with not much appearance of fossil remains.

9.—A coarser-grained layer, containing fossil remains; somewhat crystalline, and partly weathered.

These eleven samples were severally treated for the determination of phosphoric acid alone. One gramme of each, dried at 212° F., was digested in nitric acid with a little chlorhydric, and then, after evaporation to dryness, the residue was digested for some hours in nitric acid, diluted and filtered. The phosphoric acid was then determined by a careful use of the molybdic acid process, and the results obtained were as follows, viz:

PERCENTAGE OF PHOSPHORIC ACID IN THESE ELEVEN SAMPLES.

| | | | |
|---|---|---|---|
| In sample 1*a* | contained | 7.931 | per cent. of phosphoric acid. |
| In sample 1*b* | contained | 19.183 | per cent. of phosphoric acid. |
| In sample 2 | contained | 17.973 | per cent. of phosphoric acid. |
| In sample 3 | contained | 11.501 | per cent. of phosphoric acid. |
| In sample 4 | contained | 21.940 | per cent. of phosphoric acid. |
| In sample 5 | contained | 18.421 | per cent. of phosphoric acid. |
| In sample 6*a* | contained | 20.021 | per cent. of phosphoric acid. |
| In sample 6*b* | contained | 11.705 | per cent. of phosphoric acid |
| In sample 7 | contained | 16.502 | per cent. of phosphoric acid. |
| In sample 8 | contained | 5.053 | per cent. of phosphoric acid. |
| In sample 9 | contained | 13.624 | per cent. of phosphoric acid. |

It will be seen that the *maximum* proportion, that in No. 4, is 21.940 per cent.; the *minimum*, in No. 8, is 5.053 per cent., and the *general average* proportion 15.896 per cent.

The greatly varying proportions of this ingredient, within small limits, point to a very irregular local origin.

Frequently the phosphoric acid of the ancient limestone layers is traceable to the brachiopod and other shells and fossils which they contain. In order to ascertain how much of it in the specimens examined is attributable to this source, the specimens described below were collected and analyzed, viz:

No. 2005—"FOSSIL SHELLS, *mostly Orthis testudinaria, from Lower Silurian limestone layers. Farm of R. Peter, about seven miles north of Lexington, near Elkhorn creek.*"

No. 2006—"FOSSIL BRANCHING CHŒTETES, *from the same locality. Collected by R. Peter.*"

Specimen 2005 yielded only 1.317 per cent. of *phosphoric acid*, and contained 11.04 per cent. of silicious matter.

Specimen 2006 gave only 0.294 per cent. of *phosphoric acid*, and 6.16 per cent. of silicious matters.

Evidently there must have been some other source of the abundant phosphates of these layers than the shells of the mollusca, or the corals. Possibly they may have been accumulated by some process of segregation; possibly they may be due to the fortuitous presence of some of the large animals of the ancient seas, which, subsisting on the more simple forms of organic life, may have left their excretions and exuviæ in these localities.

However this may be, while the examination of these layers of our limestone develops an unexpected richness in phosphates, their too irregular distribution amongst the poorer layers may make their special application to the manufacture of fertilizers too practically expensive or precarious.

FRANKLIN COUNTY.

No. 2007—"POTTER'S CLAY, *from a bed several feet in thickness, in the bottom land, in what is supposed to be an old prehistoric channel of the Kentucky river, half a mile north of Frankfort. Collected by Jno. R. Procter.*"

The specimen is part of an unburnt vessel made of the clay at the pottery. The clay is of a grey-drab or neutral tint; it contains some very small specks of mica and of ferruginous matter. It calcines of a very light brick color. Fuses before the blow-pipe.

COMPOSITION, DRIED AT 212° F.

| | |
|---|---|
| Silica | 69.300 |
| Alumina, with iron and manganese oxides | 21.780 |
| Lime carbonate | .158 |
| Magnesia | .331 |
| Phosphoric acid | .060 |
| Potash | 2.351 |
| Soda | .585 |
| Water and loss | 5.435 |
| Total | 100.000 |

Ten grammes of the clay, dried at the common temperature, washed quickly with water, gave 2.45 grammes of *fine sand*, containing some larger, rounded quartz grains.

This clay, while fitted for the manufacture of ordinary pottery ware, is not sufficiently refractory to be used as a fire-clay.

GRANT COUNTY.

In an investigation made by Mr. C. J. Norwood of the character of the subsoils, under-clays, and other earthy material, excavated in making some of the deep cuts on the line of the Cincinnati Southern Railroad in this county, the samples described below were collected by him, and sent to the Chemical Laboratory for analysis.

No. 2008—"MATERIAL, *from just below the top soil, extending in thickness from eighteen inches to two feet, down to the surface of the material claimed to be "Hard Pan," next below described, at section 29, in the cut at station 295 on the C. S. R. R.*"

Quite a tough clayey material, generally of a light grey-buff color when dry, mottled with light grey, and penetrated in all directions with what appear to have been vegetable rootlets, now mainly decomposed, and of a deep manganese oxide color.

No. 2009—"MATERIAL, *claimed to be 'Hard Pan,' beginning at two feet below the surface and extending to the bed-rock.*"

Rather more tough than the preceding, which it resembles in color, except that it has more of the light grey mottling and less of the manganese-like infiltrations. The bolting-cloth separated, from the silicious residue of these two under-clays, only a very few quartz grains.

No. 2010—"TOP SOIL, *from an old field owned by the heirs of Richard Dickerson. Section 30, cut at station 337 on the C. S. R. R.*"

Dried soil of a light grey-brown color; friable.

No. 2011—"SOIL, *from just below the top soil, from the same locality as the next preceding," &c., &c.*

This dried subsoil, of a firmer, more clayey consistence than the preceding, is of a nearly uniform grey-buff color, mottled somewhat with light bluish-grey, and with some manganese oxide-like infiltrations.

No. 2012—"SUBSOIL, *from the same locality as the two preceding, from just below the next preceding, to the depth of two feet.*"

A clayey subsoil, grey-buff, mottled with light bluish-grey, with some dark-colored manganese oxide infiltrations. Very much like 2008 and 2009, but not so tough as these.

No. 2013—"SUBSOIL OR UNDER-CLAY, *seven inches thick, from the same locality, and immediately below the next preceding," &c.*

Resembles the next preceding, but shows more manganese infiltrations, with some small spheroidal concretions of the same, forming blackish spots.

No. 2014—"SUBSOIL OR UNDER-CLAY, *from the same locality, one foot thick, lying immediately below the next preceding.*"

This is a very tough clay-like material, darker in color than the next preceding; of an ochreous greyish-brown tint, with some little mottlings of bluish-grey, and some manganese-like infiltrations.

No. 2015—"SUBSOIL OR UNDER-CLAY, *from the same locality, one foot thick, lying just below the next preceding, and immediately above the bed-rock.*"

This is also quite a tough material, showing more mottling with bluish-grey clay than the preceding, and some manganese infiltrations, and containing some small calcareous nodules.

The bolting-cloth separated from the silicious residues of all these six subsoils or under-clays a considerable proportion of dull, angular fragments of what appeared to be hard silicates, which had not been decomposed by the acids in which they had been digested in the process of analysis.

COMPOSITION OF THESE EIGHT GRANT COUNTY SOILS, SUBSOILS, &c., DRIED AT 212° F.

| | No. 2008 | No. 2009 | No. 2010. | No 2011 | No. 2012. | No. 2013. | No. 2014 | No. 2015. |
|---|---|---|---|---|---|---|---|---|
| Alumina and iron and manganese oxides | 13.849 | 12.675 | 6.847 | 9.199 | 11.672 | 12.564 | 15.237 | 24.465 |
| Lime carbonate | 1.420 | 1.465 | .200 | .190 | .165 | .225 | 2.290 | 9.425 |
| Magnesia | .513 | .600 | .420 | .420 | .398 | .609 | .383 | .286 |
| Phosphoric acid | .636 | .435 | .188 | .086 | .168 | .236 | .823 | .589 |
| Potash | .952 | .780 | .568 | .156 | .579 | .259 | 1.124 | .669 |
| Soda | .082 | .617 | .317 | .368 | .104 | .246 | .019 | .245 |
| Water and organic matters lost on ignition | 5.515 | 5.400 | 5.425 | 4.100 | 4.450 | 5.600 | 4.950 | 4.425 |
| Sand and insoluble silicates | 77.640 | 78.965 | 86.165 | 85.460 | 82.490 | 80.115 | 75.240 | 59.940 |
| Total | 100.607 | 100.937 | 100.130 | 99.979 | 100.046 | 99.854 | 100.066 | 100.044 |
| Hygroscopic moisture | 5.710 | 5.950 | 2.750 | 3.400 | 3.825 | 5.950 | 6.575 | 5.250 |
| Potash in the insoluble silicates | 2.524 | 2.511 | 1.687 | 1.958 | 1.533 | 2.004 | 2.410 | 2.703 |
| Soda in the insoluble silicates | .499 | 1.214 | .388 | .260 | .638 | .397 | .407 | .265 |
| Character of the sample | Subsoil | Under-clay. | Soil. | Subsoil. | Under-clay. | Under-clay. | Under-clay. | Under-clay. |

Subsoils 2008 and 2009, from the same locality, resemble each other, nearly, in chemical composition; their great toughness, mainly due, no doubt, to their large proportions of alumina, may be partly owing to their peculiar mode of aggregation. Their composition, with the exception of the absence of any notable quantity of *humus*, is that of our richest soils; but their physical condition is no doubt unfavorable to fertility. These, as well as the six other samples, were doubtless derived mainly from the so-called "mudstone" strata of the Lower Silurian formation. In these latter samples a regular increase, in the proportion of the aluminous materials, may be observed, as the depth from the surface increases, indicating probably the influence of the infiltration of surface waters. In nearly all of these clays there are large proportions of phosphoric acid and potash.

Other similar samples, collected by Mr. Charles J. Norwood, from the deep cuts of this railroad in Grant county, are described below, as follows:

No. 2016—"SUBSOIL, *twenty-one inches thick, just below the top soil, which is one foot thick. In front of Mrs. Mary Renslaer's house. Section* 33. *Second cut from the north end of the C. S. R. R., Grant county*."

Dried subsoil in yellowish-brown, somewhat friable clods. Some little mixture of light ash-grey material observable in it.

The bolting-cloth removed, from its silicious residue, a considerable proportion of soft granules of partly decomposed silicates, but no silicious particles.

No. 2017—"UNDER-CLAY, *from the same locality, eighteen inches thick, lying immediately under the preceding subsoil, and extending down to the underlying limestone*," *&c.*

This resembles the preceding generally, in color, but is much more tough, and has some dark ferruginous or manganese discolorations, and a little more of the light colored material.

The silicious residue also contains a large proportion of soft, partly decomposed silicate granules.

No. 2018—"SURFACE SOIL, *to the depth of fifteen inches. Section 34. Second cut from the south end, C. S. R. R.,*" *&c.*

A friable earth of a light grey-umber color, containing a few dark concretions. The silicious residue all passed through the bolting-cloth, except a few soft granules of partly decomposed silicates.

No. 2019—"SUBSOIL, *from the same locality as the last, nineteen inches thick, next below the surface soil,*" *&c.*

A somewhat friable subsoil, having a more ferruginous tint than the preceding, and showing some dark colored infiltrations. Silicious residue like the preceding.

No. 2020—"UNDER-CLAY, *one foot thick, same locality as the preceding,*" *&c.*

A somewhat tough clay. Mottled, with light grey-ferruginous of various tints, and nearly black infiltrated manganese oxide. Silicious residue like the preceding.

No. 2021—"UNDER-CLAY, *eighteen inches thick, just below the preceding,*" *&c., &c.*

A tough clay; mottled like the preceding.

No. 2022—"UNDER-CLAY, *two feet thick, on the bed rock, same locality as the preceding,*" *&c., &c.*

Mottled like the preceding. Some parts of it compact and laminated. Contains occasional fragments of limestone and sandstone. Silicious residue like the preceding.

COMPOSITION OF THESE SOILS, SUBSOILS, &c., DRIED AT 212° F.

| | No. 2016. | No. 2017. | No. 2018 | No. 2019 | No. 2020. | No. 2021. | No. 2022. |
|---|---|---|---|---|---|---|---|
| Alumina and iron and manganese oxides | 17.502 | 27.353 | 9.540 | 10.222 | 18.593 | 15.437 | 11.792 |
| Lime carbonate | 1.115 | 4.555 | .575 | .290 | .275 | 1.225 | 8.240 |
| Magnesia | .151 | .266 | .312 | .266 | .402 | .679 | .824 |
| Phosphoric acid | .473 | .457 | .345 | .313 | .393 | .473 | .793 |
| Potash | .809 | 1.585 | .587 | .150 | .611 | .809 | 1.778 |
| Soda | .052 | .125 | . . . . . | . . . . . | .165 | .066 | .359 |
| Water and organic matters lost on ignition | 5.365 | 4.675 | 5.675 | 3.780 | 6.290 | 6.085 | 4.290 |
| Sand and insoluble silicates | 75.090 | 60.967 | 83.790 | 84.890 | 73.575 | 75.890 | 71.924 |
| Total | 100.557 | 99.983 | 100.824 | 99.911 | 100.304 | 100.664 | 100.000 |
| Hygroscopic moisture | not est. | not est. | not est. | not est. | not est. | not est | not est. |
| Potash in the insoluble silicates | 1.542 | 1.487 | 1.679 | 1.881 | 1.489 | 2.428 | 2.423 |
| Soda in the insoluble silicates | .297 | .212 | .510 | .552 | .486 | .376 | .324 |
| Character of the sample | Subsoil. | Under-clay. | Surface soil. | Subsoil. | Under-clay. | Under-clay. | Under-clay. |

These seven soils, subsoils, and under-clays present a general resemblance, in composition as well as in physical character, to the eight described above. The same remark will apply to the six remaining samples described below, from section No. 35, on the same railroad.

No. 2023—"TOP SOIL *to about one foot in depth, from the cut at the north end in section* 35, *on the Cincinnati Southern Railroad, Grant county. Collected by C. J. Norwood.*"

The dried soil is in friable clods of a dirty drab color, mottled with yellowish and ferruginous. The silicious residue, left after digestion of the soil in acids, all passed through the bolting-cloth, except many soft, whitish, rounded grains of partly decomposed silicates.

No. 2024—"SUBSOIL, *twenty-one inches thick, immediately below the top soil, from the same locality,*" *&c.*

Dried subsoil in friable lumps; mottled with light grey and ferruginous of different tints. Silicious residue like that of the preceding.

No. 2025—"UNDER-CLAY, *two feet thick, lying just under the preceding. Same locality,*" *&c., &c.*

A tough clay, mostly of an ochreous yellow color, mottled with grey-ferruginous, with some nearly black infiltrations of manganese oxide.

No. 2026—"UNDER-CLAY, *eight inches thick, just under the next preceding. Same locality,*" *&c., &c.*

Dried clay not quite so tough as the next preceding; of rather a lighter yellowish color; mottled like that, but with less of the dark colored material. Silicious residue like that of the preceding.

No. 2027—"UNDER-CLAY, *six inches thick, just below the next preceding. Same locality,*" *&c., &c.*

Dried clay in rather friable lumps, generally of a light yellowish brown color, mottled with light ochreous yellow. Silicious residue resembling that of the preceding.

No. 2028—"UNDER-CLAY, *twenty-six inches thick, just under the next preceding, lying on the limestone bed rock, and in some places seeming to replace the bed rock. Same locality as the preceding,"* &c., &c.

Dried clay in rather tough clods, of a brownish yellow color, much mottled with dark brownish ferruginous. Silicious residue like that of the preceding.

COMPOSITION OF THESE SIX GRANT COUNTY SOILS, SUBSOILS, AND UNDER-CLAYS, DRIED AT 212° F.

| | No. 2023. | No. 2024. | No. 2025. | No. 2026. | No. 2027. | No. 2028. |
|---|---|---|---|---|---|---|
| Alumina and iron and manganese oxides | 7.225 | 9.852 | 16.827 | 14.492 | 21.124 | 23.100 |
| Lime carbonate | .470 | .390 | 1.640 | 2.315 | 4.305 | 3.640 |
| Magnesia | .303 | .447 | .645 | .609 | .420 | .223 |
| Phosphoric acid | .185 | .358 | .358 | .358 | .361 | .505 |
| Potash | .738 | .282 | .213 | .760 | .210 | .534 |
| Soda | . . . . . | . . . . . | .337 | . . . . . | .308 | . . . . . |
| Water and organic matters lost on ignition | 4.650 | 3.940 | 5.400 | 4.450 | 5.025 | 5.850 |
| Sand and insoluble silicates | 87.065 | 84.760 | 75.040 | 77.440 | 68.515 | 66.390 |
| Total | 100.636 | 100.029 | 100.460 | 100.424 | 100.268 | 100.242 |
| Hygroscopic moisture | not est. | not est. | not est. | not est. | not est. | not est. |
| Potash in the insoluble silicates | 1.812 | 1.673 | 2.103 | 2.851 | 2.700 | 2.865 |
| Soda in the insoluble silicates | .722 | .677 | .433 | .417 | .378 | .449 |
| Character of the sample | Top soil. | Subsoil. | Under-clay. | Under-clay. | Under-clay. | Under-clay. |

The general remarks on the first and second groups of these samples will apply equally well to these.

## GRAYSON COUNTY.

No. 2029—"VIRGIN SOIL, *to the depth of about eight inches; from Grayson Springs, about four hundred yards west of the railroad. On the Leitchfield marl. Chester Group. Native forest growth, mostly white oak. Yield: of corn,* 25 *to* 40 *bushels; of wheat,* 12 *to* 15 *bushels; of tobacco,* 800 *to* 1,000 *pounds per acre. Good for clover and grasses. Collected by John H. Talbutt."*

Dried soil, somewhat cloddy, of a light buff-grey color. The silicious residue all passed through the bolting-cloth.

No. 2030—"SUBSOIL *of the preceding, taken to the depth of three feet. Collected by John H. Talbutt.*"

The dried subsoil is of a dirty orange-grey color. The silicious residue, after digestion in acids, all passed through the bolting-cloth.

COMPOSITION OF THESE SOILS, DRIED AT 212° F.

| | No. 2029. | No. 2030. |
|---|---|---|
| Organic and volatile matters | 3.239 | 2.534 |
| Alumina and iron and manganese oxides | 3.096 | 4.781 |
| Lime carbonate | .020 | .045 |
| Magnesia | .097 | .061 |
| Phosphoric acid | .144 | .159 |
| Sulphuric acid | not est. | not est. |
| Potash | .160 | .100 |
| Soda | .268 | .102 |
| Water, expelled at 380° F. | .506 | .483 |
| Sand and insoluble silicates | 91.865 | 91.490 |
| Total | 99.395 | 99.775 |
| Hygroscopic moisture | 1.200 | 1.575 |
| Potash in the insoluble silicates | 0.927 | 1.198 |
| Soda in the insoluble silicates | .262 | .254 |
| Character of the soil | Virgin soil. | Subsoil. |

These soils, of average natural fertility, would require the application of lime or marl, with phosphatic and alkaline fertilizers, to enable them to maintain, indefinitely, a high degree of productiveness. Judicious rotation of crops, including the sufficient use of ameliorating clover or grass crops, to be grazed or plowed in, together with barn-yard manure, might keep them in good condition for quite a long period, without the application of any outside fertilizers, especially if the products were consumed upon the farm; but when these are exported a gradual deterioration must result in all soils, unless the essential mineral ingredients carried off in the products are in some manner restored.

## GREENUP COUNTY.

### Coals.

No. 2031—"Coal, *from Cane Creek Mines. New opening in the No. 3 Coal, near Hunnewell Furnace. Average sample No.* 1; *sent by Mr. H. W. Bates, Vice President of the Eastern Kentucky Railway Company.*"

A fine-looking coal, pitch black, breaking into thin laminæ, with no apparent pyrites, and some fibrous coal.

No. 2032—"Coal. *Average sample No.* 2; *taken from about one hundred yards from the place of the preceding sample. Same locality,*" *&c., &c.*

Coal not quite so bright as the preceding sample. Some granular pyrites apparent between the laminæ.

No. 2033—"Coal. *Average sample No.* 3; *from the same locality as the two preceding; taken about one hundred yards distant from the others.*"

Resembles the last sample, but has no apparent granular pyrites. Some fibrous coal between the laminæ.

COMPOSITION OF THESE GREENUP COUNTY COALS, AIR-DRIED.

| | No. 2031. | No. 2032. | No. 2033. |
|---|---|---|---|
| Specific gravity | 1.345 | 1.344 | 1.383 |
| Hygroscopic moisture | 6.33 | 5.77 | 6.03 |
| Volatile combustible matters | 32.42 | 33.28 | 30.77 |
| Coke | 61.25 | 60.95 | 63.20 |
| Total | 100.00 | 100.00 | 100.00 |
| Total volatile matters | 38.75 | 39.05 | 36.80 |
| Carbon in the coke | 53.30 | 52.40 | 50.65 |
| Ash | 7.95 | 8.55 | 12.55 |
| Total | 100.00 | 100.00 | 100.00 |
| Character of the coke | Dense spongy. | Dense spongy. | Dense spongy. |
| Color of the ash | Light lilac-grey. | Light lilac-grey. | Light lilac-grey. |
| Percentage of sulphur | 1.277 | 0.900 | 1.458 |

Considerable local differences may be observed, in the relative proportions of ash and sulphur, in these samples from the same coal bed. They are all good coals of the variety "splint," or "semi-cannel," to which the celebrated "block coal" of Indiana belongs.

HARDIN COUNTY.

SOILS.

No. 2034—"VIRGIN SOIL, *from the farm of Gov. Jno. L. Helm, one mile north of Elizabethtown, Hardin county. Forest growth: beech, hickory, and oaks. Geological formation: St. Louis limestone. Collected by the Rev. H. Hertzer.*"

The dried soil is of a light yellowish-grey umber or dark drab color. The clods are friable. The coarse sieve removed from it a small quantity of ferruginous gravel. The silicious residue, after digestion in acids, all passed through the bolting-cloth, except a small quantity of fine quartz sand and a few particles of partly decomposed silicates.

No. 2035—"SURFACE SOIL, *which has been in cultivation for sixty years. From the same locality as the preceding soil. Average crops:* 35 *to* 45 *bushels of corn;* 12 *bushels of wheat, &c. This farm is considered a poor and worn out one. Decayed rock six to eight feet. Collected by Rev. H. Hertzer.*"

The dried soil is of a dirty-buff color; the clods quite firm. The coarse sieve separated from it a small quantity of ferruginous gravel. The silicious residue left on the bolting-cloth some fine quartz sand of various colors, and some grains of partly decomposed silicates.

No. 2036—"SUBSOIL *of the two preceding soils," &c., &c.*

This dried subsoil is of a handsome deep orange buff color. Its clods are quite firm. The coarse sieve removed from it about five per cent. of rounded ferruginous gravel. The silicious residue resembled that of the two preceding samples.

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

| | No. 2034. | No. 2035. | No. 2036. |
|---|---|---|---|
| Organic and volatile matters | 4.495 | 2.575 | 2.350 |
| Alumina and iron and manganese oxides | 5.579 | 6.520 | 9.807 |
| Lime carbonate | .340 | .215 | .140 |
| Magnesia | .286 | .227 | .223 |
| Phosphoric acid | .071 | .070 | .083 |
| Sulphuric acid | not est. | not est. | not est. |
| Potash | .149 | .119 | .270 |
| Soda | .037 | . . . . . | . . . . . |
| Water, expelled at 380° F. | 1.675 | .950 | .925 |
| Sand and insoluble silicates | 87.675 | 89.140 | 85.590 |
| Total | 100.307 | 99.816 | 99.388 |
| Hygroscopic moisture | 1.900 | 1.510 | 2.050 |
| Potash in the insoluble silicates | 1.250 | 1.037 | 0.848 |
| Soda in the insoluble silicates | .432 | .376 | .286 |
| Character of the soil | Virgin soil. | Old field soil. | Subsoil. |

The greatest apparent deficiency in these soils is of the phosphoric acid; this is apparent even in the so-called virgin soil. There can be little doubt that the use of top-dressings of bone-dust, superphosphate, or guano would greatly increase their fertility. Although the old field soil shows evidence of the diminution of its essential mineral ingredients, as well as of its organic and volatile matters, *humus*, it is by no means to be considered "worn out." Judicious culture to restore its *humus*, by means of clover or other green crops, grazed and plowed in, with the use of phosphatic fertilizers, &c., would soon restore its fertility, if the land is properly drained.

No. 2037—"VIRGIN SOIL, *from the farm of J. W. Fowler, Colesburg, Hardin county. Forest growth: poplar, beech, sugar-tree, white and black oaks, hickory, &c. Geological formation: St. Louis Group. Blue calcareo-argillaceous shales. Decomposed rock three to four feet. Collected by the Rev. H. Hertzer.*"

This dried soil is of an umber-grey color. The coarse sieve separated from it 4.31 per cent. of rounded fragments of silicio-ferruginous concretions or sandstone, with a little chert. The bolting-cloth removed from the silicious residue, after the usual digestion in acids, some small particles of partly decomposed silicates, and a portion of a very small encrinital stem.

No. 2038—"SURFACE SOIL, *thirty-four years in cultivation. From the same farm as the preceding soil, &c., &c. Average crops: of corn,* 35 *bushels; wheat,* 16 *bushels; oats,* 15 *to* 20 *bushels; of hay, one and a half tons per acre. Collected by Rev. H. Hertzer.*"

Dried soil of a lighter and more yellowish-grey color than the preceding. The coarse sieve removed from it nearly seven per cent. of rounded ferruginous sandstone gravel or concretions, with some cherty fragments. The silicious residue resembled that of the preceding soil.

No. 2039—"SUBSOIL *of the next preceding,*" *&c., &c.*

The dried subsoil resembles the next preceding soil in color. The coarse sieve separated from it nearly nine per cent. of angular cherty fragments, with some silicified portions of encrinital stems and ferruginous gravel. The bolting-cloth removed from the silicious residue a few particles of partly decomposed silicates, one or two small clear quartz grains, and two fragments of minute silicified encrinital stems.

No. 2040—"VIRGIN SOIL, *from the farm of Van Buren Vandecraft, on Muldraugh's Hill, at Colesburg, Hardin county. Forest growth: poplar, beech, white oak, chestnut oak, sugar-tree. Geological formation: St. Louis Group. Decayed rock one to two feet. Collected by Rev. H. Hertzer.*"

Dried soil of a light buff-grey color. The coarse sieve removed from it 10.55 per cent. of angular cherty fragments, with some silicified encrinital stems and iron gravel. The bolting-cloth separated from the silicious residue a considerable proportion of partly decomposed silicate grains, some resembling reddish felspar, with some minute silicified entrochi, and a few quartz grains.

No. 2041—"SURFACE SOIL, *fifty years in cultivation. From the same farm as the preceding soil. Average crop of corn, twenty bushels. Collected by Rev. H. Hertzer.*"

This dried soil is of a brownish salmon color. The coarse sieve separated from it only a small proportion of iron gravel, and a small rounded quartz pebble. The silicious residue resembled that of the preceding soil.

No. 2042—"SUBSOIL *of the next preceding soil,*" *&c., &c.*

The dried subsoil is of a handsome light brick red color. It all passed through the coarse sieve. The bolting-cloth removed from the silicious residue a considerable quantity of partly decomposed silicate grains, which were easily crushed under the finger, together with some blackish silicified portions of encrinital stems, &c.

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

| | No 2037. | No. 2038. | No. 2039. | No. 2040 | No. 2041 | No. 2042. |
|---|---|---|---|---|---|---|
| Organic and volatile matters | 9.185 | 5.400 | 4.500 | 4.610 | 3.085 | 3.550 |
| Alumina and iron and manganese oxides | 8.705 | 8.228 | 8.347 | 6.033 | 6.597 | 11.254 |
| Lime carbonate | 1.350 | .625 | .465 | .390 | .290 | .215 |
| Magnesia | .124 | .107 | .142 | .070 | .040 | .025 |
| Phosphoric acid | .203 | .172 | .123 | .102 | .038 | .061 |
| Sulphuric acid | not est. | not est. | not est. | not est. | not est. | not est. |
| Potash | .595 | .279 | .175 | .316 | .035 | .251 |
| Soda | .011 | .018 | .077 | .098 | .025 | .168 |
| Water, expelled at 380° F. | 2.715 | 2.075 | 2.000 | 1.625 | 1.150 | 1.550 |
| Sand and insoluble silicates | 77.905 | 83 090 | 84.440 | 86.355 | 88.940 | 83.490 |
| Total | 100.793 | 99.994 | 100.269 | 99.599 | 100.200 | 100.564 |
| Hygroscopic moisture | 2.885 | 2.315 | 2.265 | 1.815 | 1.335 | 2.575 |
| Potash in the insoluble silicates | 2.910 | 2.226 | 1.137 | 0.956 | 1.302 | 1.329 |
| Soda in the insoluble silicates | 1.166 | .786 | .733 | .197 | .443 | .256 |
| Character of the soil | Virgin soil | Old field soil. | Subsoil. | Virgin soil | Old field soil. | Subsoil. |

It is interesting to notice in these soils the changes in composition brought about by long cultivation without the use of fertilizers. In the case of soils Nos. 2037 and 2038 the organic and volatile matters have been reduced from 9.185 to 5.400 per cent. by the thirty-four years of cultivation; the lime carbonate from 1.350 to 0.625; the phosphoric acid from 0.203 to 0.172, and the potash from 0.595 to 0.279 per cent., while the percentage of sand and insoluble silicates is increased from 77.915 to 83.090 per cent. In the soils Nos. 2040 and 2041 we find that the sixty years' cropping of the latter have reduced some of its essential ingredients in still greater proportion. The organic matters, &c., are reduced from 4.610 per cent. to 3.085; the lime carbonate from 0.390 to 0.290; the phosphoric acid from 0.102 to 0.038 per cent., the potash from 0.316 to 0.035 per cent., and the sand and insoluble silicates are increased from 86.355 to 88.940 per cent.

The first set of soils was evidently naturally the richer; and the relative present productiveness of the soil of the two old fields corresponds nearly with their comparative richness or poverty, as shown by their chemical composition; for while the soil No. 2038 produces thirty-five bushels of corn per acre, soil No. 2041 yields only twenty bushels. This latter soil is greatly in want of phosphatic fertilizers, as well as those containing potash salts. There is no apparent reason why, by the proper use of such fertilizers, barn-yard manure, and a judicious system of rotation, with the cultivation of ameliorating green crops for grazing purposes and for plowing under, these soils may not be brought to and maintained in a condition of profitable productiveness.

### HARRISON COUNTY.

No. 2043—*Some* LEAD ORE (*galena*), *mixed with zinc blende; in a gangue of barium sulphate, which included some angular fragments of embedded limestone; was brought to the laboratory by Mr. John R. Procter for analysis.*

This ore, reported to be argentiferous, is found in a vein of heavy spar, on the farm of the late Mr. Shawhan, one mile on the Lexington side of Cynthiana, on the Kentucky Central Railroad.

The lead sulphide was disseminated, in rather small proportion in the samples brought, throughout the gangue, and when reduced in the usual way, and analyzed, both by the wet way and by cupellation, it was not found to yield more than a trace of silver, in a lead button weighing more than eight grammes, obtained from thirty grammes of the galena: so that it evidently could not be profitably worked for this precious metal. The rather small proportion of lead ore seems also to preclude the profitable operation of this mine for the baser metal.

### HOPKINS COUNTY.

#### SOILS.

No. 2044—"VIRGIN SOIL; *surface soil to the depth of thirteen inches; from woods on the farm of Mr. Mills, near Nortonsville. Collected by John H. Talbutt." Forest growth generally oaks. Slope of the surface west-south. Sample taken near the base of the hill, near a coal-shaft.*

The dried soil is of a dark umber-grey color. The coarse sieve removed from it a few small ferruginous concretions. The bolting-cloth separated from the silicious residue, remaining after the digestion in acids, 16.5 per cent. of the soil of fine white sand, composed of rounded quartz grains.

No. 2045—"SUBSOIL *of the preceding," &c., &c.*

The dried subsoil is in friable clods, of a brownish buff color. It all passed through the coarse sieve. The bolting-cloth removed from the silicious residue 10.50 per cent. of the soil of fine white sand, like that of the preceding.

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

| | No. 2044. | No. 2045. |
|---|---|---|
| Organic and volatile matters | 2.850 | 2.090 |
| Alumina and iron and manganese oxides | 4.952 | 6.883 |
| Lime carbonate | .080 | a trace. |
| Magnesia | .106 | .181 |
| Phosphoric acid | .083 | .077 |
| Sulphuric acid | not est. | not est. |
| Potash | .145 | .307 |
| Soda | .050 | . . . . . |
| Water, expelled at 380° F. | .737 | .660 |
| Sand and insoluble silicates | 90.540 | 89.700 |
| Total | 99.543 | 99.898 |
| Hygroscopic moisture | 1.085 | 1.285 |
| Potash in the insoluble silicates | 1.693 | 1.458 |
| Soda in the insoluble silicates | .687 | .697 |
| Character of the soil | Virgin soil. | Subsoil. |

These must be classed amongst the naturally weak soils, especially because of their small proportion of lime and phosphoric acid. These necessary ingredients can, however, be easily supplied in bone-dust, superphosphate, or guano, which, with a further supply of potash in some appropriate fertilizer, might make this soil quite productive, especially if proper means be used to increase the proportion of *humus*, organic and volatile matters, which are also in too small proportion in this soil.

## JACKSON COUNTY.

No. 2046—"BLACK BAND IRON ORE. *On top of the thirty-four inch coal. Coyle's Bank. Big Hill, Jackson county. Collected by John R. Procter.*"

A dull, rusty-black ore; ferruginous on the weathered surfaces; shaly in structure. Some small reedy impressions between some of the irregular laminæ. Some granular pyrites apparent also.

COMPOSITION, DRIED AT 212° F.

| | | |
|---|---|---|
| Iron carbonate | 70.168, | containing 33.875 iron. |
| Alumina and trace of manganese oxide | .430 | |
| Lime carbonate | .930 | |
| Magnesia carbonate | 2.898 | |
| Phosphoric acid | .345 | = .151 phosphorus. |
| Sulphur | .264 | |
| Bituminous matters | 18.540 | |
| Silicious residue | 6.230, | containing 4.960 silica. |
| Total | 99.805 | |

If this ore is found in sufficient abundance, it may be smelted with advantage, for the production of iron of a low grade for ordinary purposes. Deducting the 18.54 per cent. of bituminous matters, which will act in the smelting furnace like so much fuel, the percentage of iron to the remainder is more than forty-one and a half.

JESSAMINE COUNTY.

No. 2047—"MINERAL WATER. *Salt sulphur water, from a well fifteen feet deep; in the Lower Silurian blue limestone; on the farm of James Llewellyn, on the Russell's Tavern turnpike, about two miles west of Nicholasville. Sample brought by Mr. B. M. Arnott.*" (Analyzed by my son, Alfred Meredith Peter, under my supervision.)

The water, brought to the laboratory in a stone-ware jug, corked and well sealed with wax, smelt strongly of hydrogen sulphide, but was somewhat turbid with a dark grey precipitate of iron sulphide, &c.

SUMMARY OF THE ANALYSIS MADE.

Carbonic acid gas, present but not estimated, because a part had escaped. Hydrogen sulphide gas, the quantity yet remaining was 0.015 gramme per litre, equal to 0.109 grain or 0.3 cubic inch per wine pint. Of course much more is present in the water at the well. The following named carbonates were found in the water, they being held in solution by the carbonic acid present, viz: lime, magnesia, iron and strontia carbonates, making a total weight of 0.276 gramme per litre; equal to 1.592 grains per wine pint of the water. (The litre equals 1000 grammes.) In the water, which had been boiled and had deposited these carbonates, the following ingredients were found:

| | In 1000 parts. | In a wine pint of the water. |
|---|---|---|
| Lime sulphate | 0.016 | 0.117 of a grain. |
| Potash sulphate | not estimated. | |
| Magnesium chloride | .171 | 1.244 grain. |
| Sodium chloride | much; not est. | |
| Lithium chloride | a marked trace. | |
| Sodium bromide | considerable. | |
| Sodium sulphide | .052 | .379 of a grain. |
| Silica | not estimated. | |
| Organic matters | not estimated. | |
| Total saline matters | 4.882 per litre. | 35.585 grains in the wine pint. |

This is a very good salt sulphur water, resembling in its general composition the waters of the Blue Lick Springs and of Col. J. W. Hunt Reynolds' well, near Frankfort, as well as that of the salt sulphur well at the Olympian Springs, in Bath county.

The free hydrogen sulphide (sulphuretted hydrogen) and the sodium sulphide are nearly in the same proportions as in the Lower Blue Lick water; but the total saline matters are only about half as much. The difference may be mainly in the sodium chloride or common salt. These total saline matters, about five parts to the 1000 of the water, or about 55.5 grains to the wine pint, are nearly in the same amount as in the salt sulphur water of the Olympian Springs; but this water contains larger proportions of sodium sulphide and iron carbonate than that. It also is evidently somewhat stronger in hydrogen sulphide than the Olympian water.

There can be no doubt that this salt sulphur water may be beneficially employed, under judicious medical advice, in the treatment of many cases of disease for which sulphur waters are appropriate, especially as it is somewhat chalybeate when taken fresh from the well. Like all other sulphur waters, it soon decomposes when exposed freely to the air.

A more complete analysis would be necessary to determine the exact proportions of all its ingredients, requiring a visit to the well, for the testing of the recent water, and the use of a larger quantity of it at the laboratory.

LINCOLN COUNTY.

No. 2048—MINERAL WATER. "*Salt sulphur water, from a spring in the Black Devonian shale, at the Cincinnati Southern Railroad bridge over Green river; at about the level of the river; discovered by excavating for a 'borrow pit.' Sent for examination by R. M. Bishop, Esq. (now Governor of Ohio).*"

Although the water had been brought in a rather loosely stoppered bottle, it yet smelt and tasted strongly of compounds of sulphur. It was slightly turbid from the spontaneous precipitation of sulphur and iron sulphide, and was of a slightly yellowish tint, doubtless from the presence of sulphuretted sulphides, the result of partial decomposition of the hydrogen sulphide. Of course only a qualitative analysis could be made with the small amount of water supplied, under the circumstances.

SUMMARY.

The water was found to contain carbonic acid and hydrogen sulphide gases in considerable proportion. Held in solution by the carbonic acid were carbonates of lime, magnesia, and iron, and probably of strontia. It contains a large proportion of sodium chloride (common salt), with magnesium chloride and a trace of lithium chloride, besides a notable quantity of lime, magnesia, and potash sulphates, and sodium sulphide. It resembles, therefore, the Blue Lick water, but is much stronger in total saline matters and probably in sodium sulphide. The total saline matters of the Lower Blue Lick water amount to somewhat more than ten parts in the thousand, while those of this water equal about nineteen to the thousand of the water.

If this spring proves to be a constant one, the water deserves a complete quantitative analysis, and it could no doubt be made available as a remedial agent in many cases of disease.

LOGAN COUNTY.

SOILS.

No. 2049—"VIRGIN SOIL, *from the bottom land of Wm. Morton, one mile north of Russellville, Logan county. Collected by Rev. H. Hertzer. Geological formation, St. Louis limestone. Forest growth: a natural canebrake, sycamore, elm, wild cherry, burr oak,*" &c.

The dried soil is mostly in friable clods, of a yellowish, light umber color. It contains no gravel. The silicious residue, left after digestion in acids, all passed through bolting-cloth, except a few particles of partly decomposed silicates and a small quantity of small rounded quartz grains, mostly colorless.

No. 2050—"SUBSOIL *to the bottom land above described,*" &c.

The dried subsoil is in clods, less friable than those of the above surface soil; of a light yellowish-brick color. It contains no gravel. The bolting-cloth separated from the silicious residue a considerable quantity of small rounded grains of milky and transparent quartz, also much of partly decomposed silicates in small, rounded, soft particles.

No. 2051—"SURFACE SOIL, *in cultivation thirty years; bottom land; from same farm as the two preceding. Average crops: of corn,* 30 *bushels; wheat,* 10 *bushels; oats,* 10 *to* 15 *bushels per acre. Collected by Rev. H. Hertzer.*"

Dried soil in pretty firm clods; of a dark umber-buff color, or light buff-umber. Clods mottled with light brick color. The coarse sieve removed from it a very few small ferruginous quartzy particles. The silicious residue contained rather more small quartz grains, and soft partly decomposed silicate particles, than the preceding.

No. 2052—"BLACK SOIL" (so-called); "*non-productive; all vegetables raised on it look sickly. Surface soil, from the Edgetown stock farm of H. B. Tully, Russellville. Collected by Rev. H. Hertzer.*"

The dried soil is in pretty firm clods, of a dark snuff-brown color. It contains no gravel. The silicious residue all passed through bolting-cloth, except a few small quartz grains, and a considerable proportion of soft rounded particles of partly decomposed silicates.

No. 2053—"SUBSOIL, *taken from a depth of six feet. From the same locality as the next preceding. Collected by Rev. H. Hertzer.*"

"It is the richest virgin soil from the decomposition of the St. Louis limestone, which rests underneath, partly decayed to six feet in depth. This subsoil, mixed with the lighter surface soil, makes very good bricks, and always enriches the surface soil when properly plowed up. It is preferred for the production of fine tobacco, characterized by broad silky leaves and small stems or midribs. Forest growth, cedar and black walnut."

This dried subsoil is of a bright brick-red color. It is somewhat cloddy. The coarse sieve removed from it some few angular particles of partly decomposed chert. The silicious residue all passed through the bolting-cloth, except a few small rounded grains of transparent quartz, and a considerable quantity of soft particles of partly decomposed silicates.

No. 2054—"SURFACE SOIL, *in cultivation for about thirty years. From the same locality as the preceding. Crops, generally of corn, the average yield of which is thirty bushels. Original growth: black walnut, elm, wild cherry, red and post oaks. Collected by Rev. H. Hertzer.*"

The dried soil is in friable clods of a light buff-umber color. Contains no gravel. Silicious residue like that of the next preceding.

No. 2055—"SUBSOIL *of the next preceding*," *&c.*, *&c.*

Dried subsoil of a light brick color, in pretty firm clods. The coarse sieve separated from it a few particles of decomposing chert. The silicious residue is like that of the preceding.

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

| | No. 2049. | No. 2050. | No. 2051. | No. 2052 | No. 2053 | No. 2054. | No. 2055. |
|---|---|---|---|---|---|---|---|
| Organic and volatile matters | 2.900 | 2.585 | 2.560 | 3.925 | 3.675 | 2.775 | 3.048 |
| Alumina and iron and manganese oxides | 3.247 | 7.095 | 5.297 | 8.315 | 11.811 | 4.812 | 9.158 |
| Lime carbonate | .395 | .210 | .195 | .640 | .245 | .180 | .180 |
| Magnesia | .115 | .196 | .100 | .346 | .227 | .170 | .214 |
| Phosphoric acid | .093 | .115 | .093 | .125 | .109 | .093 | .077 |
| Sulphuric acid | not est. | not est. | not est. | not est. | not est. | not est. | not est. |
| Potash | .132 | .169 | .121 | .060 | .212 | .085 | .326 |
| Soda | . . . . . . | . . . . . . | .068 | . . . . . . | .015 | . . . . . . | .050 |
| Water, expelled at 380° F. | .875 | .765 | .765 | 1.275 | .950 | .600 | .775 |
| Sand and insoluble silicates | 92.350 | 88.755 | 90.935 | 85.035 | 82.365 | 91.090 | 86.275 |
| Total | 100.107 | 99.890 | 100.194 | 99.721 | 99.609 | 99.805 | 100.103 |
| Hygroscopic moisture | 1.435 | 2.385 | 1.550 | 2.675 | 3.800 | 1.250 | 2.525 |
| Potash in the insoluble silicates | 0.890 | 1.334 | 1.286 | 1.212 | 1.349 | 1.474 | 1.320 |
| Soda in the insoluble silicates | .301 | .357 | .299 | .353 | .266 | .532 | .265 |
| Character of the soil | Virgin soil | Subsoil. | Old field soil. | Black soil | Subsoil. | Old field soil. | Subsoil. |

The group of soils Nos. 2049, 2050, and 2051 are naturally of average fertility, if they are sufficiently underdrained, with the exception that the virgin surface soil appears to be rather deficient in phosphoric acid and organic matters or *humus*. The use of phosphatic fertilizers, and the cultivation of green crops—of clover or grasses—to be grazed or plowed under, or of barn-yard manure, would no doubt greatly increase their productiveness. The surface could also be improved by a gradual mixture of the heavier subsoil with the surface soil during this process of amelioration.

The unproductiveness of the black soil seems to be partly due to a deficiency of potash. Possibly, however, the land is not sufficiently underdrained. If there is no want of drainage, the application of wood ashes, or other fertilizers containing potash, would undoubtedly restore productiveness, especially, as in other respects, this soil is not deficient in the essential elements. The red subsoil of the same locality, No.

2052, would no doubt answer the same purpose, because of its considerable proportion of potash, which may account for its favorable influence on the tobacco plant. Subsoils, however, should generally be *gradually* mixed with the surface soil, and accompanied by barn-yard manure, or some other organic fertilizer, to supply *humus*.

The influence of the thirty years' cultivation on the soil of the old fields is manifest in the reduction of the proportions of potash, phosphoric acid, lime, &c., and the increased proportion of the silicious material, as compared with the original soil. The continued cultivation of hoed or plowed crops, such as corn, for a long series of years, has a very deteriorating effect upon the soil, not only because the single crop generally draws inordinately on one kind of mineral matter, as, for example, the corn makes a great demand on the phosphoric acid of the soil, but also because the constantly exposed surface is greatly subject to the washing action of the atmospheric waters, which continually carry off its lighter and richer ingredients, while its *humus* is more than usually removed by the oxydating action of the air. A judicious rotation, in which green crops, covering the soil for a time, undisturbed by the plow, may protect the land from this washing and decomposing influence of the atmospheric agencies, while they, when grazed or plowed under, in whole or in part, may renew the *humus*, and bring the mineral ingredients of the soil into a soluble and available condition for the nourishment of intermediate grain crops, or even of tobacco crops, would conduce greatly to profitable farming, more especially if manures or fertilizers are applied to the green crops. The tobacco plant, which makes so heavy a demand on the soil for potash and lime, as well as phosphoric acid, undoubtedly requires a system of this kind for its continued or profitable cultivation.

## LYON COUNTY.

### IRON ORES.

No. 2056—"LIMONITE. *Labeled iron ore, from Hall's patch drift, Lyon county. Centre Furnace. Collected by P. N. Moore.*"

Mostly in dense, hard, brown, irregular laminæ, but containing a considerable proportion of red and yellow porous and soft ochreous material.

No. 2057—"LIMONITE. *Ore from Skillian Bank. Centre Furnace, Lyon county. Collected by P. N. Moore.*"

Mostly in dense, hard, dark-brown and blackish irregular layers, with but little of softer, reddish, brownish and yellow ochreous material.

Other Centre Furnace iron ores may be found under Trigg county.

COMPOSITION OF THESE LYON COUNTY IRON ORES, DRIED AT 212° F.

| | No. 2056. | No. 2057. |
|---|---|---|
| Iron peroxide | 66.192 | 68.162 |
| Alumina } Manganese oxide } | 1.393 | 1.763 |
| Lime carbonate | a trace. | a trace. |
| Magnesia | a trace. | a trace. |
| Phosphoric acid | .185 | .505 |
| Sulphuric acid | a trace. | a trace. |
| Combined water | 10.000 | 9.630 |
| Silica and insoluble silicates | 22.910 | 20.050 |
| Total | 100.680 | 100.110 |
| Percentage of iron | 46.320 | 47.703 |
| Percentage of phosphorus | .079 | .220 |
| Percentage of sulphur | a trace. | a trace. |
| Percentage of silica | 21.820 | 19.060 |

These are evidently very good iron ores, more especially No. 2056, which contains much the less of the injurious ingredient, phosphorus, and which, consequently, would yield quite a tough iron by judicious smelting.

MADISON COUNTY.

No. 2058—"COAL, *from Marshall Moran's Bank, Big Hill. Thickness of the bed about thirty-four inches. Average sample by John R. Procter.*"

A sub-conglomerate coal. A firm, pure-looking splint coal. Has some fibrous coal between the thin laminæ, but very little appearance of pyrites.

COMPOSITION, AIR-DRIED.

| | | | |
|---|---|---|---|
| Hygroscopic moisture | 3.57 | Total volatile matters | 40.10 |
| Volatile combustible matters | 36.53 | | |
| Light spongy coke | 59.90 | Carbon in the coke | 55.77 |
| | | Light yellowish-grey ash | 4.13 |
| | 100.00 | | 100.00 |

The percentage of sulphur is only 0.749.

In volume IV of new series of these Reports, pages 109, 110, may be found the analyses of other samples of the coal from this layer, exhibiting considerable differences in the relative proportions of sulphur, &c., &c. No doubt the present sample is a better average sample than No. 1878, which exhibits so much larger quantity of sulphur.

No. 2059—MINERAL WATER. "*Sulphur water; from a well owned by Dr. J. Reed; bored seven hundred and fifty feet deep; begun in the Black Devonian shale, and probably passing into the Trenton limestone, near Paint Lick. Collected by John R. Procter.*"

This water, brought to the laboratory in a corked bottle, had of course lost most of its hydrogen sulphide by decomposition. It yet smelt of this compound, and was of a slightly yellowish tint, from the presence of a little sodium sulphide. It could not be quantitatively analyzed, but the evaporation of a portion of it showed that it contained a quantity of solid saline matters equal to 0.2892 to the 1000 parts, or about two grains to the wine pint. These were found, by testing, to consist of carbonates of lime, magnesia, iron, &c., held in solution by carbonic acid, and sulphates of magnesia, lime, and probably of potash, with small quantities of chloride and sulphide of sodium, &c. No doubt it is a good sulphur water, which deserves a complete analysis.

No. 2060—"RED BUD SOIL, *from the Covington farm, thirty-four miles east of Lexington, half a mile back of Elliston, Madison county. Collected by Mr. L. H. DeFriese.*"

"On the hill slope, nineteen degrees west, below the outcrop of the magnesian limestone and black Devonian shale. Depth of the surface soil, twelve to fifteen inches. Forest growth: red oak, burr oak, honey and black locusts, white and black walnuts, hickories, sycamore, maple, black, blue, and white ash, &c. Yield: thirty to fifty bushels of corn, eight to fifteen of wheat, fifteen to twenty of oats. No hemp raised, and but little rye."

The dried soil is of a brown-umber color. The coarse sieve separated from it 1.14 per cent. of ferruginous and cherty particles. The bolting-cloth removed, from its silicious residue, a considerable portion of fine rounded quartzose grains, mostly transparent, with a few dark colored particles of undecomposed silicates.

COMPOSITION, DRIED AT 212° F.

| | |
|---|---|
| Organic and volatile matters | 5.825 |
| Alumina and iron and manganese oxides | 10.434 |
| Lime carbonate | .615 |
| Magnesia | .043 |
| Phosphoric acid | .301 |
| Potash | .379 |
| Soda | .094 |
| Water, expelled at 380° F. | 2.415 |
| Sand and insoluble silicates | 78.965 |
| Total | 99.071 |
| Hygroscopic moisture | 3.165 |
| Potash in the insoluble silicates | 1.537 |
| Soda in the insoluble silicates | .300 |

On reference to volume IV, first series of Reports of the Kentucky Geological Survey, page 215, it will be seen that this rich soil has undergone some deterioration since the analyses there reported were made, about eighteen years ago. According to the description of soil No. 1128, given on page 214, it was collected from the same place, or nearly so, as the soil above described. Local differences, however, may exist, making the comparison imperfect.

M'CRACKEN COUNTY.

No. 2061—"SURFACE SOIL, *to the depth of eight inches. From the farm of L. M. Flournoy, three miles from Paducah. Tertiary formation, &c. Forest growth: mostly oaks of various species, with some hickories, &c. The corn crop averages twenty-five to forty bushels per acre. It is good tobacco soil, and considered average soil of the county. Some sandstone in the ravines, and indications of iron ore within half a mile. Collected by John H. Talbutt.*"

The dried soil is of a light greyish-buff color; friable. The coarse sieve removed from it only a few small fragments of decomposing chert. The bolting-cloth separated, from its silicious residue, only a few small particles of partly decomposed silicates.

No. 2062—"SUBSOIL *of the next preceding,*" *&c.*

The dried subsoil is of a darker buff color, and the clods are more adhesive than those of the above; they are mottled with greyish and darker buff. It all passed through the coarse sieve. Silicious residue like that of the preceding.

No. 2063—"UNDER-CLAY *of the two preceding soils, &c. (Sand beneath this),*" *&c.*

The dried under-clay resembles the subsoil, but the clods are more firm. All passed through the coarse sieve. The bolting-cloth removed from the silicious residue a large proportion of particles of partly decomposed silicates.

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

| | No. 2061. | No. 2062. | No. 2063 |
|---|---|---|---|
| Organic and volatile matters | 2.050 | 2.650 | 2.675 |
| Alumina and iron and manganese oxides | 5.497 | 12.300 | 10.834 |
| Lime carbonate | .115 | .190 | .190 |
| Magnesia | .268 | .521 | .649 |
| Phosphoric acid | .093 | .115 | .061 |
| Potash | .167 | .284 | .643 |
| Soda | .171 | . . . . . | .087 |
| Water, expelled at 380° F. | 1.000 | 1.000 | 1.000 |
| Sand and insoluble silicates | 90.940 | 82.490 | 83.865 |
| Total | 100.301 | 99.550 | 100.004 |
| Hygroscopic moisture | 1.425 | 4.000 | 3.425 |
| Potash in the insoluble silicates | 1.700 | 1.605 | 1.427 |
| Soda in the insoluble silicates | .598 | .911 | .668 |
| Character of the soil | Surface soil | Subsoil. | Under-clay |

These soils, of average natural fertility, could no doubt be greatly improved in productiveness by the use of top-dressings of phosphatic fertilizers, such as bone-dust, superphosphate, or guano. The subsoil is richer than the surface, especially in potash, and might be gradually plowed up and mixed with it in cultivation with advantage. The manurial products of the barn-yard and stables, both solid and liquid, should be carefully husbanded and regularly used upon the soil. There is no reason why a very high degree of productiveness may not be maintained on this soil by a judicious system of farming, in the proper use of fertilizers, and a due rotation of crops, if it is well drained.

## MEADE COUNTY.

### SOILS.

No. 2064—"VIRGIN SURFACE SOIL, *from the land of Mr. McCarty, Muldraugh, Meade county. Sample taken twenty yards from the railroad, half a mile from the station. Underlying rock, buff and blue sandstone of the Waverly Group. Collected by John H. Talbutt.*"

"Forest growth, white oaks, some trees five feet in diameter; poplar (liriodendron), some eight feet in diameter; large chestnut, beech, red oak, shellbark hickory, some sugar-tree, &c. Average corn crop, twenty to thirty bushels."

Dried soil of a brownish umber-grey color. Clods somewhat adhesive. It all passed through the coarse sieve, except some small angular fragments of weathered chert, and a little shot iron ore. The bolting-cloth removed, from the silicious residue, some rounded grains of quartz and of dark colored silicates.

No. 2065—"SUBSOIL *to the preceding*," *&c.*, *&c.*

The dried subsoil is cloddy. Its general color is reddish ferruginous, mottled with lighter colored and grey. It contains fragments of weathered chert. The clods are quite firm. The silicious residue contains a small quantity of small rounded quartz grains.

No. 2066—"UNDER-CLAY *below the two preceding*," *&c.*, *&c.*

Clods quite adhesive. Generally of a handsome buff color, mottled and infiltrated with red ferruginous. It contains a considerable proportion of fragments of weathered chert.

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

| | No. 2064. | No. 2065. | No. 2066. |
|---|---|---|---|
| Organic and volatile matters | 3.565 | 5.665 | 3.600 |
| Alumina and iron and manganese oxides | 5.091 | 15.741 | 11.604 |
| Lime carbonate | .095 | .070 | .045 |
| Magnesia | .133 | .242 | .538 |
| Phosphoric acid | .109 | .140 | .156 |
| Potash | .156 | .425 | 1.082 |
| Soda | . . . | . . . . . | . . . . . |
| Water, expelled at 380° F. | 1.000 | 1.335 | .650 |
| Sand and insoluble silicates | 89.725 | 75.825 | 82.125 |
| Total | 99.874 | 99.443 | 99.800 |
| Hygroscopic moisture | 1.600 | 4.265 | 2.950 |
| Potash in the insoluble silicates | 1.297 | 1.540 | 2.259 |
| Soda in the insoluble silicates | .471 | .304 | .150 |
| Character of the soil | Virgin surface soil. | Subsoil. | Under-clay |

These soils would be greatly improved by top-dressings of lime or calcareous marl in considerable quantity. The subsoil and under-clay are quite rich in potash, and might be gradually mixed with the upper soil during cultivation. The small average crop of corn is probably due, in part, to the paucity of lime in these soils.

### MERCER COUNTY.

No. 2067—"LIMESTONE, *containing green sand or glauconite. Sent by Mr. H. L. Tabler, of Harrodsburg, who says there is a bed of it two feet thick near that place.*"

A dull, grey, fine-granular limestone, containing a large proportion of small, rounded, bluish-green grains of what seems to be green sand or glauconite, together with a considerable proportion of bright, minute, cubical iron pyrites.

Some of the limestone, coarsely powdered, was digested in a warm solution of ammonium nitrate, afterwards in weak chlorhydric acid, to remove the calcium carbonate. The residue was then ignited to remove sulphur from the iron bi-sulphide, after which the iron proto-sulphide was separated by means of a magnet.

The remaining green particles were fused with mixed alkalies, and analyzed, with the following result, viz:

| | |
|---|---|
| Silica | 58.120 |
| Iron and manganese oxides and alumina | 32.398 |
| Lime | .784 |
| Magnesia | .807 |
| Phosphoric acid | .102 |
| Alkalies and loss | 7.789 |
| Total | 100.000 |

The proportion of the green particles in the limestone was not ascertained, but the whole material fused readily before the blow-pipe, with intumescence, into a dark colored slag. Some of the original limestone was also examined as to its alkaline ingredients, and was found to yield: of potash, 3.372

per cent.; of soda, .319 per cent.; so that there is little doubt that the green particles are glauconite.

As to the probable economic uses of this green limestone layer, little can be said. Some of it was calcined, in a powdered state, and tested as to its availability in the manufacture of hydraulic cement, but it was found not to harden in water. Possibly calcination with more lime might develop this property. It is possible, also, that careful calcination alone, or with more lime, might make it available as an alkaline fertilizer.

## NICHOLAS COUNTY.

No. 2068—"MINERAL WATER. *Re-examination of the salt sulphur water of the celebrated Lower Blue Lick Spring.*"

About twenty-seven years have passed since the present writer submitted this water to a quantitative chemical analysis, the results of which, published at the time, are reproduced in volume III of the first series of Reports of the Geological Survey of Kentucky (see pages 361 to 368). Desiring to ascertain whether any material change had occurred during this lapse of time, in the general composition of this water, and also to search for and determine some of its minuter ingredients, not at that time sought for, a new examination was made of it; Messrs. Hamilton, Gray & Co., of Maysville, having kindly placed at the disposal of the writer a barrel of the recent water.

The comparative results of the two analyses, made twenty-seven years apart, show a remarkable resemblance, proving that this celebrated water has not been sensibly weakened or altered in composition during this period, as follows:

COMPOSITION IN 1000 MEASURED PARTS OF THE WATER.

| | Analysis 1850. | Analysis 1877. |
|---|---|---|
| Specific gravity | 1.007 | 1.0072 |
| Sulphuretted hydrogen gas | 0.3947 | not determ'd. |
| Free carbonic acid gas | .3547 | not determ'd. |
| Lime carbonate | 0.3850 | 0.3184 |
| Magnesia carbonate | .0022 | .0211 |
| Alumina, phosphate of lime and iron carbonate | .0058 | .0038 |
| Sodium chloride | 8.3473 | 8.3571 |
| Potassium chloride | .0227 | .1860 |
| Magnesium chloride | .5272 | .4864 |
| Magnesium bromide | .0039 | .0195 |
| Magnesium iodide | .0007 | .0003 |
| Lime sulphate | .5533 | .5508 |
| Potash sulphate | .1519 | . . . . . . . |
| Calcium chloride | . . . . . . . | .0606 |
| Lithium chloride | . . . . . . . | .0060 |
| Sodium sulphide | . . . . . . . | .0307 |
| Soda carbonate | . . . . . . . | .0140 |
| Soda bi-borate | . . . . . . . | .0298 |
| Baryta sulphate | . . . . . . . | .0002 |
| Strontia sulphate | . . . . . . . | .0011 |
| Silicic acid | .0179 | .0149 |
| Organic acids and loss | .2821 | .4573 |
| Total saline matters in 1000 parts | 10.3000 | 10.5580 |

The minuter ingredients discovered in this water, in this more complete analysis, are compounds of lithium, barium, strontium, and boron, as well as small quantities of sodium sulphide and soda carbonate.

The two latter compounds, with the soda bi-borate, give a slightly alkaline reaction to the water, and the sodium sulphide gives it greater durability as a *sulphur* water than the hydrogen sulphide alone does. The notable proportion of soda bi-borate doubtless adds to its medicinal virtues. As for the compounds of barium and strontium, they are in so small proportions, and probably in the nearly inert form of sulphates, that it is doubtful whether any influence can be attributed to them. It has not been fully determined whether the compounds of lithium, in such small quantities as they are usually found in mineral waters, exert any curative influence whatever; but doubtless these, as well as the other minute ingredients, are not without effect in this complex solution. Practical experience alone in the use of such waters must determine these questions.

OHIO COUNTY.

IRON ORES.

No. 2069—"CLAY IRONSTONE, *from Wm. Downs' 'Iron Mountain.' Rough creek, above Hartford, near the base of the coal measures. Second bed, three to six inches thick. Collected by C. J. Norwood.*"

A compact, fine granular, dark-grey ore. Not adhering to the tongue. Exterior thinly incrusted with limonite.

No. 2070—"CLAY IRONSTONE. *From the same locality. Third ore bed. Composed of two layers, with a thin clay parting, measuring from three to four and two to four inches, severally. Collected by C. J. Norwood.*"

Resembles the preceding.

No. 2071—"CLAY IRONSTONE. *From the same locality. Fourth ore bed. Six inches thick. Collected by C. J. Norwood.*"

Resembles the preceding, but has more exterior limonite.

COMPOSITION OF THESE CLAY IRONSTONES, DRIED AT 212° F.

| | No. 2069. | No. 2070. | No. 2071. |
|---|---|---|---|
| Iron carbonate | 60.012 | 69.117 | 48.211 |
| Iron peroxide | not est. | not est. | 9.227 |
| Alumina and manganese oxide | 11.451 | 7.437 | 7.307 |
| Lime carbonate | 4.430 | 4.780 | 5.880 |
| Magnesia carbonate | 5.395 | 4.639 | 4.298 |
| Phosphoric acid | .377 | .786 | 1.805 |
| Sulphuric acid | trace. | .084 | .030 |
| Silica and insoluble silicates | 17.280 | 11.480 | 19.850 |
| Water and organic matters | 1.055 | 1.677 | 3.392 |
| Total | 100.000 | 100.000 | 100.000 |
| Percentage of iron | 29.557 | 32.294 | 29.484 |
| Percentage of phosphorus | .146 | .343 | .475 |
| Percentage of sulphur | trace. | .034 | .012 |
| Percentage of silica | 13.860 | 6.860 | 17.460 |

While these claystone ores could not be made to compete with limonite ores of favorable composition in the production of the best tough iron, they may yet be made available in the vicinity of abundant cheap fuel and limestone, for the production of cheap iron for many uses. Of course the preliminary of roasting these ores will be necessary.

No. 2072—"LIMESTONE, *under Coal A, Ben's Lick Hill. On the hill above Brown's Coal Bank, three miles southwest from Hartford, Ohio county. Collected by C. J. Norwood.*"

A compact or fine granular fossiliferous limestone, of a dirty grey color, presenting a somewhat brecciated appearance in parts, with ferruginous stains in the veins.

No. 2073—"LIMESTONE, *ferruginous, below Coal D, on Rough creek, mouth of Brush creek, three miles below Hartford. Collected by C. J. Norwood.*" (*Will it serve for cement?*)

A compact or very fine-grained limestone. Interior generally dark slate-grey; exterior, and in the veins, ochreous. Somewhat brecciated in parts.

Some of this rock, in the state of powder, was heated to redness in an open crucible, for an hour and a half, then mixed into a stiff paste with cold water—a portion with sand, and a part without sand; the wet lumps were exposed to a moist atmosphere for a day, and then immersed in water. The lump containing no sand *hardened completely;* that with the sand did not become so hard.

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

| | No. 2072. | No. 2073. |
|---|---|---|
| Lime carbonate | 90.780 | 41.680 |
| Magnesia carbonate | 1.501 | 22.748 |
| Alumina and iron and manganese oxides | 1.189 | 8.640 |
| Phosphoric acid | .371 | .153 |
| Sulphuric acid | not est. | not est. |
| Potash | .327 | 1.253 |
| Soda. | .100 | .323 |
| Silicious residue | 4.160 | 24.060 |
| Moisture and loss | 1.572 | 1.143 |
| Total | 100.000 | 100.000 |
| Percentage of lime | 50.837 | 23.341 |

While the first sample will yield very good lime for ordinary purposes, the second may make very good hydraulic cement by careful calcination. It does not require as much sand as other hydraulic limestones which contain a smaller proportion of silicious matters.

### CLAYS OF OHIO COUNTY.

No. 2074—"INDURATED CLAY, *below Coal F, mouth of Brush Run, on Rough creek. Collected by C. J. Norwood.*"

A dark-grey shaly-clay, with impressions and remains of reed-like leaves, and some ferruginous stains.

No. 2075—"CLAY, *from near Elm Lick, on R. B. Thompson's land. Coal measures. A good deal used in Louisville. Collected by C. J. Norwood.*"

An irregularly laminated clay, mottled with grey of various tints, and ferruginous infiltrations. Has some imperfect vegetable impressions, and minute glimmering specks of mica.

No. 2076—"CLAY, *from Bald Knob Church, Caney precinct, on the Pinchico road, about two feet below a coal bed. Collected by C. J. Norwood.*"

In friable lumps, showing imperfect and irregular stratification. Of a light bluish-grey color, with infiltrations of ochreous and ferruginous, occasionally nearly black, especially in the cracks and along the course of rootlets which have penetrated it. Before the blow-pipe it appears to be quite refractory, not fusing, but softening and shrinking somewhat into a hard, porcelain-like, nearly white mass. When not so intensely heated it burns of a light salmon color.

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

| | No. 2074. | No. 2075. | No. 2076. |
|---|---|---|---|
| Silica | 69.260 | 70.860 | 62.760 |
| Alumina | 16.640 | 19.240 | 26.420 |
| Iron oxide | 4.520 | 3.120 | 1.580 |
| Lime | a trace. | a trace. | .325 |
| Magnesia | .893 | .425 | a trace. |
| Phosphoric acid | a trace. | a trace. | not est. |
| Potash | 3.102 | 2.351 | .916 |
| Soda | .210 | .253 | .268 |
| Water and loss | 5.375 | 3.751 | 7.731 |
| Total | 100.000 | 100.000 | 100.000 |

No. 2076 contains 5.3 per cent. of fine transparent colorless sand grains. This seems to be a very good fire-clay.

OLDHAM COUNTY.

SOILS.

No. 2077—"VIRGIN SOIL, *from the surface, and to the depth of thirteen inches. From the farm of Dr. Coy Kaye, Pewee Valley. Upper Silurian formation. Forest growth: beech, oak, poplar, black gum, &c. Soil better than usual in this locality. Collected by John H. Talbutt.*"

Dried soil, of a brownish-grey color; friable; contains no gravel. Its silicious residue all passed through the bolting-cloth.

No. 2078—"SUBSOIL *of the preceding,*" *&c., &c.*

Dried subsoil of a bright brick color, somewhat cloddy. Contains no gravel. The bolting-cloth separated, from the silicious residue, a very few small rounded quartz grains.

No. 2079—"SURFACE SOIL, *from white oak land, Pewee Valley. Collected by A. W. Kaye.*" *Uncultivated.*

The dried soil is in friable clods, of a dark umber-grey color. Contains no gravel. The silicious residue, left after digestion in acids, all passed through the bolting-cloth, except a few small milky quartz grains.

No. 2080—"SUBSOIL *to the preceding,*" *&c., &c.*

The dried subsoil is generally of a dark, orange-buff color, mottled with light grey and ferruginous. It contains some nearly black concretions and infiltrations. The clods are somewhat firm. It contains a few small fragments of weathered chert. The bolting-cloth separated, from the silicious residue, some hard particles—reddish and white—of undecomposed silicates, resembling felspar.

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

| | No 2077. | No. 2078. | No. 2079. | No. 2080. |
|---|---|---|---|---|
| Organic and volatile matters | 4.612 | 3.016 | 4.215 | 3.250 |
| Alumina and iron and manganese oxides | 4.449 | 8.882 | 5.010 | 9.008 |
| Lime carbonate | .145 | .195 | .245 | .220 |
| Magnesia | .313 | .304 | .250 | .178 |
| Phosphoric acid | .141 | .098 | .125 | .077 |
| Sulphuric acid | not est. | not est. | not est. | not est. |
| Potash | .388 | .521 | .138 | .349 |
| Soda | .055 | .117 | .035 | .330 |
| Water, expelled at 380° F. | .713 | .607 | 1.535 | 1.150 |
| Sand and insoluble silicates | 88.665 | 86.465 | 88.240 | 84.825 |
| Total | 99.481 | 100.205 | 99.793 | 99.387 |
| Hygroscopic moisture | 1.900 | 2.875 | 1.850 | 3.300 |
| Potash in the insoluble silicates | 1.281 | 1.109 | 1.428 | 1.088 |
| Soda in the insoluble silicates | .381 | .444 | .663 | .022 |
| Character of the soil | Virgin soil. | Subsoil. | Surface soil | Subsoil. |

Soils Nos. 2077, 2078, and 2080 are exceptionally rich in potash; the other contains an average amount. The subsoils in both samples are somewhat deficient in phosphoric acid. These may be classed as good rich soils, but their productiveness might be improved and maintained by increasing their proportion of *humus* in a rotation of crops, and by the use of phosphatic fertilizers. It is also probable that plaster of Paris on the clover crop may be beneficial on soils Nos. 2077 and 2078.

TRIGG COUNTY.

No. 2081—"LIMONITE *iron ore. From a bank one mile south of Centre Furnace. Average sample, by P. N. Moore.*"

This ore is mostly in dense, hard, irregular hematitic layers, dark brown and nearly black, with but little of the softer ochreous ore.

COMPOSITION, DRIED AT 212° F.

| | | |
|---|---|---|
| Iron peroxide | 71.708 | = 50.195 per cent. of iron. |
| Alumina and manganese oxide | .945 | |
| Lime carbonate | trace. | |
| Magnesia | trace. | |
| Phosphoric acid | .217 | = .095 per cent. of phosphorus. |
| Sulphuric acid | trace. | |
| Combined water | 9.630 | |
| Silicious residue | 17.280 | = 16.960 per cent. of silica. |
| Total | 99.780 | |

This is quite a rich and pure ore, which would doubtless produce a very tough iron, provided the fuel and flux employed in the smelting process are free from sulphur and phosphorus.

PIG IRONS OF CENTRE AND TRIGG FURNACES, TRIGG COUNTY.

No. 2082—"PIG IRON NO. 1. *Foundry iron. From Centre Furnace. Collected by P. N. Moore.*"

A moderately coarse-grained grey iron. Yields readily to the file. Large fragments of it break readily, but the smaller ones extend considerably under the hammer.

No. 2083—"PIG IRON NO. 2. *Foundry iron. Centre Furnace. Collected by P. N. Moore.*"

Somewhat finer grained than the preceding, especially on the outer surfaces, and a little lighter colored. Yields readily to the file, and extends considerably under the hammer.

No. 2084—"PIG IRON NO. 3. *Mill iron. Centre Furnace,*" *&c., &c.*

Lighter colored, finer grained, and more brittle than the preceding.

No. 2085—"PIG IRON. *Mill iron. From Trigg Furnace,*" *&c., &c.*

Quite a fine grained grey iron. The small fragments extend considerable under the hammer. Yields to the file.

No. 2086—"PIG IRON. *Silver Grey. From Trigg Furnace, &c. Collected by P. N. Moore,*" as were also the above described.

Hard; easily splintered on the edges. The small fragments extend very little, before breaking, under the hammer.

COMPOSITION OF THESE CENTRE AND TRIGG FURNACE PIG IRONS.

| | No. 2082 | No. 2083. | No. 2084. | No. 2085. | No. 2086. |
|---|---|---|---|---|---|
| Specific gravity | 6.872 | 7.027 | 7.183 | 6.934 | 6.864 |
| Iron | 92.349 | 92.953 | 93.946 | 91.173 | 89.576 |
| Graphite | 3.380 | 3.140 | 2.860 | 3.400 | 1.000 |
| Combined carbon | . . . . . | 1.010 | 1.060 | . . . . . | 1.380 |
| Aluminum and manganese | not est. | not est. | not est. | not est. | not est. |
| Silicon | 3.794 | 2.641 | 1.932 | 4.592 | 6.637 |
| Slag | .660 | .100 | .360 | 1.160 | 1.560 |
| Phosphorus | .318 | .318 | .276 | .262 | .221 |
| Sulphur | .067 | .074 | .104 | .094 | .121 |
| Total | 100.568 | 100.236 | 100.538 | 100.681 | 100.495 |
| Total carbon | 3.380 | 4.150 | 3.920 | 3.400 | 2.380 |

These are all good samples of pig iron. The mill iron does not contain enough phosphorus to prevent it from producing good tough bar iron by judicious puddling.

WARREN COUNTY.

No. 2087—"MINERAL WATER. *Sulphur water. From a bored well two hundred and thirty feet deep. Smith's Grove, one hundred miles from Louisville, on the Louisville and Nashville Railroad. Sent by Junius Wooten, M. D.*"

The water was brought in tightly corked bottles, but when it arrived at the laboratory the hydrogen sulphide had all been decomposed; it was slightly opalescent, probably from the consequent precipitation of sulphur. It is slightly alkaline.

As there was an insufficient quantity of the water, a complete analysis could not be made; but from the preliminary examination of it, the following provisional summary of its composition is given: hydrogen sulphide gas, quantity not estimated; carbonic acid gas, not estimated.

SALINE CONTENTS.

| | | |
|---|---|---|
| Lime carbonate | 0.1445 | Dissolved by the carbonic acid. |
| Magnesia carbonate | .0177 | |
| Strontia carbonate | not est. | |
| Lime sulphate | .0998 | |
| Magnesia sulphate | .2856 | |
| Potash sulphate | .0041 | |
| Soda sulphate | .0213 | |
| Sodium chloride | .0520 | |
| Lithium chloride | not est. | |
| Soda carbonate | .0381 | |
| Silica | .0022 | |
| Ingredients undetermined and loss | .2547 | |
| Saline ingredients in 1000 parts | 0.7200 | |

It is desirable that a more thorough analysis should be made of this water, which seems to be a good saline sulphur water, which may be made serviceable in the treatment of various ailments.

This well is within six miles of the Chalybeate and Chameleon Springs of Edmonson county, and its use is said by Dr. Wooten to be beneficial in dyspepsia and indigestion, &c. The spectroscope showed in it traces of lithium and strontium compounds.

# APPENDIX.

## TEXAS CRETACEOUS SOILS.

With a view to comparison with our Kentucky soils, some of the black soils from the cretaceous formation of Texas were analyzed.

No. 2088—"BLACK SANDY SOIL. *From three miles northwest of Sherman, Grayson county, Texas. Prairie soil, in cultivation. Collected by Mr. Jesse H. Talbutt.*"

A dark, mouse-colored sandy soil, containing many fragments of roots, &c. The silicious residue, after digestion in acids, all passed through the bolting-cloth, except a small quantity of colorless, transparent, rounded grains of quartz.

No. 2089—"SOIL. *From 'black waxy' land, half a mile east of Sherman, farm of H. H. Allen. Prairie land. Collected by Mr. Jesse H. Talbutt.*"

Quite an adhesive soil; in clods; of a greyish-black color. The silicious residue all passed through the bolting-cloth.

No. 2090—"SOIL. *From 'black waxy' land, H. M. Stone's, two miles west of Playno, Collins county, Texas. Prairie land, in corn. Collected by Mr. Jesse H. Talbutt.*"

Not quite so black as the preceding; not in clods; friable. Effervesces strongly with acids.

COMPOSITION OF THESE TEXAS SOILS, DRIED AT 212° F.

| | No. 2088. | No. 2089. | No. 2090. |
|---|---|---|---|
| Organic and volatile matters | 4.977 | 7.233 | 7.097 |
| Alumina and iron and manganese oxides | 2.616 | 8.157 | 11.447 |
| Lime carbonate | .880 | 1.745 | 17.085 |
| Magnesia | .169 | .223 | .231 |
| Phosphoric acid | .124 | .083 | .143 |
| Sulphuric acid | not est. | not est. | not est. |
| Potash | .078 | .211 | .497 |
| Soda | .052 | .051 | . . . . . |
| Water, expelled at 380° F. | .799 | 1.391 | 1.660 |
| Sand and insoluble silicates | 89.690 | 80.690 | 61.840 |
| Total | 99.385 | 99.784 | 100.000 |
| Hygroscopic moisture | 3.075 | 0.665 | 0.850 |
| Potash in the insoluble silicates | 0.670 | 0.764 | 0.443 |
| Soda in the insoluble silicates | .322 | .159 | .307 |
| Character of the soil | Bl'k sandy. | Bl'k waxy. | Bl'k waxy. |

These Texas prairie soils differ from most of our Kentucky soils in their smaller proportion of alkalies in the silicious residue; they also present a larger quantity of carbonate of lime, which is very large in soil No. 2090, and which helps to give the waxy character to the land. The so-called black sandy soil is quite deficient in potash, and would not prove durably productive without the continued use of fertilizers. The richest of them all is No. 2090. The rock substratum to these soils is an indurated chalk, the imperfect analysis of which is given below.

No. 2091—"INDURATED CHALK ROCK. *From near Sherman, Texas. Collected by Mr. Jesse H. Talbutt.*"

A whitish, somewhat friable rock, stained irregularly with light ferruginous. Adheres firmly to the tongue.

COMPOSITION, DRIED AT 212° F.

| | |
|---|---|
| Lime carbonate | 86.270 |
| Magnesia carbonate | trace. |
| Alumina and iron and manganese oxides | 2.980 |
| Silicious residue | 10.276 |
| Alkalies, phosphoric acid, &c. | not det'd. |
| Total | 99.526 |

No doubt the action of the large quantity of carbonate of lime, derived from this soft substratum, in gradually decomposing the silicates of the soil, is the cause of the rather small proportion of the alkalies in the insoluble silicates of the silicious residue.

CHEMICAL EXAMINATION OF THE ASHES OF THE HUNGARIAN GRASS (PANICUM GERMANICUM) AND GERMAN MILLET (PANICUM ——).

No. 2092—"HUNGARIAN GRASS (*black-headed*), *taken roots and all, the leaves being nearly all green, and the seeds in the soft or doughy state. Plants about three feet high, in the condition in which they are generally mown for hay.*"

The field on which they were grown had been in winter rye, which had been all grazed down by cattle, and the cattle had been fed with corn fodder on the ground during the winter. The grass had been sown about the first of June, 1875, and it was mown August 9th to 13th. Rich blue-grass soil. Farm of R. Peter, Newtown Turnpike.

The quantity taken for analysis; weighing 524 grammes in the green state, after washing it in the evening and subsequent drying through the night; grew on less than a square foot of surface, and when thoroughly air-dried weighed 182 grammes, or 34.751 per cent. of the green plants, No. 2093—"HUNGARIAN GRASS, *same variety as the preceding. From the adjoining farm of Mr. C. M. Keiser; gathered June 27th*, 1876.

Plants three to three and a half feet high. The heads just forming.

No. 2094—"GERMAN MILLET. *From a field of ten acres, just outside the city limits of Lexington, on the Newtown Turnpike; property of Mr. J. K. Drake.*"

This field has been fully seventy-six years in cultivation, mostly in corn and garden stuffs, with occasional small grain. Five years ago it was manured with seventy-five cart-loads of stable manure to the acre, and sowed in clover, which was allowed to remain until last year, when the ground was put in hemp, which was rotted on the same surface. The clover was mowed only one year, and in the other years very few cattle were grazed on it; so that most of it rotted on the ground. The German millet sown this year, 1875-'6, gave seventeen stacks, estimated at two tons each, of hay, equal to more than three tons to the acre. The grass grew nearly five feet high, and was coarse and hard in the stalks. The sample, gathered about the time of mowing it, August 28th, had its heads heavy with ripe seed; lower leaves dead.

In the green state it weighed two hundred and four grammes. After two months air-drying in the laboratory it weighed ninety-six and a half grammes, of which there were thirty-seven grammes of seed. The stalks and leaves were incinerated separately from the seeds.

No. 2095—"THE SEEDS *of the above described sample.*"

For comparison, the analysis of the ash of the buckwheat and clover plants are appended (the latter in Table II), copied from a memoir by the writer (in volume II, pages 157, 158 (lower paging), Kentucky Geological Reports, second series).

TABLE I. COMPOSITION, CALCULATED IN 100 PARTS OF THE ASH. CARBONIC ACID EXCLUDED.

| | No. 2092. | No. 2093. | No. 2094. | No. 2095. | Vol. 2, p. 158,* second series, Geological Reports. |
|---|---|---|---|---|---|
| | Hungarian grass. | Hungarian grass. | German millet, stalks and leaves. | German millet, seeds. | Buckwheat plants in flower |
| Lime | 0.957 | 0.937 | 11.330 | 7.711 | 33.434 |
| Magnesia | .490 | 1.260 | 3.237 | 6.916 | 10.518 |
| Alumina and iron and manganese oxides | 2.090 | 3.378 | 3.624 | 1.690 | not est. |
| Potash | 21.724 | 47.707 | 32.609 | 24.265 | 32.900 |
| Soda | .167 | .135 | .474 | . . . . . . . | 1.266 |
| Phosphoric acid | 9.170 | 10.033 | 10.776 | 16.994 | 16.824 |
| Sulphuric acid | .811 | 2.008 | .717 | .578 | 1.378 |
| Chlorine | .097 | 2.620 | .243 | .319 | .431 |
| Silica, soluble | 1.914 | .254 } | 37.070 | 40.387 | { 3.249 |
| Silica, insoluble | 61.835 | 31.609 } | | | . . . . . . |
| Total | 99.265 | 99.941 | 100.080 | 98.860 | 100.000 |
| Percentage of ash to dried plants | 8.067 | 6.461 | 4.968 | 2.505 | 8.762 |
| Percentage of ash to green plants | 2.802 | not est. | 2.350 | . . . . . . . | 1.577 |
| Percentage of dried to green plants | 34.751 | not est. | 47.300 | . . . . . . . | 18.000 |

* The lower paging.

TABLE II. COMPOSITION OF THE ASH OF THESE PLANTS, SEEDS, &c. CARBONIC ACID EXCLUDED. CALCULATED IN 100 PARTS OF THE DRIED PLANTS, &c.

| | No. 2092. | No. 2093. | No. 2094. | No. 2095. | Vol. 2, p. 158,* second series, Ky. Geological Reports. | Vol. 2, p. 157,* second series, Ky. Geological Reports. |
|---|---|---|---|---|---|---|
| | Hungarian grass. | Hungarian grass. | German millet, stalks and leaves. | German millet, seeds. | Buckwheat plants in flower | Clover plants. |
| Lime | 0.076 | 0.060 | 0.562 | 0.193 | 2.929 | 2.30 |
| Magnesia | .040 | .082 | .161 | .173 | .922 | .89 |
| Alumina, iron and manganese oxides | .168 | .218 | .180 | .042 | . . . . . . . | . . . . . . . |
| Potash | 1.752 | 3.082 | 1.619 | .608 | 2.883 | 2.30 |
| Soda | .013 | .009 | .023 | . . . . . . . | .111 | .10 |
| Phosphoric acid | .738 | .648 | .535 | .426 | 1.470 | .65 |
| Sulphuric acid | .065 | .130 | .037 | .015 | .120 | .20 |
| Chlorine | .007 | .169 | .012 | .008 | .038 | .25 |
| Silica, soluble | .155 | .016 } | 1.842 | 1.012 | { .285 | .20 |
| Silica, insoluble | 5.069 | 2.042 } | | | . . . . . . . | . . . . . . . |

* The lower paging.

It can be seen in these tables that the ash of the Hungarian grass, as well as that of the German millet, is remarkably silicious, and that a large portion of the silicious matter is in the insoluble condition.

At first, it was supposed that, although care had been taken to wash the plants thoroughly, much of this silicious matter might be excluded from the results of the analyses, as sand accidentally derived from the soil, and adherent as dust to the plants; but a more thorough examination, with the aid of the microscope, in the hands of our experienced microscopist, Mr. Alexander T. Parker, showed that much of it was in the form of a silicious skeleton of the plant tissue. This fact was made more manifest by digesting portions of the stem and leaves in diluted nitric acid, with and without the addition of chlorate of potash, until the organic matters were mostly decomposed and removed, when beautiful silicious skeletons were obtained, which, under the microscope, showed silicious casts or incrustations of the vegetable cells, and curious dumb-bell forms, proving that the silicious matter, in a dissolved state, had penetrated through the cell walls, and changing into the insoluble form, had incrusted the interior of the cells.

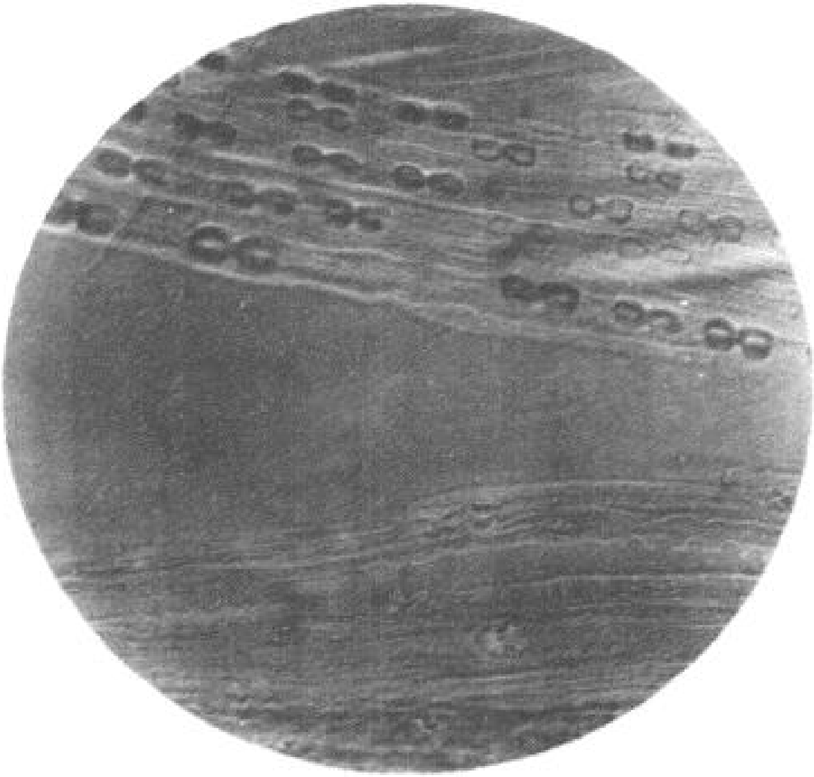
Some beautiful photographs were obtained by Mr. Parker, with the aid of our skilled photographer, James Mullen, directly from the enlarged microscopic images formed from the silicious residue, after digestion in the acid and subsequent ignition to destroy all the organic matters. The German millet gave fewer of the dumb-bell-like casts than the Hungarian grass, and the seeds of the former less than any.

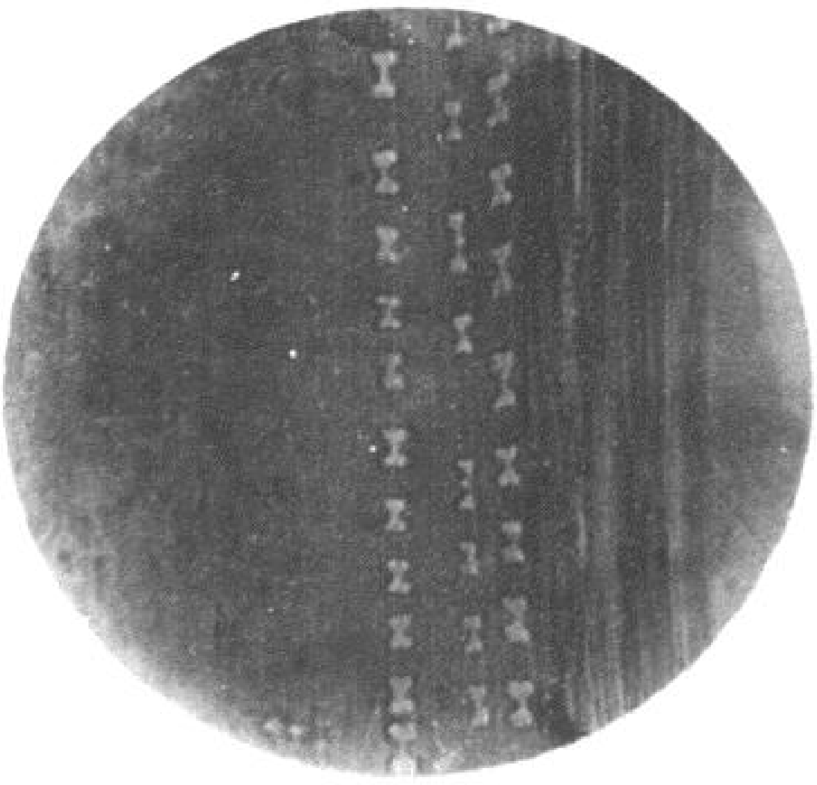
DESCRIPTION OF THE MICROSCOPIC PHOTOGRAPHS.

No. 1. Silicious material of the stem of Hungarian grass, which had been digested for several days in nitric acid diluted with six parts of water, to which chlorate of potash was added and thorough washing. Magnified about 312 diameters, and photographed by Alex. T. Parker.

No. 2. A similar preparation from the leaf of this plant. Magnified about 312 diameters, and photographed by Alex. T. Parker.

These photographs of the purely silicious skeletons of the tissue of the vegetable leaf and stem are interesting as exhibiting casts of the cells, produced, no doubt, by the infiltration





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of dissolved silicic acid, as also as showing, in their dumb-bell shapes, these cells apparently in the act of multiplication by the process of division.

It is well krown to chemists that silica, in its ordinary separated state in the soil, is almost completely insoluble in water or the ordinary acids; but it is also well known that it takes the unstable soluble form of silicic acid when separated, by the decomposition of silicates by the action of acids in the presence of water. Doubtless the acid sap of the plants, coming in contact with the silicates of the soil, by osmose, caused this decomposition, and the relative amount of the silicious incrustation of the plant cells may give some measure of this local individual plant action on the soil.

It is well known the Hungarian grass is a very vigorous growing plant, even on soils comparatively poor, and that it is a very rough feeder, seeming to have greater power of assimilating insoluble, or difficultly soluble, soil ingredients than most other cultivated plants. Moreover, as is seen, it is eminently silicious. All these facts seem to show that it in some manner dissolves or decomposes the silicates of the soil in a greater degree than is common to most growing vegetables.

It has been known for a length of time that certain vegetables, especially of the lichen family, corrode the limestone, or even the basaltic or granitic rock or glass, on which they grow, and that, as was ascertained by Braconnet, some of these plants are known to contain oxalate of lime to the extent of half their weight. Other plants, as those of the lycopodium family, possess the power of dissolving and absorbing alumina by means of malic acid which they produce; so that the compound of this earth, so rarely found in vegetable tissue, is present in them in large proportion. That the roots of most plants, while alive or growing, give an acid reaction, is well known, and easy to verify by placing them in contact with blue litmus paper or infusion; but what is the nature or relative quantity of the acid or acids secreted by the various species of vegetables, or how they may act on the soil to decompose it, and in what manner their action may modify the ash composition of the several plants, has not as yet been made a subject of systematic investigation.

It is well known that plants of different species, growing in precisely the same soil, will vary greatly in their mineral or ash constituents; and the late Baron Liebig was perhaps the first to declare (see Natural Laws of Husbandry, edited by John Blyth, M. D., New York, 1863, page 118) that "plants receive their food principally from the earthy particles with which the roots are in direct contact, out of a solution forming around the roots themselves." This solution, other things being equal, will vary according to the nature and quantity of the solvent, which solvent seems to be provided by the plants themselves, and secreted by the roots, and is evidently of an acid nature.

It is beginning to be generally understood that different plants secrete this acid solvent of the soil in different quantities, and probably of different strength and composition. Some of them, like the lichens which grow on the rock or lava surface, being able, by their special solvents, to extract their essential mineral elements from the hard material, which they thus decompose, while others, not being able to exert such a powerful decomposing and corroding agency, can only live on more soluble and available materials, which they may find in the decomposing remains of these pioneers of the vegetable world, or in solution in fertile soils generally.

To these special solvents—these peculiar digestive fluids of the vegetable kingdom—may very probably be attributed, in some measure, the special selective power of plants, by which different species, growing on the same soil, will appropriate to themselves not only very different quantities of the mineral elements, but different kinds of these matters; so that while one plant may be characterized by a large proportion of potash in its ash ingredients, another may always select a very large amount of lime, and yet another an unusual quantity of silica, &c., &c., and, practically, when a soil will no longer profitably produce one crop, it may yet be quite productive of another.

Some experiments of Dietrich, quoted in Johnson's "How Crops Feed" (pages 327–8), illustrate very clearly the different action of different plants in this relation. He caused these to grow in coarsely powdered sandstone and basalt rock, severally, watering them with equal quantities of distilled water, &c. He took also similar quantities of the same rocks and washed them with the same amount of the water, in order to exclude the mineral materials dissolved out of the rocks by the water alone. The special and very different solvent and decomposing action of the several plants on the rock materials is clearly shown in the following table, which we quote:

MATTERS DISSOLVED BY ACTION OF ROOTS.

| | On 9 lbs. of sandstone. | On 11 lbs. of basalt. |
|---|---|---|
| Of 3 lupin plants | 0.608 grams. | 0.749 grams. |
| Of 3 pea plants | .481 " | .713 " |
| Of 20 spurry plants | .268 " | .365 " |
| Of 10 buckwheat plants | .232 " | .327 " |
| Of 4 vetch plants | .221 " | .251 " |
| Of 8 wheat plants | .027 " | .196 " |
| Of 8 rye plants | .014 " | .132 " |

The three pea plants extracted from these hard rocky materials more than forty times as much as the eight rye plants, and nearly twenty times as much as the eight wheat plants, under the same external conditions.

From the large proportion of ash ingredients in the Hungarian grass, and especially of silica, and its rank growth, it was considered probable by the present writer that it exerted an unusually great "root action" on the soil, by means of an acid solvent. To verify this supposition, some of this grass was gathered by him early in July, 1877, just as it was beginning to form its heads, and submitted to examination. The moistened roots, placed in contact with blue litmus paper, reddened it decidedly. A handful of the entire plants, which had been pulled up by the roots, the dirt having been shook off as completely as possible, was placed with the roots immersed in a saturated cold solution of carbonate of ammonia, and allowed to remain for twenty-four hours. The solution, which had become of a light brown color, was then evaporated to dryness at a heat below 212° F. It left a dark brown residue, which was re-dissolved in water, filtered and precipitated with a solution of acetate of lead and a little ammonia. This precipitate, after washing with cold water, was suspended in water and decomposed with hydrogen sulphide, &c., and the filtrate, still somewhat colored, was tested for acids in the usual manner. It was found that oxalic and phosphoric acids were present in marked quantities, together with some malic acid, and probably a small amount of tartaric. Tannic acid was not observed.

Some of the same grass was gathered July 23d, when the seeds were beginning to ripen, and submitted to the same process, with very nearly the same results; the oxalic and phosphoric acids being found in largest proportions.

Some *buckwheat* plants, gathered on September 4th and 6th, when they were in full flower, were treated in a similar manner. Two handfuls of the plants were placed, successively, with roots immersed in the same saturated solution of carbonate of ammonia, each being allowed to remain in it twenty-four hours. The solution, which became also of a brownish color, treated in the manner above described, gave marked evidence of the presence of oxalic and phosphoric acids, with a notable quantity of malic acid, and small proportions of other vegetable acids; but no tannic acid could be detected with iron perchloride. The buckwheat roots did not react so decidedly acid with litmus paper as those of the Hungarian grass.

Although in these experiments the strong chemical affinity of the alkaline carbonate of ammonia may have caused the exosmose of more of the dissolved acids of the plant-sap than would pass out into any ordinary soil, and may have even exerted some decomposing action on the soft tissues or the fluids of the plants themselves, yet they are not without some value as indicating how, possibly, the plant may form a special solution, different probably for different species, in the immediate vicinity of the rootlets, of mineral substances in the soil which may be insoluble in the ordinary surface waters. Researches into the nature of the special soil solvents of different plants may aid the practical farmer in the selection of crops in an ameliorating rotation, as it seems highly probable that some kinds of vegetables can exert a more powerful decomposing action on the silicates of the soil than others.

## TABLE I. SOILS, SUBSOILS, UNDER-CLAYS, &c., DRIED AT 212° F.

| Number in Report. | County. | Organic and volatile matters.* | Alumina and iron and manganese oxides. | Lime carbonate. | Magnesia. | Phosphoric acid. | Potash | Soda. | Sand and insoluble silicates. | Water, expelled at 380° F. | Water, expelled at 212° F. | Potash in the insoluble silicates. | Soda in the insoluble silicates. | Remarks. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1967 | Allen . . . . . | 2.215 | 3.616 | 0.110 | 0.106 | 0.019 | 0.144 | 0.489 | 92.980 | 0.650 | 0.950 | 0.992 | 0.253 | Virgin soil, Buncombe tract. |
| 1968 | Allen . . . . . | 2.045 | 5.872 | .030 | .097 | .013 | .160 | .312 | 90.840 | .615 | 1.250 | .958 | .269 | Subsoil of the above. |
| 1969 | Allen . . . . . | 5.475 | 5.629 | .520 | .124 | .156 | .148 | .210 | 85.740 | 2.200 | 2.425 | .958 | .314 | New upland soil, W. H. H Mitchell's. |
| 1970 | Allen . . . . . | 4.000 | 7.394 | .470 | .097 | .141 | .380 | .175 | 85.090 | 1.625 | 2.215 | .853 | .242 | Subsoil to the same. |
| 1971 | Allen . . . . . | 2.745 | 5.452 | .070 | .079 | .083 | .221 | .143 | 90.440 | .865 | 1.175 | 1.081 | .354 | Old field, same locality, &c. |
| 1972 | Allen . . . . . | 2.450 | 8.090 | .080 | .140 | .045 | .219 | .115 | 88.040 | .850 | 1.550 | 1.188 | .258 | Subsoil to the same. |
| 1973 | Barren . . . . | 4.175 | 7.365 | .215 | .197 | .125 | .209 | . . . . | 86.065 | 1.575 | 1.805 | 1.227 | .394 | Virgin soil, barrens, Maj. J. S. Barlow. |
| 1974 | Barren . . . . | 5.475 | 7.740 | .465 | .250 | .275 | .126 | .004 | 84.990 | 2.275 | 2.500 | 1.074 | .334 | Old field, same locality, &c. |
| 1975 | Barren . . . . | 2.615 | 8.323 | .090 | .197 | .092 | .308 | . . . . | 86.665 | .935 | 1.775 | 1.253 | .373 | Subsoil of the two preceding |
| 1976 | Barren . . . . | 5.465 | 4.310 | .340 | .047 | .125 | .184 | .029 | 87.470 | 1.600 | 2.150 | .934 | .300 | Virgin soil (silicious grit), D. Davasher's. |
| 1977 | Barren . . . . | 3.065 | 4.942 | .225 | .065 | .093 | .158 | .053 | 90.185 | 1.015 | 1.500 | 1.102 | .318 | Old field, same locality. |
| 1978 | Barren . . . . | 2.300 | 6.142 | .125 | .080 | .093 | .092 | .055 | 89.985 | .800 | 1.700 | 1.179 | .256 | Subsoil of the next preceding. |
| 1979 | Barren . . . . | 4.700 | 4.632 | .425 | .061 | .118 | .069 | .060 | 87.985 | 1.650 | 2.100 | .722 | .234 | Virgin soil (silicious grit), Mrs. M. E. Davis |
| 1980 | Barren . . . . | 3.450 | 4.622 | .190 | .061 | .198 | .126 | .024 | 89.685 | 1.300 | 1.650 | 1.223 | .381 | Old field, same locality, &c. |
| 1981 | Barren . . . . | 2.415 | 6.186 | .190 | .065 | .124 | .225 | .086 | 89.650 | 1.000 | 1.735 | 1.151 | .318 | Subsoil of next preceding. |
| 1982 | Barren . . . . | 4.150 | 5.967 | .475 | .017 | .093 | .105 | . . . . | 87.710 | 1.325 | 1.800 | 1.156 | .372 | Old field, bottom land, same locality. |
| 1983 | Barren . . . . | 3.725 | 6.034 | .475 | .115 | .131 | .161 | . . . . | 87.835 | 1.375 | 1.900 | 1.127 | .446 | Subsoil of next preceding. |
| 1999 | Fayette . . . . | 4.325 | 12.168 | .295 | .214 | .492 | .268 | .038 | 80.090 | 1.800 | 2.850 | 1.343 | .359 | Surface soil, lawn at Ashland. |
| 2000 | Fayette . . . . | 3.535 | 15.666 | .345 | .331 | .604 | .372 | . . . . | 77.715 | 1.300 | 3.375 | 1.273 | .332 | Subsoil of the same. |
| 2008 | Grant . . . . . | 5.515 | 13.849 | 1.420 | .513 | .636 | .952 | .082 | 77.640 | Included in the water and organic matters lost on ignition. | 5.710 | 2.524 | .499 | Subsoil, cut at station 295, section 29, C. S. R. R. |
| 2009 | Grant . . . . . | 5.400 | 12.675 | 1.465 | .600 | .435 | .780 | .617 | 78.965 | | 5.950 | 2.511 | 1.214 | Under-clay (hard pan?), same locality. |
| 2010 | Grant . . . . . | 5.425 | 6.847 | .200 | .420 | .188 | .568 | .317 | 86.165 | | 2.750 | 1.087 | .388 | Top soil, old fi'd, cut, st'n 30, sec. 30, C. S. R. R. |
| 2011 | Grant . . . . . | 4.100 | 9.199 | .190 | .420 | .086 | .156 | .368 | 85.460 | | 3.400 | 1.958 | .260 | Subsoil of same. |
| 2012 | Grant . . . . . | 4.450 | 11.672 | .165 | .398 | .188 | .579 | .104 | 82.490 | | 3.825 | 1.533 | .638 | Subsoil, just under next preceding. |
| 2013 | Grant . . . . . | 5.600 | 12.564 | .225 | .609 | .236 | .259 | .246 | 80.115 | | 5.950 | 2.004 | .397 | Under-clay, just under next preceding. |
| 2014 | Grant . . . . . | 4.950 | 15.237 | 2.290 | .383 | .823 | 1.124 | .019 | 75.240 | | 6.575 | 2.410 | .407 | Under-clay, just under next preceding. |
| 2015 | Grant . . . . . | 4.425 | 24.465 | 9.425 | .286 | .589 | .669 | .245 | 59.940 | | 5.250 | 2.703 | .265 | Under-clay, just below next preceding. |
| 2016 | Grant . . . . . | 4.365 | 17.502 | 1.115 | .151 | .473 | .809 | .052 | 75.090 | | not est. | 1.542 | .297 | Subsoil, section 33, second cut from north end. |
| 2017 | Grant . . . . . | 4.675 | 27.353 | 4.555 | .266 | .457 | 1.585 | .125 | 60.967 | | not est. | 1.487 | .212 | Under-clay, same locality. |
| 2018 | Grant . . . . . | 5.675 | 9.540 | .575 | .312 | .345 | .587 | . . . . | 83.790 | | not est. | 1.679 | .510 | Surface soil, sec. 34, second cut from south end. |
| 2019 | Grant . . . . . | 3.780 | 10.222 | .290 | .266 | .313 | .150 | . . . . | 84.890 | | not est. | 1.881 | .552 | Subsoil, same locality. |
| 2020 | Grant . . . . . | 6.290 | 18.593 | .275 | .408 | .393 | .611 | .165 | 73.575 | | not est. | 1.489 | .486 | Under-clay, same locality. |
| 2021 | Grant . . . . . | 6.085 | 15.437 | 1.225 | .679 | .473 | .809 | .066 | 75.890 | | not est. | 2.428 | .376 | Under-clay, below last, same locality. |
| 2022 | Grant . . . . . | 4.290 | 11.792 | 8.240 | .824 | .793 | 1.778 | .359 | 71.924 | | not est. | 2.423 | .324 | Under-clay, just below preceding. |
| 2023 | Grant . . . . . | 4.650 | 7.225 | .470 | .303 | .185 | .738 | . . . . | 87.065 | | not est. | 1.812 | .722 | Top soil, sec. 35, cut at north end, C. S. R. R. |
| 2024 | Grant . . . . . | 3.940 | 9.852 | .390 | .447 | .358 | .282 | . . . . | 84.760 | | not est. | 1.673 | .677 | Subsoil, same locality. |
| 2025 | Grant . . . . . | 5.400 | 16.827 | 1.640 | .645 | .358 | .213 | .337 | 75.040 | | not est. | 2.103 | .433 | Under-clay, same locality. |
| 2026 | Grant . . . . . | 4.450 | 14.492 | 2.315 | .609 | .358 | .760 | . . . . | 77.440 | | not est. | 2.851 | .417 | Under-clay, below preceding. |
| 2027 | Grant . . . . . | 5.025 | 21.124 | 4.305 | .480 | .361 | .210 | .308 | 68.515 | | not est. | 2.700 | .378 | Under-clay, next below preceding. |
| 2028 | Grant . . . . . | 5.850 | 23.100 | 3.640 | .283 | .505 | .534 | . . . . | 66.390 | | not est. | 2.865 | .449 | Under-clay, under preceding. |
| 2029 | Grayson. . . . | 3.239 | 3.096 | .080 | .097 | .144 | .160 | .268 | 91.865 | .506 | 1.200 | .927 | .262 | Virgin soil, over the Leitchfield marl. |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2030 | Grayson. . . . | 2.534 | 4.781 | .045 | .061 | .159 | .100 | .102 | 91.490 | .483 | 1.575 | 1.198 | .254 | Subsoil to the same. |
| 2034 | Hardin . . . . | 4.495 | 5.579 | .340 | .286 | .071 | .149 | .037 | 87.675 | 1.675 | 1.900 | 1.250 | .435 | Virgin soil, St. Louis limestone, Gov. Helm's. |
| 2035 | Hardin . . . . | 2.575 | 6.520 | .215 | .227 | .070 | .119 | . . . . | 89.140 | .950 | 1.510 | 1.037 | .376 | Old field soil, same locality. |
| 2036 | Hardin . . . . | 2.350 | 9.807 | .140 | .223 | .083 | .270 | . . . . | 85.590 | .925 | 2.050 | .848 | .265 | Subsoil of the two preceding. |
| 2037 | Hardin . . . . | 9.185 | 8.705 | 1.350 | .124 | .203 | .595 | .011 | 77.905 | 2.715 | 2.885 | 2.910 | 1.166 | Virgin soil, St. Louis Group, J. W. Fowler's. |
| 2038 | Hardin . . . . | 5.400 | 8.228 | .625 | .107 | .172 | .279 | .018 | 83.090 | 2.075 | 2.315 | 2.226 | .782 | Old field, same locality. |
| 2039 | Hardin . . . . | 4.500 | 8.347 | .465 | .142 | .123 | .175 | .077 | 84.440 | 2.000 | 2.265 | 1.137 | .733 | Subsoil of preceding |
| 2040 | Hardin . . . . | 4.610 | 6.033 | .390 | .070 | .102 | .316 | .098 | 86.335 | 1.625 | 1.815 | .956 | .197 | Virgin soil, St Louis Group, Vandecraft's. |
| 2041 | Hardin . . . . | 3.085 | 6.597 | .290 | .040 | .038 | .035 | .025 | 88.940 | 1.150 | 1.335 | 1.302 | .443 | Old field, same locality. |
| 2042 | Hardin . . . . | 3.550 | 11.254 | .215 | .025 | .061 | .251 | .168 | 83.490 | 1.550 | 2.575 | 1.329 | .256 | Subsoil of the preceding. |
| 2044 | Hopkins . . . | 2.850 | 4.952 | .080 | .106 | .083 | .145 | .050 | 90.540 | .737 | 1.085 | 1.693 | .687 | Virgin soil, woods, Mr. Miles' |
| 2045 | Hopkins . . . | 2.090 | 6.883 | trace. | .181 | .077 | .307 | . . . . | 89.700 | .660 | 1.285 | 1.458 | .697 | Subsoil of preceding. |
| 2049 | Logan. . . . . | 2.900 | 3.247 | .395 | .115 | .093 | .132 | . . . . | 92.350. | .875 | 1.435 | .890 | .301 | Virgin soil, bottom land, W. Morton's. |
| 2050 | Logan. . . . . | 2.585 | 7.095 | .210 | .196 | .115 | .169 | . . . . | 88.755 | .765 | 2.385 | 1.334 | .357 | Subsoil to next preceding soil. |
| 2051 | Logan. . . . . | 2.560 | 5.297 | .195 | .160 | .093 | .121 | .068 | 90.935 | .765 | 1.550 | 1.286 | .299 | Old field soil, same locality. |
| 2052 | Logan. . . . . | 3.925 | 8.315 | .640 | .346 | .125 | .060 | . . . . | 85.035 | 1.275 | 2.675 | 1.212 | .353 | Black soil, unproductive, H. B. Tully's. |
| 2053 | Logan. . . . . | 3.675 | 11.811 | .245 | .227 | .109 | .212 | .015 | 82.365 | .950 | 3.800 | 1.349 | .266 | Subsoil, St. Louis limestone, same locality. |
| 2054 | Logan. . . . . | 2.775 | 4.812 | .180 | .170 | .093 | .085 | . . . . | 91.090 | .600 | 1.250 | 1.474 | .532 | Old field soil, same locality. |
| 2055 | Logan. . . . . | 3.048 | 9.158 | .180 | .214 | .077 | .326 | .050 | 86.275 | .775 | 2.525 | 1.320 | .265 | Subsoil, from same locality. |
| 2060 | Madison . . . | 5.825 | 10.434 | .615 | .043 | .301 | .379 | .094 | 79.965 | 2.415 | 3.165 | 1.537 | .300 | Red Bud soil, Covington farm. |
| 2061 | McCracken . . | 2.050 | 5.497 | .115 | .268 | .093 | .167 | .171 | 90.940 | 1.000 | 1.425 | 1.700 | .598 | Surface soil, L. M. Flournoy's. |
| 2062 | McCracken . . | 2.650 | 12.300 | .190 | .521 | .115 | .284 | . . . . | 82.490 | 1.000 | 4.000 | 1.605 | .911 | Subsoil of the same. |
| 2063 | McCracken . . | 2.675 | 10.834 | .190 | .649 | .061 | .643 | .087 | 83.865 | 1.000 | 3.425 | 1.427 | .668 | Under clay of the same. |
| 2064 | Meade . . . . | 3.565 | 5.091 | .095 | .133 | .109 | .156 | . . . . | 89.725 | 1.000 | 1.600 | 1.297 | .471 | Virgin soil, sandstone, Waverly G'p, McCarty's. |
| 2065 | Meade . . . . | 5.665 | 15.741 | .070 | .242 | .140 | .425 | . . . . | 75.825 | 1.335 | 4.265 | 1.540 | .304 | Subsoil of the same. |
| 2066 | Meade . . . . | 3.600 | 11.604 | .045 | .538 | .156 | 1.082 | . . . . | 82.125 | .650 | 2.950 | 2.259 | .150 | Under-clay of the same. |
| 2077 | Oldham . . . . | 4.612 | 4.449 | .145 | .313 | .141 | .388 | .055 | 88.665 | .713 | 1.900 | 1.281 | .381 | Virgin soil, Pewee Valley, Upper Silurian. |
| 2078 | Oldham . . . . | 3.016 | 8.882 | .195 | .304 | .098 | .521 | .117 | 86.465 | .607 | 2.875 | 1.109 | .444 | Subsoil of the same. |
| 2079 | Oldham . . . . | 4.215 | 5.010 | .245 | .250 | .125 | .138 | .035 | 88.240 | 1.535 | 1.850 | 1.428 | .663 | Surface soil, white oak land, Pewee Valley. |
| 2080 | Oldham . . . . | 3.250 | 9.008 | .220 | .178 | .077 | .349 | .330 | 84.825 | 1.150 | 3.300 | 1.088 | .022 | Subsoil of the same. |
| | TEXAS SOILS. | | | | | | | | | | | | | |
| 2088 | Grayson. . . . | 4.977 | 2.616 | .880 | .169 | .124 | .078 | .052 | 89.690 | .799 | 3.075 | .670 | .322 | Black sandy soil, prairie, in cultivation. |
| 2089 | Grayson. . . . | 7.233 | 8.157 | 1.745 | .223 | .083 | .211 | .051 | 80.690 | 1.391 | .665 | .764 | .159 | Black waxy soil, prairie land. |
| 2090 | Collins . . . . | 7.097 | 11.447 | 17.085 | .231 | .143 | .497 | . . . . | 61.840 | 1.660 | .850 | .443 | .307 | Black waxy soil, prairie land, in corn. |

*Or loss by ignition after drying at 212°.

## TABLE II. COALS, AIR-DRIED.

| Number in Report. | County. | Specific gravity. | Hygroscopic moisture. | Volatile combustible matters. | Coke. | Total volatile matters. | Fixed carbon in the coke. | Ash. | Character of the coke. | Color of the ash. | Percentage of sulphur. | Remarks. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1995 | Butler . . . . | not de'd | 3.28 | 44.20 | 52.52 | 47.48 | 48.56 | 3.96 | Spongy . . . . | Dark lilac-grey . . | 3.060 | Mining City Coal B'k, new op'ng, Mud Cr'k. |
| 2031 | Greenup. . . . | 1.345 | 6.33 | 32.42 | 61.25 | 38.75 | 53.30 | 7.95 | Dense spongy . | Light lilac-grey . . | 1.277 | Cane Cr'k Mine, new op'g, n'r Hun'w'l Fur. |
| 2032 | Greenup. . . . | 1.344 | 5.77 | 33.28 | 60.95 | 39.05 | 52.40 | 8.55 | Dense spongy . | Light lilac-grey . . | .900 | Same locality (sample 2). |
| 2033 | Greenup. . . . | 1.383 | 6.03 | 30.77 | 63.20 | 36.80 | 50.65 | 12.55 | Dense spongy . | Light lilac-grey . . | 1.458 | Same locality (sample 3). |
| 2058 | Madison . . . | not de'd | 3.57 | 36.53 | 59.90 | 40.10 | 55.77 | 4.13 | Light spongy . | Light yellowish-grey | .749 | Marshall Moran's Bank, Big Hill. |

## TABLE III. IRON ORES (LIMONITE ORES), DRIED AT 212° F.

| Number in Report. | County. | Iron peroxide. | Manganese oxide. | Alumina. | Lime carbonate. | Magnesia. | Phosphoric acid. | Sulphuric acid. | Combined water. | Silica and silicates. | Percentage of iron. | Percentage of phosphorus. | Percentage of sulphur. | Percentage of silica. | Remarks. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2056 | Lyon. . . . . . | 66.192 | 1.393 | | trace. | trace. | 0.185 | trace. | 10.000 | 22.910 | 46.320 | 0.079 | trace. | 21.820 | From Hall's patch drift. |
| 2057 | Lyon. . . . . . | 68.162 | 1.763 | | trace. | trace. | .505 | trace. | 9.630 | 20.150 | 47.703 | .220 | trace. | 19.060 | From Skillian Bank. |
| 2081 | Trigg . . . . . | 71.708 | .945 | | trace. | trace. | .217 | trace. | 9.630 | 17.280 | 50.195 | .095 | trace. | 16.960 | From one mile south of Centre Furnace. |

## TABLE IV. IRON ORES (CLAY IRON-STONES AND BLACK BAND ORES), DRIED AT 212° F.

| Number in Report. | County. | Specific gravity. | Iron carbonate. | Iron oxide. | Alumina and manganese oxide | Lime carbonate. | Magnesia carbonate. | Phosphoric acid. | Sulphuric acid. | Silica and silicates. | Per cent. of iron. | Per cent. of phosphorus. | Per cent. of sulphur. | Per cent. of silica. | Bituminous matters and water. | Remarks. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2046 | Jackson . . . . | not est | 70.168 | . . . | 0.430 | 0.930 | 2.898 | 0.345 | . . . | 6.230 | 33.875 | 0.151 | 0.264 | 4.960 | 18.540 | Black band ore, Coyle's Bank. |
| 2069 | Ohio . . . . . | not est | 60.012 | not est | 11.451 | 4.430 | 5.395 | .377 | trace. | 17.280 | 29.557 | .146 | trace. | 13.860 | 1.055 | From Wm. Downe's Iron Mountain. |
| 2070 | Ohio . . . . . | not est | 69.117 | not est | 7.437 | 4.780 | 4.639 | .786 | .084 | 11.480 | 32.294 | .343 | .034 | 6.860 | 1.677 | From Wm. Downe's Iron Mountain. |
| 2071 | Ohio . . . . . | not est | 48.211 | 9.227 | 7.307 | 5.880 | 4.298 | 1.805 | .030 | 19.850 | 29.484 | .475 | .012 | 17.460 | 3.392 | From Wm. Downe's Iron Mountain. |

## TABLE V. PIG IRONS.

| Number in Report. | County. | Specific gravity. | Iron. | Graphite. | Combined carbon. | Manganese. | Silicon. | Slag. | Phosphorus. | Sulphur. | Total carbon. | Remarks. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2082 | Trigg . . . . . | 6.872 | 92.349 | 3.380 | . . . . | not est. | 3.794 | 0.660 | 0.318 | 0.067 | 3.380 | No. 1, foundry iron, Centre Furnace. |
| 2083 | Trigg . . . . . | 7.027 | 92.953 | 3.140 | 1.010 | not est. | 2.641 | .100 | .318 | .074 | 4.150 | No. 2, foundry iron, Centre Furnace. |
| 2084 | Trigg . . . . . | 7.183 | 93.946 | 2.860 | 1.060 | not est. | 1.932 | .360 | .276 | .104 | 3.920 | No 3, mill iron, Centre Furnace. |
| 2085 | Trigg . . . . . | 6.934 | 91.173 | 3.400 | . . . . | not est. | 4.592 | 1.160 | .262 | .094 | 3.400 | Mill iron, Trigg Furnace. |
| 2086 | Trigg . . . . . | 6.864 | 89.576 | 1.000 | 1.380 | not est. | 6.637 | 1.560 | .221 | .121 | 2.380 | Silver-grey iron, Trigg Furnace. |

## TABLE VI. CLAYS, DRIED AT 212° F.

| Number in Report. | County. | Silica. | Alumina. | Iron oxide. | Lime. | Magnesia. | Phosphoric acid. | Potash. | Soda. | Water, expelled at red heat. | Remarks. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 2007 | Franklin . . . | 69.300 | 21.780 | | *0.158 | 0.331 | 0.060 | 2.351 | 0.585 | 5.435 | Potter's clay, bottom land, near Frankfort. |
| 2074 | Ohio . . . . . | 69.260 | 16.640 | 4.520 | trace. | .893 | trace. | 3.102 | .210 | 5.375 | Indurated clay, below coal F, mouth of Brush Creek. |
| 2075 | Ohio . . . . . | 70.860 | 19.240 | 3.120 | trace. | .425 | trace. | 2.351 | .253 | 3.751 | Clay, coal measures, near Elm Lick. |
| 2076 | Ohio . . . . . | 62.760 | 26.420 | 1.580 | .325 | trace. | trace. | .916 | .268 | 7.731 | Clay, Bald Knob Church, Caney precinct. |

* Carbonate.

## TABLE VII. MARLY SHALES, &c., DRIED AT 212° F.

| Number in Report. | County. | Silica. | Alumina. | Iron oxide, &c. | Lime. | Magnesia. | Phosphoric acid. | Potash. | Soda. | Water, carbonic acid, &c., and loss. | Remarks. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1994 | Breckinridge . | 66.960 | 15.606 | 8.380 | 0.493 | 0.677 | 0.154 | 3.295 | 0.628 | 3.787 | Marly shale, Tar Hill, near Cloverport. |
| 1996 | Butler . . . . | 51.660 | 15.560 | 7.680 | 7.269 | .817 | not est. | 3.276 | .293 | 13.445 | Marly shale, below coal, Mud Creek Mines. |