

THIRD CHEMICAL REPORT

OF THE

SOILS, MARLS, ORES, ROCKS, COALS,

MINERAL WATERS, &c.,

OF KENTUCKY,

BY

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INTRODUCTORY LETTER.

CHEMICAL LABORATORY OF THE GEOLOGICAL SURVEY, }
Lexington, Ky. September 14, 1857. }

D. D. OWEN, M. D.:

Dear Sir:—In obedience to your instructions, I herewith transmit to your address, my report of the Chemical Work, done in this Laboratory, since the preparation of the second volume.

As you will perceive, the time employed has been mainly occupied with the analyses of soils and sub-soils, which have generally been collected by you in series of three or four from each locality; including the *virgin soil, soil from an old cultivated field, sub-soil from the old field, and sometimes the under-clay and underlying rock stratum*, so as, if possible, to exhibit, by means of the Chemical Analyses, the changes which may have been produced in the various soils by cultivation, and the removal of agricultural products, without the application of manure, as well as the character of the immediate sub-soil, under-clay, and subjacent rock strata, and the probable influence they may exert upon the superficial soil.

With very few exceptions, as you will perceive on the perusal of the accompanying report, the analyses demonstrate, in regard to these, as to the soils previously examined, a notable change attributable to the cultivation of the soil; more especially a diminution of the quantity of those mineral elements which are necessary to vegetable growth, and which have been mainly removed from it in the various agricultural products which have been carried from the soil. The analyses reported in the accompanying report, may be summed up as follows:

- 138 Soils, sub-soils, and under clays.
- 16 Limestones.
- 12 Limonite iron ores.
- 7 Carbonate of iron ores.
- 12 Coals.
- 9 Mineral waters.

- 6 Sandstones.
- 5 Shales.
- 6 Marls.
- 3 Clays.
- 2 Iron furnace slags.
- 2 Pig irons.
- 2 Efflorescence and mineral Chætetes.

220 in all.

There remain, however, in my possession, a large number of interesting specimens, of your recent collections, consisting of between fifty and a hundred soils, &c., and more than an equal number of iron ores, coals, limestones, (hydraulic and common,) marls, &c. &c., which will be examined early next year, should the next General Assembly make the necessary appropriations for the continuance of the Geological Survey.

All of which is respectfully submitted.

ROBERT PETER.

INTRODUCTORY REMARKS.

SOIL ANALYSIS.

The processes pursued in the analyses of the soils, during the progress of this Geological Survey, have not been previously detailed, because it was thought that it might prove tedious and uninteresting to the general reader; but, with a view to enable those who are qualified, by chemical studies, to judge of the accuracy of the methods of research, by which the results detailed in this and the preceding reports were obtained, it is thought advisable now to record the routine of the operations. The general reader will, at least, be able to form an opinion of the time, care, and labor necessary to make a good and useful analysis of a soil.

Preliminary operations.—The soil to be analyzed, after it was brought to the laboratory, was allowed to remain, in the cotton bag in which it was first collected, fully exposed to the warm free air of the room, until it had been thoroughly dried at the common temperature. It was then passed through a wire sieve of about one hundred and fifty apertures to the inch, and, if in clods, rubbed to powder in a mortar, with precaution not to grind up any of the gravel or fragments of rock, &c., which it might contain; which were thus removed and estimated. The object of this operation is to bring the whole specimen of soil to a state of uniform mixture, and to remove from it the coarser gravel, vegetable roots, &c., which it might contain.

Digestion in water charged with carbonic acid.—For this process, by which we hope to estimate the proportion of *soluble matter* in the soil, which is immediately available for vegetable nourishment, a quantity, generally thirty grammes, of the air-dried soil, is weighed and placed in an eight-ounce strong vial, with a close fitting stopper, and the bottle is filled up with distilled water, which has been charged with pure carbonic acid gas, under a pressure of about two atmospheres. The closely stopped bottle, properly numbered, is then allowed to remain, for about a month, in a sand-bath, so placed, in relation to the fire, that the temperature is generally about that of summer heat. After

this time the contents are filtered, and the clear liquid evaporated carefully to dryness, in a glass beaker, finishing the evaporation at the temperature of boiling water, in a platinum capsule. After this dried extract has been cooled under a bell-glass, over sulphuric acid, it is carefully weighed, and its proportion of *organic and volatile matters* estimated by the loss which the dried extract sustains after these matters had been completely burnt off at a red heat over the spirit-lamp. The fixed residuum of the extract, after burning off the organic and volatile matters, was next dissolved in pure hydrochloric acid, with a little nitric acid added to per-oxidate the iron, if necessary; the solution filtered, and the undissolved *silica*, after drying and ignition, was weighed. But, of most of the soils treated in this way, the *fixed residuum* was black or very dark colored, from the presence of a large proportion of per-oxide of manganese, and consequently, when it was dissolved in hydrochloric acid, a considerable amount of chlorine gas is evolved, in mixture with the carbonic acid, which results from the dissolution of the carbonates present. From which fact it is evident that, in most soils, especially those which are rich in organic matters, the oxide of manganese exists in a condition to be easily soluble in water charged with carbonic acid.

The acid solution of the *fixed residuum* was now analyzed in the usual way, as will be described under the *general analysis*. It not being thought advisable, in the analysis of this extract, however, to spend the time which would be necessary to estimate separately the alumina, oxide of iron, oxide of manganese, and phosphoric acid, which are contained in the precipitate produced by the addition of ammonia to the solution, as these various ingredients are more completely estimated in the *general analysis* of the soil—the object of the digestion of the soil in water charged with carbonic acid being, as above stated, mainly to ascertain the relative proportion of easily soluble matter present in it, which would probably represent the quantity of *immediate available* food for plants which it contained.

It is to be observed, however, that as the carbonates of lime, magnesia, and manganese, as well as some forms of the organic matter of the soil, are quite soluble in the carbonated water, the *extract* may be in comparatively large quantity, if these substances are in considerable proportion in the soil, whilst there may be a relative deficiency of potash and soda, or of phosphoric and sulphuric acids; so that, conse-

quently, the actual weight of the *soluble matter*, extracted by the water charged with carbonic acid, will not exactly represent the present fertility of the soil. The analysis of this extract, however, it is believed, is carried far enough to enable us to judge of these relationships.

Estimation of the fine and coarse sand.—The thirty grammes of soil which have been digested in the water charged with carbonic acid, whilst still wet, is washed out of the filter into a glass cylinder, in which, in the course of several days, the *sand* which it contains is washed as clean as possible from the clay and finer particles of the soil: this is done by mixing it thoroughly with water, allowing it to stand until the sand has subsided, then pouring off the turbid water, and repeating this operation until the sand and coarser particles, generally, settle perfectly clear. The sand, &c., are now poured on a filter, dried at 212° F., and weighed; it is then sifted through a sieve of fine bolting cloth, of five thousand apertures to the inch, and the coarser particles weighed, and examined with the aid of the microscope.

It is to be understood, however, that although, in all the soils examined, very fine silicious sand exists in large proportion, all that is washed out in the operation just described is not of this character; for, in many of the soils—especially those from the central limestone districts of the state—there is a considerable quantity of rounded, soft, ferruginous mineral, resembling concretions, generally small, called by some “shot iron ore,” or larger, called “iron gravel,” which add their weight to that of the silicious sand washed out by the water. These ferruginous particles dissolve, mainly, in the acids in which the soil is digested for analysis; and thus it sometimes appears that the sand, &c., washed out of the soil by water may be more in weight than the *sand and insoluble silicates* found in the general analysis.

The coarser particles of some other of the soils, especially those from the Quaternary Formation, Coal Measures, or sub-carboniferous sandstone, are frequently silicious sand; and sometimes the microscope discloses in it rounded grains of quartzose minerals, of various kinds, similar in appearance to those of the boulders of the drift period.

GENERAL ANALYSIS.

The general analysis of the soil is usually completed long before the processes just detailed are brought to a conclusion. The quantity

of soil taken for this purpose is generally two grammes. This quantity, introduced into a weighed platinum crucible, is exposed to the temperature of 400° F., in an oil-bath, for three or four hours, and weighed after it has again been allowed to cool down to the ordinary temperature under a bell-glass over sulphuric acid. The loss of weight which it experiences is the weight of the *moisture*, generally called *Hygrometric moisture*; the quantity of which generally exemplifies the absorptive power of the soil—in other words, the relative amount of water which it is capable of holding, at the ordinary temperature, when it is apparently perfectly dry. The *aluminous* soils hold more of this *moisture* than the *sandy*; and those which contain a large proportion of *organic matters* hold the most of any; the *organic matters*, called *Humus*, *Geine*, &c., &c., by writers, having a higher hygrometric power than almost any common substances known. This same quantity of soil in which the moisture has been estimated is now ignited in the crucible, over the spirit-lamp, with free exposure to the air, until all the *organic and volatile matters* are burnt off and dissipated. Weighed with the same precautions the loss of weight gives that of these substances, which consist of black or brownish organic matter, (humus, geine, &c., &c.) water, with traces of ammonia and nitric acid.

This same portion of the soil is now transferred into a small beaker glass, and digested for about ten days, at a moderate temperature, in strong nitric acid, to which a little hydrochloric acid has been added, for the estimation of the phosphoric acid of the soil, by the process of Sonnenschein. For this purpose, at the end of this time, the mixture is filtered, and a sufficient amount of molybdate of ammonia is added to the filtrate,* which is then evaporated nearly, but not quite, to dryness, on the sand-bath. During the evaporation, the excess of nitric acid, with the aid of the chlorine from the hydrochloric acid, decomposes all the ammonia of the molybdate of ammonia, and the molybdic acid goes down, with all the phosphoric acid present, as a precipitate, insoluble in water and in pure nitric acid. After diluting with pure water the concentrated acid residuum, and allowing it to stand for some hours to settle and cool thoroughly, the precipitate, containing the phosphoric and molybdic acids, is collected in a filter and washed with cold distilled water; all the other materials of the soil, soluble in

*The term *filtrate* is applied to the clear liquid which passes through the filter.

diluted nitric acid or water, pass through the filter. This moist precipitate is now dissolved out from the beaker and the filter, by means of water of ammonia, and from the solution the ammonio-sulphate of magnesia precipitates all the *phosphoric acid*, as ammonio-phosphate of magnesia; which, after standing for about twelve hours, is collected in a filter, washed thoroughly with diluted water of ammonia, dried, ignited, and weighed, and the phosphoric acid estimated—its proportion to the soil, dried at 400° F., being obtained by calculation. When, as sometimes occurs, a considerable excess of molybdic acid has been thrown down with the phosphoric acid, the addition to the ammoniacal solution of an excess of chloride of ammonium is necessary, to prevent some of it from falling with the ammonio-phosphate of magnesia, and causing an error of excess in the estimation of the phosphoric acid; but, when conducted with the precautions indicated, this method, which is a slight modification of the process of Sonnenschein, is found to be far superior, in rapidity, accuracy, and delicacy, as a general process applicable to most complex mixtures, to any other hitherto used for the estimation of phosphoric acid; and, more especially, its use will greatly increase the certainty and utility of analyses of the soil, in which it has hitherto been a matter of great difficulty accurately to estimate this essential ingredient.

The filtrate from the mixed precipitate of molybdic and phosphoric acids, not being further employed in the analysis, another quantity of two grammes of the same soil, which has been sufficiently dried at the temperature of 400° F., is digested for about ten days, at a moderate temperature, in the sand-bath, in a hard glass flask, with an excess of pure hydrochloric acid, to which a little pure nitric acid has been added—the mixture being allowed to boil for a few minutes at the end of the process. After dilution with water the mixture is then filtered, and the *sand and insoluble silicates*, washed, dried, and ignited, are now accurately weighed and recorded.

The filtered solution is immediately precipitated with pure water of ammonia,* and the precipitate, (which consists of alumina, oxides of iron and manganese, phosphates, and generally some magnesia,) after

*In some of the early analysis this acid filtrate was first evaporated to full dryness, and redissolved in diluted hydrochloric acid, to estimate the *soluble silica*, but this additional process was soon abandoned, because it was believed the time necessary for it could be more profitably employed in increasing the number of the comparative analyses.

being well washed with hot water is transferred, while yet moist, into a silver crucible, in which it is digested for some hours in the water-bath, in pretty strong solution of absolutely pure potash; which dissolves out the alumina from the other ingredients, (except some of the phosphoric acid which is disregarded in this process.) The potash solution, filtered from the remaining oxides of iron and manganese and the magnesia, is now acidulated with hydrochloric acid, some chlorate of potash being added to destroy any organic matter which might interfere with the full precipitation of the alumina, and, after the solution has been concentrated to a small volume by evaporation, the *alumina* is thrown down from it by an excess of ammonia and some sulphuret of ammonium; it is washed very carefully with hot water, dried, ignited, and weighed. The mixed oxides of iron and manganese, and the magnesia, remaining from digestion in the potash solution, are now dissolved from the filter in hydrochloric acid, the solution carefully neutralized with ammonia, and the oxide of iron precipitated by the addition of succinate of ammonia, which throws it down as basic succinate of iron, leaving, if the process is carefully performed, all the oxide of manganese and the magnesia in the solution. On filtering the mixture, to separate the succinate of iron, after it has been somewhat washed from the filtrate, some ammonia is added to the precipitate in the filter, which, by withdrawing from it the succinic acid, facilitates the subsequent process of ignition preparatory to weighing the *oxide of iron*.

The *oxide of manganese* is now precipitated from the filtrate, after it has been concentrated by evaporation to a small bulk, by the addition of sulphuret of ammonium, and from the concentrated filtrate, any magnesia which may be present, is thrown down and estimated as triple phosphate, by the use of phosphate of soda and ammonia. It is recommended by Rose, to re-dissolve in hydrochloric acid, the sulphuret of manganese, (precipitated by sulphuret of ammonium,) and re-precipitated it with carbonate of soda, &c.; but it was found by experiment, that thorough roasting of the sulphuret of manganese, converted it easily into the brown oxide, and this complication of the process was thus avoided.

Returning to the first filtrate from the precipitate, by the addition of ammonia, to the original acid solution, which contains all the lime, most of the magnesia, some oxide of manganese, the sulphuric acid, and the alkalies;—simultaneous with the operations which have just

been described, we throw down the lime, from this filtrate, by the addition to it of oxalate of ammonia; collect the precipitate on a filter, dry, ignite it, treat it with solution of carbonate of ammonia, and weigh it; the *lime* is thus estimated as *carbonate of lime*, in the usual way. To the filtrate from the oxalate of lime, which now contains a large quantity of ammonia salts is next added an excess of *perfectly pure* nitric acid, and it is evaporated to complete dryness, on the sand-bath. In this process, proposed by Prof. J. Lawrence Smith, the nitric acid destroys all the ammonia salt, and leaves the magnesia, oxide of manganese, and alkalies, as nitrates, with any sulphuric acid which may have been in the soil, provided a heat sufficient to dissipate that acid has not been used at the latter end of the operation. It sometimes happens, however, where there is a considerable quantity of free ammonia, or of oxalate of ammonia, in the liquid, that some of the ammonia is left as nitrate of ammonia, which is more difficult to decompose than the hydrochlorate in an excess of nitric acid; and which, if left in the residuum, would interfere with the subsequent processes. To remove this, it is only necessary to add a new portion of nitric acid with a little pure hydrochloric acid, which, by the evolution of chlorine, soon destroys the ammonia which is present.

The dried residuum of nitrates, &c., is now removed from the sand-bath, allowed to cool, and drenched with *pure* acetic acid, and a sufficient quantity of distilled water, and enough of pure acetate of baryta is added to the dilute solution to precipitate all the sulphuric acid; after the precipitate of sulphate of baryta has subsided, it is collected by filtration, washed, dried, ignited, and weighed, and thus the *sulphuric acid* of the soil is estimated.

The filtrate from the sulphate of baryta is now evaporated to dryness, and transferred, by means of a little oxalic acid and water, into a small porcelain capsule, in which it is heated and evaporated again to dryness with an excess of pure oxalic acid, which changes the nitrates into oxalates. The dried residuum, which contains the magnesia, some oxide of manganese, and the alkalies, is next perfectly ignited, which changes the oxalates to carbonates, any excess of baryta from the acetate being also changed to carbonate.

To separate the *alkalies* from the other ingredients of this residuum, it is thoroughly washed with water through a filter, and the dissolved alkaline carbonates changed to chlorides by the addition of a little hy-

drochloric acid; the saline residuum, after complete evaporation and ignition of this solution in a platinum or porcelain crucible, is weighed and the weight of the *alkaline chlorides* is recorded. Re-dissolving this mixture of chlorides of potassium and sodium, in water, the two alkalies are separated and estimated in the usual way, by evaporation of the solution in a water-bath with chloride of platinum, washing the soda-chloro-platinate from the potash salt, which, collected on a weighed filter, and dried at 212° , is weighed, and thus the *potash* and *soda* are estimated.

The *magnesia*, which remains in the portion of the residuum which is insoluble in water, is now dissolved on the filter in diluted sulphuric acid, and after evaporation of the solution, and ignition in a platinum capsule, it is weighed as sulphate. Should there be much *oxide of manganese* in the insoluble residuum, the *magnesia* is dissolved out of the mixture by means of diluted nitric acid, (sulphuric acid being subsequently added to the filtrate &c., to convert it to sulphate,) and the oxide of manganese separately estimated.

By this mode of analysis, it will be seen, that with the exception of the moisture, organic matters, and phosphoric acid, which are estimated in a separate quantity of the soil, all its ingredients are determined from a single weighed portion, and thus a useful control over the general accuracy of analysis is secured; for if the sum of all the ingredients found, varies much from the weight of the quantity of soil taken for analysis, it is a proof that some error exists, and the processes must be repeated.

Other constituent ingredients of soils might have been estimated in these analyses, as for example, *chlorine*, *nitric acid*, or *nitrates*, and especially *ammonia*; but whilst it is known that these, or some of them, are almost constantly present in soils, their determination would have required separate processes, and would have increased the time and labor necessary for the analysis, probably more than would have been justified by the value of the results, diminishing in a proportionate degree the number of different soils which could be submitted to examination in the limited time. This is especially the case with *ammonia*, which, according to recent experiments in the laboratory of Liebig and elsewhere, is *always present*, in considerable proportion, in all soils, even the most sterile. The reader will readily admit that time and

labor enough are required to complete the analysis of a soil, even without the separate estimation of these ingredients.

The same remarks would apply to the separate determination, in the analysis of the soils, of the *various kinds* of organic matters which is present in them, by means of various alkaline solutions, &c., &c. It has been usual to attach much importance to the separation and estimation of the different varieties of these substances found in soils; but it is believed that these determinations, which consume a great deal of time, are of comparatively little practical value, as it is known that these varieties of organic matters of the soil pass readily into each other, and that doubts even exist as to the separate identity of some of these *humic acids*. Moreover, experience and chemical analyses demonstrate, that the fertility of a soil is far from being in proportion to the quantity of organic matters present in it.

With a view to reduce the expenditure of time and labor to as small a limit as possible, and hence to increase, to the greatest extent, the amount of work done in the laboratory in a given time, the writer has, during the course of these investigations, carried on a great number of separate analyses at the same time, taking care to ticket each digestion flask, beaker, funnel, capsule, &c., with a number and letter corresponding with those attached to the record of the operation in the Laboratory note-book—in which every single process performed is recorded at the instant, under its proper head—he generally has had as many as twenty to forty different soils in the course of analysis at once, in various stages of progress; and three times that number of operations—as drying, digestion, precipitation, filtration, washing, evaporation, weighing, &c.—progressing at the same time, so that the oil-bath, sand-bath, and water-bath; the range of filter stands, twelve in number, are sometimes all crowded at once; and the operator, having every instant of his time in active and profitable use, never has occasion to wait a moment on any of the operations, which, by the use of a little forethought, follow each other in a constant succession, without injury to any, or confusion.

In this manner, by the most careful attention to the numbers on the beakers, filters, &c., &c., and the continual and careful record of every operation at the time of its performance, and of every product or educt as it is obtained and weighed, error and confusion may be avoided; and with the final summing up of the analysis a demonstration of

its accuracy is generally obtained. In fact the influence of any unconscious bias of the mind, in relation to any soil under analysis, is thus prevented, as it is not generally known, except by reference to the record book, to what soil the substance in hand belongs, which is designated on the beaker, filter, funnel, &c., by its key number only. In this mode of working, also, many of the mechanical operations, as those of trituration, filtration, washing precipitates or the sand, &c., &c., have been performed by an intelligent young assistant, and thus the amount of effective work has been doubled, for the time being, without a corresponding increase of expense to the state; and, consequently, a larger number of minute analyses have been completed in the time employed than would be thought possible by many experienced analytical chemists, some of whom are persuaded that no more than one analysis of this kind—classed amongst the most difficult—can be carried on at one time.

As already stated, it is believed by many persons, and even some chemists of experience, that the art of chemical analysis has not arrived at that degree of certainty and accuracy, that the changes produced in the soil by cultivation can be ascertained by this means, even with the aid of the purest reagents and the most delicate balances. This opinion is strengthened by the memorable failure of the experienced German chemists, who were employed by the *Landes Oeconomie Collegium*, (board of agriculture,) of Prussia, to endeavor to ascertain the changes produced in soil on which a single kind of crop had been cultivated until it refused to bear it any longer. To make the determination more accurate each sample of the soil so treated, by different farmers, from fourteen parts of the kingdom, were entrusted to three different chemists to be analyzed; and the results obtained were so very discrepant as to be entirely useless, as may be inferred, from the inspection of the following table, giving a view of the proportional quantities, in round numbers, of phosphoric acid, of soda, and of potash, in three corresponding analyses, by three different chemists:

From Liebig and Kopp's *Jahresbericht* for 1849.

Number of the soil.	Phosphoric acid			Potash			Soda		
	In first analysis.	In 2nd analysis.	In third analysis.	In first analysis.	In 2nd analysis.	In third analysis.	In first analysis.	In 2nd analysis.	In third analysis.
1	1	3	7	3	1	0	6	1	0
2	1	19	92	1	12	6	1	19	67
9	trace	114	1	3	1	2	2	2	1
10	1	103	18	trace	0	0.05	trace	0	0.04

Liebig attributes these great variations to the difficulty of procuring, from a field, a perfectly uniform average specimen of the soil; but we cannot help believing that other causes, such as want of care to secure the utmost degree of accuracy, use of the reagents sold commonly as chemically pure, &c., &c., must have helped to produce the discordant results; we will not, however, pretend to sustain an opinion on this peculiar case, in the face of such high authority, but will be content with the assertion, that, in our laboratory, experience in many such operations, sometimes repeated more than once on the same specimens of soil, has now fully demonstrated, that whilst, in operating with the small quantities, necessarily taken in a soil analysis, to learn the composition of the millions of tons of soil of a whole district of country, and especially the changes produced in it by cultivation, it is necessary to use every precaution, and the utmost degree of delicacy and accuracy in all the operations; yet, that with the means and appliances now at the service of the analytical chemist, such a result is attainable; and we think this statement, however hazardous it may seem, will be found to be sustained in the following report.

It is agreed, however, that it could not be attained before the balance of the analytical chemist had been brought to its present degree of delicacy; it could not be done before the discovery of some of the improved modern processes of analysis—for example, those for the easy and certain determination of the phosphoric acid and the alkalis. It cannot yet be done without constant attention to every precaution, and the utmost watchfulness against error in every operation. Some of the necessary precautions it may be well enough briefly to enumerate:

1. All the acids and other reagents, and the distilled water, used in the processes, must be *absolutely and perfectly pure*; and, as *perfectly pure* reagents are somewhat rare, even amongst those which are sold by

manufacturing chemists as *chemically pure*, it is always necessary fully to test, as to their purity, all the substances employed, and, very frequently, to purify them. It has been necessary, for example, during the course of these investigations, to purify, by re-distillation, all the nitric acid, hydrochloric acid, and sulphuric acid used, notwithstanding they had been purchased from chemical manufacturing houses, with the express stipulation that they should be supplied perfectly *chemically pure*. The oxalic acid, oxalate of ammonia, acetic acid, other reagents supplied were also almost always to be purified, to secure accuracy in the results.

2. The best Swedish filter-paper, purified first by digestion in diluted hydrochloric acid, and thorough subsequent washing, for some hours, by displacement, with distilled water, must be employed.

3. The digestion flasks and beakers, in which the soil is submitted to the action of acids, must be of the very *hardest* glass, which is not attacked, in the slightest degree, by hot hydrochloric acid.

4. To secure a fair comparison, in analyzing several specimens from the same locality, in order to ascertain the effects of cultivation upon the soil, or the relative nature of the sub-soil or under-clay, it is necessary to digest each sample in about the same quantity of acid of equal strength, and expose each to the same temperature for the same length of time; because, many of the ingredients of the soil—even potash and soda, and especially alumina, oxide of iron, lime and magnesia, and perhaps phosphoric acid—are in combination with the silica, as silicates, which are acted on with difficulty, even by concentrated acids; it is found that the stronger the acids, the greater the relative quantity of them employed, the longer the time of the digestion, and the higher the temperature, the more of *these insoluble silicates* are decomposed, and the more of the above mentioned ingredients, and the less of insoluble residue, are found in the analysis.

We take occasion here, incidentally, to remark, that the quantities of the essential ingredients of the soil—of the potash, soda, lime, magnesia, phosphoric acid, &c.—which are stated in the following analyses, do not *fully* represent the total of those contained in the soil analyzed, because of the fact that some of these substances still remain locked up, for the present, in the *insoluble silicates*, which resisted the action of the acids as applied, but which can only become available for the

uses of growing plants, after a slow decomposition of those silicates, under the atmospheric agencies, during a great lapse of time.

5. In the estimation of the potash, by evaporation, in the water-bath, of the solution of the mixed alkaline chlorides with chloride of platinum, the capsule containing the mixture must be entirely secluded from the ammoniacal fumes which are frequently floating in the air of the laboratory, for the obvious reason that as these fumes are greedily absorbed by the mixture, the additional weight of the ammonia—chloride of platinum—thus produced, would increase the apparent weight of the potash found, and thus cause a serious irregularity.

6. The use of the most delicate and perfect balances, the most careful attention to accuracy in weighing, to the weights, and counterpoise, and to the most scrupulous cleanliness of every vessel or article used in the processes.

In addition to all, may be mentioned, the necessity for a good deal of preliminary training in chemical manipulations in the laboratory, without which it would be useless to attempt such delicate operations with any hope of success. The idea proposed by some, that a farmer might be able to analyze his own soil, is founded on an erroneous view of the nature and objects of a good soil analysis.

If it were true, as was believed by even some distinguished chemists, not very long ago, that the value of the soil, and its influence upon crops, depended mainly on its *mechanical or physical properties*, it might be easy, by a series of careful siftings and washings with water—such as were proposed by persons having this idea of soil analysis—for a farmer to perform these operations for himself, with the aid of very simple apparatus. But since it has been discovered—as will be seen to be demonstrated also by the analyses of Kentucky soil—that, although much depends upon the physical properties of a soil—as on its relative degree of fineness, or coarseness, &c.,—yet the real source of its ability to support vegetable growth is mainly in its *chemical constitution*; and that the *difference between a fertile and a sterile soil*, both frequently having nearly the same *physical properties*, is caused by the difference in their proportion of those essential ingredients which generally exist in the soil in the smallest quantities—quantities, which, when compared with the whole weight of the soil, may seem to be very insignificant, and which, in such a portion as is generally ta-

ken for a soil analysis, could often not be appreciated by means of a common balance.

This fact may be seen to be exemplified in the two following analyses taken from the preceding volume of this report. The one of soil No. 226, from the knob formation in Russell county, and the other of soil No. 550, virgin soil, from the blue limestone of Lower Silurian formation in Woodford county—rich “blue-grass” soil—which may be taken as extreme cases:

	No. 226	No. 550
Soluble extract given up, by 1000 grains of the soil, to water charged with carbonic acid, - - - - -	2.221	6.014
Organic and volatile matters, - - - - -	4.170	7.771
Alumina, and oxides of iron and manganese, - - - - -	4.478	12.961
Carbonate of lime, - - - - -	.176	2.464
Magnesia, - - - - -	.066	.173
Phosphoric acid, - - - - -	.088	.319
Sulphuric acid, - - - - -	.227	.150
Potash, - - - - -	.063	.394
Soda, - - - - -	.068	.130
Sand and insoluble silicates, - - - - -	90.786	75.266

The difference in the productiveness of these two soils does not depend on their mechanical or physical properties, as is proved by the fact that they are both in an equally fine state of division and are perhaps equally well drained, &c. It does not depend on their relative proportions of organic matters, or of alumina and oxides of iron and manganese, for it is found that soils may be comparatively unfertile, although they may contain large proportions of these; but it depends upon the greater relative amount of lime, magnesia, phosphoric acid, potash, and soda, contained in the blue limestone soil.

Of these important substances, the difference in quantity, in the two soils, may seem insignificant at first sight, or to the experienced observer—as for instance, in the case of the phosphoric acid, only the difference between 0.088 and 0.319 of a part in a hundred parts of the soil; or, in the case of the potash, only the difference between 0.063 and 0.394 of a part in the same quantity; yet they will be found to be relatively quite large, on comparing together the various soil analyses in the following report, and swell to something enormous when we apply these proportions to the whole quantity of soil in an acre of ground. Thus, the whole of the phosphoric acid in soil No. 226,

on the acre of ground, estimated to weigh about three millions of pounds, (3,000,000 pounds,) taken to the depth of one foot, is two thousand six hundred and forty pounds, (2,640 pounds); that in soil No. 550, in the same space, is equal to nine thousand five hundred and seventy pounds (9,570 pounds;) and whilst the potash on the acre of soil No. 226, to the depth of one foot, is only equal to one thousand eight hundred and ninety pounds, (1,890 pounds,) that in soil No. 550 amounts to eleven thousand eight hundred and twenty pounds, (11,820 pounds,) to the acre.

Taking the relative amounts of *soluble matters*, given up by one thousand grains of each of these two soils, to water charged with carbonic acid, No. 220 gave 2.221 grains, or a little more than two grains; No. 550 gave 6.014 grains, more than six grains. Or, one pound of the former soil gave up only 15.547 grains, a little more than fifteen and a half grains—whilst a pound of the latter yielded more than forty-two grains, (42,098 grs.); the former in the proportion of six thousand six hundred and sixty-three pounds (6,663 lbs.) to the acre, to the depth of one foot, and the latter in that of eighteen thousand and forty-two pounds, (18,042 lbs.) to the acre, of soluble matters immediately available for vegetable nourishment.

The great importance, now generally acknowledged, of these, mineral elements of the soil which usually exist in it in small proportions, has only been recently established, and by means of numerous analyses of soils and vegetables, and especially of their mineral elements, as exhibited in their ashes, accompanied by many experiments in agriculture and horticulture, and on the growth of vegetables generally.

Even the great Berzelius, the best analytical chemist of the beginning of the present century, seems not to have fully appreciated the paramount value of these, nor the real objects of a soil analysis; and the equally celebrated Sir Humphrey Davy, exhibits an equal want of this appreciation in the analyses of soils published by him. Let us, for example, glance at two soil analyses by these distinguished men quoted by Liebig in his *Chemistry applied to Agriculture, &c.*, and see how much of the real value and properties of the soils can be learnt from them:

"Surface-soil of a field which produces the most abundant crops, and has never been manured, (Berzelius,) one hundred parts, consist of—

Silicious sand,	57.900
Silica,	14.500
Alumina,	2.000
Phosphates of lime and iron,	6.000
Carbonate of lime,	11.000
Carbonate of magnesia,	1.000
Insoluble extractive matter,	1.250
Insoluble extractive matter, destructible by heat,	4.000
Animal matter,	1.600
Resin,	.250
Loss,	.400

100.000

"This great chemist has strangely omitted to detect in this soil, potash, soda, chlorine, sulphuric acid, and manganese. As this soil is eminent for its fertility, there cannot be a doubt that all these ingredients must have existed in it."—*Liebig*.

"Surface-soil of a very fertile sandy field, from the vicinity of Tunbridge, Kent. According to Davy, one hundred parts consisted of—

Loose stones and gravel,	13.250
Sand and silica,	50.250
Alumina,	3.250
Peroxide of iron,	1.250
Carbonate of lime,	4.750
Carbonate of magnesia,	.750
Common salts and extractive matter,	.750
Gypsum,	.500
Matter destructible by heat,	3.750
Vegetable fibre,	3.500
Water,	5.000
Loss,	5.000

100.000

"The great Davy, who was convinced of the importance of the inorganic constituents of soils, has omitted to detect phosphoric acid, potash, soda and manganese. All of these must have been present in the soil, for we are informed that it produced good hops, for which these ingredients are indispensable."—*Liebig*.

Even as late as the time of the great New York State Survey, the distinguished chemist to that work, Dr. Emmons, of Albany, while fully appreciating the great value of the phosphoric acid, and the alka-

lies of the soils, and claiming to have demonstrated the presence of the former in many rocks and soils, where previously they were not known to exist, fails to give the determination of these valuable ingredients in almost all the numerous soil analyses published in his splendid volumes. And so has it been in most of the publications of this kind in this country and in England, so that almost the whole record of soil analyses is nearly useless to scientific agriculture, except some of Sprengel and others, in Germany and France—such as are quoted in the supplementary chapter on soils, of Liebig's "*Chemistry in its application to Agriculture and Physiology*."

As late as 1838, in Germany, where the industrious Carl Sprengel had been for many years urging on the attention of the scientific and agricultural world, through his publications, the true *mineral* theory of vegetable nourishment, we find in Schubler's *Agricultural Chemistry*, published in that year, the opinion gravely supported, that the earthy and saline matters which are found in all plants, and are necessary to their constitution, are actually produced by them, by their growth, out of the common elements of the atmosphere and of water; and the reader is asked, by him, "how can it happen that crops can be produced for twenty to a hundred years, the ashes of which contain large quantities of phosphate of lime and of certain alkaline salts, of which not a trace could be found in the soil on which they grew!" And the author adds—"When Hermbstadt, out of 2,261 pounds of ashes of the Mugwort, (*Artemisia vulgaris*), which grew on 18,000 square feet of sandy soil, obtained 936 pounds of calcined potash, it was evident that each cubic foot of this sandy earth must have contained 340 grains of potash, in order that the Mugwort could have obtained it from that source; as this is not to be believed, in regard to this Berlin sandy soil, so it is necessary to ascribe the production of this potash in the Mugwort only to the luxuriant growth of the plant itself."

But Sprengel, by carefully analyzing the soil, proved that within the range of the roots of the mugwort there was greatly more than the requisite quantity of potash. So has it been found in regard to every element which enters into the vegetable or animal composition; the idea that any of them can be *made*, or even obtained by transmutation from other elements, by the force of vitality, is fully exploded by accurate investigation, by means of the balance.

The Mineral Theory of Vegetable Nourishment.—The importance of what has been termed the mineral elements of vegetable food consists principally in the fact, that whilst all those elements of organized beings which exist in the atmosphere and in water, such as carbon, hydrogen, oxygen, and nitrogen, are everywhere abundant, and can never be exhausted, those elements, necessary to the constitution of these beings, which are peculiar to the soil, called by distinction the *mineral elements*, which are contained in the soil in limited quantities, and partially withdrawn from it in every vegetable which grows or animal which feeds on it, may readily be entirely removed from it, and the soil, consequently, rendered sterile.

The credit of this theory, which in latter times has been prominently and eloquently brought forward to public attention by Liebig—if that could be confined to a single individual which has gradually been developed by the labors and writings of many—would more properly belong to Carl Sprengel, a most industrious and accurate agricultural chemist of Germany, who had demonstrated it by his numerous analyses of soils, manures, and vegetables, and published it in his works, long before the time of Liebig's celebrated publications. This last distinguished author, indeed, acknowledges as much in his "*Chemistry applied to Agriculture and Physiology*," in the supplementary chapter on the chemical constituents of soils, where, after quoting some soil analyses from Dr. Sprengel, he adds: "The analyses are those of Dr. Sprengel, a chemist who has unceasingly occupied himself for the last twenty years in endeavoring to point out the importance of the inorganic ingredients of a soil for the developement of plants cultivated upon it. He considers as essential all the inorganic bodies found in the ashes of plants. Now, although we cannot coincide with him in the opinion that iron and manganese are indispensable for vegetable life, (for these bodies are found as excrementitious matter only in the bark, and never form a constituent of an organ,*) yet we gratefully acknowledge the valuable services which he has rendered to agriculture, by furnishing a natural explanation of the action of ashes, marl, &c., in the improvement of a soil. Sprengel has shown that these mineral manures afford to a soil, alkalies, phosphates, and sulphates—and further, that they exert a notable influence only on those soils in

*In this statement Liebig is evidently wrong. (P.)

"which they are absent or deficient." The translation and publication, in this country, of some of the works of Sprengel, especially his "*Lehre vom Dunger*," &c.; would be a valuable addition to the library of the enlightened American farmer.

GENERAL REMARKS ON AGRICULTURE.

The true theory of agriculture, on which only a correct practice can be based, can only be ascertained by accurate observations and experiments, of great number and extent. A few analyses, for example, might only exhibit exceptional cases; the isolated examination of a few soils could be of very little service, for it is only by numerous and comparative analyses that the real causes of fertility or sterility can be discovered. Hence, during the short course of the investigations of modern science, in her efforts to aid this most important of all departments of human industry, agriculture, numerous and fallacious theories, based on imperfect knowledge, have been for a time proposed and maintained, and have in their turn exerted their influence against the steady onward march of real knowledge. A few analyses of the soils of Kentucky, for example, might be of some scientific interest, especially if there had been recorded, minute analyses of known soils of other regions, by which to compare them; but in the absence, or at least paucity, of these, the only mode of ascertaining the various qualities and value of the soils of our state, as well as the relative influence exerted on its fertility by the various constituents of the soil, is by the performance of a great number of analyses, of soils in all variety, from the different geological formations, and in various stages of exhaustion from cultivation. In this manner only can a complete comparison be made between them, and their relative merits and peculiarities exhibited, and, incidentally, the real and essential elements of fertility in the soil fully ascertained, by a process of comparison and exclusion.

In the establishment of a true theory and practice in agriculture, *practical experience and scientific research must go hand in hand.* The one may suggest what the other must necessarily verify. An extensive series of correct scientific investigations, in the chemical analyses of soils, manures, plants and their ashes, &c., &c., must be combined with close practical observations on the culture of various crops, in va-

rious known conditions or circumstances, of soil, manures, moisture, heat, light, &c., &c.

Empirical experience has gone a great way, in the course of ages, towards forming a correct system of agriculture; but its unaided progress is necessarily very slow and uncertain, and confined within circumscribed limits. On the other hand, scientific investigation into the nature of the essential elements of the soil, and the conditions of vegetable growth, can only be verified and established by the aid of practical experience in agriculture.

Practical experience, moreover, looking almost exclusively to immediate results, may be deceived as to the real and ulterior interests of the farmer; for example, the celebrated Jethro Tull, of Berkshire, England, (who published his "*Horse-hoeing Husbandry, and New Method of Culture, &c.*," in middle of the last century,) having observed the beneficial effects of thorough tillage and fine division of the soil, in promoting the growth of plants, came to the conclusion, by his practical experience, that all manures were nuisances which injured the good qualities of the edible plants to which they were applied, and promoted the growth of toads and other "venomous creatures," but that "the artificial Pasture of Plants may be enlarged, without any Addition of more Land, or enlarging of Bounds, and this by Division only of the same Earth." That as the intimate atom is very small, as he expresses it "an atom is nothing," and *fine division* of the soil is the only thing necessary to bring it into a condition to enter into the tissues of vegetables, the food of plants could be increased, in a given quantity of earth, "*ad infinitum*," simply by sub-dividing or pulverizing it, and thus a perennial fertility be secured. Science not having yet demonstrated to him that *earth* was not a unit in composition, of which any small part, if sufficiently finely divided, would answer for vegetable nourishment, it required some lapse of time to demonstrate to his followers the gradual but certain deterioration of the soil thus treated, and the fallacy of his system of husbandry.

In like manner, the practical experience of the early farmers of a new country, where the land is teeming with all the elements of fertility, and which, for years, shows no diminution of its productiveness, even with the rudest agriculture, impressed them with the fallacious belief that the *soil is inexhaustible*; and, consequently, the accumulations of enriching materials—the piles of manures about their barns

and stables—were considered nuisances, to be abated at the cost of the expense and labor of hauling them to the nearest stream or sink-hole, whilst exhausting crops were carried from the soil; until the further experience of fifty or a hundred years has given the melancholy demonstration that the land had, in some cases, become hopelessly deteriorated, and that those valuable elements, which alone were wanting to restore and keep it in a fertile state, had been scattered to the winds, or had found their way to that great reservoir of the drainage of the land, the ocean.

For this great practical error, on the part of our forefathers, there was this sufficient apology, however, that scientific agriculture had not yet demonstrated the true nature of vegetable food, nor the essential elements of the soil. But now the case is different, and any farmer, who is not lamentably deficient in the preliminary education which is necessary to fit him for his station, as an agriculturist and a good citizen of a republican nation, can avail himself, with little difficulty, of the aid of the scientific principles of modern agriculture. And nothing but the great abundance and cheapness of new land in this country, prevents the necessity for acquiring and applying these principles continually to the cultivation of our soil.

As long as rich new soil can be purchased for less than it would cost to restore to fertility a soil which has become exhausted, by a long series of improvident cropping, *practical experience* will continually prompt the farmer to emigrate from the home of his fathers to play the part of a pioneer in the new country, at whatever cost of feeling in the breaking up of old attachments and old associations, at whatever risk to health or life from change of climate and location, and at whatever final expense of time and money, which may be required, gradually, in the course of many years, to bring around the new settlement all the comforts and conveniences which have been temporarily undervalued in the old.

Every road laid out, graded, and turnpiked; every bridge, fence, or house constructed; every railroad, telegraph, or public means of conveyance established; every school-house, college, church, or courthouse erected—all the improvements and conveniences of the old country—have been made at the cost of some sacrifice of time, labor, and money of the land owners, in the course of years; and could the real and practical value of all these improvements, comforts, and conven-

iences be put upon the cost of the land, in the old and highly cultivated community, its price would appear extraordinarily high. Could the final cost of all those improvements, which would be necessary to bring the wild new country up to the level in these respects, with the older settlements, be put upon the new land, the difference in price between this and that of the older country would not be so great as it appears at present. But these improvements are gradually made and paid for, and their cost is distributed amongst a succession of persons, and over a considerable time, and consequently is not proportionately felt. But the *value* of a real *improvement* remains, and constantly enhances the value of the land in which it is placed, by increasing the comforts or decreasing the labors of the inhabitants; increasing the value of their products, by giving more ready access to market; diminishing the cost of articles of consumption of foreign production by decreasing that of their procurement and transportation; giving new facilities for the profitable employment of time, energy, talent, and capital, in the arts and manufactures; and a more extensive scope for profitable industry in all the departments of civilized society.

Taking all these facts into consideration, it may be more frequently found, than is generally believed, that even *practical experience* may safely admit, that notwithstanding the comparatively high price of the comparatively worn-out soil of the older and improved districts, as compared with the land of the new, it may often be more economical to improve the old, by the judicious restoration to it of its lost elements of fertility, by the application to it of the appropriate manures, than to break up and remove to the new country.

To the farmer who understands the conditions of fertility; the chemical nature of the soil, and of the crops or animals produced upon it; who has studied—as is his duty, as a part of his useful profession—the nature of manures, and the true mode of maintaining his soil always in its original state of fertility, the annual labor of restoring to the soil as much of the essential elements as had been taken away by the crops removed from it, would be comparatively little, if systematically provided for in his scheme of husbandry; whilst to renovate a soil which had been annually robbed, by a succession of owners, for fifty or a hundred years, may seem a herculean labor, and require a startling expenditure.

ROTATION OF CROPS.

It is a very prevalent idea, based on the practical experience, that after the land has become *tired*, as it were, of one crop, it will readily produce another; that a judicious *rotation of crops* may be continued for any length of time, without exhaustion of the soil. This opinion, scientific research has fully demonstrated to be erroneous. It is true, that different vegetables, whilst they require nearly the same elements for their food, consume the several materials of the soil in various proportions—as corn, wheat, and the grains generally, take more *phosphates*; potatoes, tobacco, and the green crops, more *potash*; hemp, clover, and fruit-trees, require *lime* in the soil; and flax is said to demand much *magnesia*, &c., &c.—it is equally true, that the uninterrupted cultivation of one crop on the same land, disproportionately deprives its soluble portion of the peculiar elements which enter in larger quantities into its peculiar composition, and hence reduces the productiveness of the soil to that crop, whilst it may yet retain abundance of the essential mineral elements of vegetable food in such proportions as may be entirely adapted to the wants of other vegetables; but it must be recollected, that although *this* crop may require a larger amount of the phosphates, and *that* more of the alkalies, the third more lime, or the fourth more sulphates, they all take more or less from the stock of these materials in the soil, which, although mostly present there in quantities to last for centuries, are yet limited in amount, and exhaustible in the end.

Thus, whilst during the life-time of the father, perhaps, by a judicious rotation of crops, the productive powers of the soil may seem to be fully or nearly maintained, during the subsequent experience of the son, it may be necessary to resort to sub-soil ploughing to keep up the productiveness to the profitable standard; and yet, notwithstanding the use of this means, further lapse of time may still demonstrate a gradual diminution of crops, in consequence of the gradual, although slow, exhaustion of the soil.

INFLUENCE OF THE SUB-STRATUM.

In districts where the soil is immediately underlaid by a sub-stratum which is rich in the mineral elements of vegetable food, like the easily decomposable blue limestone of the Lower Silurian Formation, or the rich under-clay which abounds in the same region, the process of

exhaustion of the surface-soil is more slow than when it is based upon a hard rock which resists the decomposing influence of the atmospheric agencies, or a stratum in which these elements are more or less wanting. For, whilst the vegetable roots of the growing crops are absorbing these elements from the superficial soil, more are being carried into it, by the agency of water and of capillary attraction, from the rich sub-stratum. This process of supply, however, is often necessarily slow, and rarely keeps pace with the demands of continued exhaustive crops. It is one main cause of the rapid renovation of the soil, in the favored region above mentioned, upon allowing it to rest in fallow or in clover crops.

INFLUENCE OF PASTURAGE.

Another prevalent opinion, also, to some extent erroneous, is, that when the land is used for pasture only, or where the products, in grass, corn, grain, hay, &c., are annually consumed upon the ground by animals—as hogs, cattle, horses, mules, &c., which are the only exports from the farm—the manure being thus restored to the soil, it is in no danger of becoming exhausted. The fact is, that this system of farming really removes from the land less than any other which can be adopted, where some products of the farm must be sold away from it, and no manure is imported to it, because all of the valuable elements of the soil which are finally removed from it, in this system of farming, are simply the phosphates of lime and magnesia, and the other earthy and alkaline salts, which are contained in the bones, and the solids and fluids of the animals reared on it—some idea of the quantity of which may be formed by weighing the skeletons of these animals—whilst, as the constant tendency of growing vegetables is to collect and bring up the essential elements, from the depths of the soil and leave them, by their decay, upon the surface, it may even frequently happen, that notwithstanding the removal from it of this relatively small quantity of phosphates, &c. in the bones and bodies of the animals sold from the farm, the *surface-soil* may be actually richer, after many years judicious treatment in this way, than it was at first.

But in the older countries, where by a long series of cropping, almost all the essential elements of the soil have been so far reduced in quantity that the mandate, “no manure, no crops,” is rigid and immutable, the effects of even the grazing of pasture land is known

and understood, especially as we are informed by Johnston, (in his *Lectures on Agricultural Chemistry and Geology*,”) in the dairy district of Cheshire, where the application of bone-dust to permanent pasture has been practiced of late years with great success, in improving the value of the pasture land, which had become measurably exhausted of its phosphates by the milk, cheese, calves, &c., sold from it; it being stated by that author that “for every cow it maintains a dairy farm will lose, (annually,) of earthy phosphates, upon the whole as much as is contained in fifty-six pounds of bone-dust.” On the principle of the exhaustion of the phosphates from the grass lands of Cheshire, by dairy farming, he accounts for “the singularly striking effects produced by bone-dust” on these lands, “while it failed materially to improve those of others on which it had been tried.”

USE OF LIME AS A MANURE.

The analyses of the limestones of the Lower Silurian formation, as well as those from other geological districts, published in these several reports, demonstrate a fact which has generally been over-looked in the efforts made to explain fully the beneficial action of the application of lime upon the soil. It is true that lime itself is generally present in very small proportion, even in soil resting immediately upon a limestone sub-stratum—the common idea of the wide prevalence of *calcareous soils*, being erroneous—yet few soils are so very deficient in lime as actually to be sterile from the absence of this material. Still, the addition of lime to soils, and even to those which are known to contain already in their composition considerable quantities of it, is found to be so beneficial, in England and in France particularly, that it is very commonly applied to the land for the production of grain crops, &c., and sometimes in as large a quantity as from three hundred to five hundred bushels to the acre, but generally in smaller amount.

Doubtless the lime, when applied in the caustic state, acts to bring to a soluble state some of the nutritious elements which may be locked up in the *insoluble silicates*, and to increase their solubility generally; and enables the soil thus to produce large crops for a few years, making available, during this short time years, perhaps that material which, in the gradual course of the natural disintegration of the harder particles of the soil, might not have been consumed in the smaller harvests for many years, and hence the adage, that “lime enriches

the father and impoverishes the son;" but these analyses have shown, at least in relation to the Kentucky limestones generally, and especially to those easily decomposable limestones of the Lower Silurian formation, that they all contain notable quantities of phosphoric acid, sulphuric acid, potash, soda, magnesia, iron and manganese, &c., and hence, when applied to land, they may not only act beneficially in virtue of the *lime* they contain, but many actually restore to it many of those mineral elements necessary to vegetable growth, which may have been exhausted from the soil by cultivation. The same remarks will apply to the calcareous marls.

The analyses of the Kentucky soils, which have been made, and are published in these volumes, it is hoped may materially aid the enlightened agriculturist, by exhibiting the causes of their fertility, showing the elements which are liable to exhaustion by cultivation, or those which are naturally deficient in soils from various districts, or which may be superabundant; as well as by pointing out, in some cases, the sources whence may be supplied the elements which may be wanting to render soils of certain districts more fertile. Secondly, it is hoped they may induce the agriculturist to study more thoroughly the fundamental principles of his noble profession, and thus enable him to attain to the knowledge of the most economical and permanently profitable system of husbandry.

A SUMMARY

OF THE

CHEMICAL ANALYSES

OF

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

OF KENTUCKY,

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

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

ANDERSON COUNTY.

No. 557—SOIL. Labeled "*Virgin soil, from John M. Walker's farm; considered the best adapted to wheat and timothy; will yield twenty bushels to the acre if well attended; white oak-land; near Lawrenceburg, Anderson county, Kentucky. Blue limestone formation.*"

The dried soil is of a dark-brownish-grey color; washed carefully with water this soil left 73.65 per cent. of *sand*, of which all but 5.64 per cent. passed through the finest bolting-cloth. This coarser portion was principally composed of small rounded ferruginous concretions, mixed with rounded quartzose particles.

One thousand grains of this soil, dried at the ordinary temperature, digested for a month in a close bottle, in water which had been charged with carbonic acid gas, under a pressure of about two atmospheres, gave up more than two grains of *greyish-brown* extract dried at 212°, which contained the following ingredients, viz:

	Grains.
Organic and volatile matters, - - - - -	0.430
Alumina, and oxide of iron and phosphates, - - - - -	.118
Carbonate of lime, - - - - -	1.178
Magnesia, - - - - -	.040
Brown oxide of manganese, - - - - -	.079
Sulphuric acid, - - - - -	.058
Potash, - - - - -	.084
Soda, - - - - -	.034
Silica, - - - - -	.180
	2.201

Dried at 400° F., this soil lost 4.125 per cent. of *moisture*, and was found to have the following *composition*:

Organic and volatile matters, - - - - -	5.463
Alumina, - - - - -	1.615
Oxide of iron, - - - - -	6.305
Carbonate of lime, - - - - -	.345
Magnesia, - - - - -	.335
Brown oxide of manganese, - - - - -	.315
Phosphoric acid, - - - - -	.181
Sulphuric acid, - - - - -	.056
Potash, - - - - -	.156
Soda, - - - - -	.023
Sand and insoluble silicates, - - - - -	84.845
Loss, - - - - -	.361
	100.000

No. 558—SOIL. Labeled "Same soil as the last, from John M. Walker's land, near Lawrenceburg, Anderson county, Kentucky; from an old field which has been from twenty to thirty years in cultivation; for four of the latter years in timothy and clover; now in corn; no green crops have ever been turned in. Blue limestone formation."

Color of the dried soil slightly lighter than that of the preceding soil. The sand left by washing this soil in water amounted to 71.1 per cent, of which only 4.91 per cent. was too coarse to pass through the finest-bolting cloth; the coarser particles are principally ferruginous, with a few rounded grains of different colored quartz.

One thousand grains of the air-dried soil, digested in water containing carbonic acid, as before described, gave up about two grains of

brownish-grey extract, dried at 212° F., which had the following *composition*, viz:

	Grains.
Organic and volatile matters, - - - - -	0.370
Alumina, and oxide of iron and phosphates, - - - - -	.159
Carbonate of lime, - - - - -	1.058
Carbonate of magnesia, - - - - -	.153
Brown oxide of manganese, not determined.	
Sulphuric acid, - - - - -	.013
Potash, - - - - -	.119
Soda.	
Silica, - - - - -	.094
Loss, - - - - -	.139
	2.105

The air-dried soil lost 3.075 per cent. of *moisture*, when dried at 400° F.

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

Organic and volatile matters, - - - - -	4.332
Alumina, - - - - -	2.165
Oxide of iron, - - - - -	2.890
Carbonate of lime, - - - - -	.215
Magnesia, - - - - -	.465
Brown oxide of manganese, - - - - -	.220
Phosphoric acid, - - - - -	.103
Sulphuric acid, - - - - -	.032
Potash, - - - - -	.101
Soda, - - - - -	.047
Sand and insoluble silicates, - - - - -	89.140
Loss, - - - - -	.290
	100.000

No. 559—SUB-SOIL. Labeled "From Jno. M. Walker's land, near Lawrenceburg, Anderson county, Kentucky. Blue limestone formation," &c., &c.

The color of this sub-soil, air-dried, is greyish-buff. Washed with water it left 66.55 per cent. of sand, of which all but 4.14 per cent. passed through the finest bolting-cloth; this coarser portion consisted of small rounded ferruginous particles, with a few quartz grains.

One thousand grains, air-dried, gave up to the carbonated water not quite a grain of *grey-brown extract*, dried at 212° F., which had the following *composition*:

Organic and volatile matters, - - - - -	0.200
Alumina, and oxide of iron and phosphates, - - - - -	.069
Carbonate of lime, - - - - -	.318
Magnesia, - - - - -	.020
Brown oxide of manganese, - - - - -	.026
Sulphuric acid, - - - - -	.027
Potash, - - - - -	.019
Soda, - - - - -	.110
Silica, - - - - -	

0.789 of a gr.

The air-dried sub-soil lost 3.25 per cent. of *moisture*, when dried at 400°, and then had the following *composition*, viz:

Organic and volatile matters, - - - - -	3.213
Alumina, - - - - -	2.465
Oxide of iron, - - - - -	3.555
Carbonate of lime, - - - - -	.070
Magnesia, - - - - -	.601
Brown oxide of manganese, - - - - -	.220
Phosphoric acid, - - - - -	.142
Sulphuric acid, - - - - -	.056
Potash, - - - - -	.130
Soda, - - - - -	.026
Sand and insoluble silicates, - - - - -	88.970
Loss, - - - - -	.552

100.000

This sub-soil does not appear to be richer than the surface soil, in the *mineral* food of plants, while it contains less *organic matters*; the turning of it up with the sub-soil plough, therefore, promises only to improve the soil *mechanically*.

It will be seen, by comparing the analyses of the soil of the old field, which has been twenty to thirty years in cultivation, with that of the virgin soil, that the former has lost a portion of all those ingredients which enter into the composition of vegetables, with the exception of soda, magnesia, and oxide of manganese, and that, particularly, the lime, and potash, the phosphoric and sulphuric acids, have been sensibly diminished, by the course of cropping, whilst the relative proportion of the silica and insoluble silicates, alumina and oxide of iron, have been increased, and the amount of organic matters reduced. The soil of the old field also gave up less of soluble matter, when digested

in water containing carbonic acid, and is slightly lighter in color than that.

When the two preceding soils, Nos. 557 and 558, were submitted to analyses, the labels had been accidentally interchanged, without the knowledge of the writer, whilst taking out specimens of each for the state cabinet; the former, therefore, was labeled "soil from an old field," and the latter "virgin soil;" the analyses of the two, however, showed the differences of composition just pointed out, and led the author to suspect that some mistake had been made in the labels. On writing to Mr. Walker to send additional specimens, or to compare the two soils, side by side, and send word which had the darker color, it was found, on his response, that the suspicion in regard to the change of labels was correct, and thus was established, in these soils, as with most of the specimens of soils which have been submitted to examination at this laboratory, the accuracy of the indications of their comparative chemical analysis, in relation to their gradual exhaustion by the process of cropping: the same thing occurred with the set of soils from G. Threlkeld's farm, Owen county.

The calculation of the amount of nutritious materials which have been withdrawn from the soil No. 558, by the course of twenty to thirty years cropping, as compared with the virgin soil No. 557, can be easily made. Supposing the soil to weigh about 71½ pounds to the cubic foot, as was found, by experiment, to be the fact with the Fayette county soil, (see former report, Fayette county,) the 43,560 cubic feet of earth on the acre of ground, taken to the depth of one foot, would weigh a little more than three millions of pounds. Let us, for example, carry out the figures in regard to the *potash* and *phosphoric acid* alone, in these two soils:

In soil No. 557 the phosphoric acid amounts to 0.156 per cent.

In soil No. 558 the phosphoric acid amounts to .111 per cent.

Difference, - - - - - 0.045 per cent.

Now 0.156, the quantity in 100 pounds of the soil, multiplied by 3,000,000, and divided by 100, gives 4,680, the number of pounds of potash in an acre of the virgin soil; and 0.111, multiplied by the same number, &c., gives only 3,330, the number of pounds contained in the soil of the old field; the difference, 1,350 pounds, shows the amount of this substance which the old soil has lost in the course of

twenty to thirty years cultivation. So in regard to the *phosphoric acid*, equal to 0.181 per cent. in the virgin soil, or six thousand four hundred and thirty pounds (6,430 pounds) to the acre, and 0.103 per cent. or three thousand and ninety pounds (3,090 pounds) to the acre; the diminution produced by the cropping amounts to three thousand three hundred and forty pounds (3,340 pounds,) to the acre.

BATH COUNTY.

The waters from five different sources, at the Olympian Springs, in this county, were *qualitatively* tested by the writer some eight years ago, and as he has not yet had the opportunity of fully analyzing these valuable waters, he thinks it proper to append to this report the account of the testing made at that time.

No. 560—MINERAL WATER. *Labeled "Sweet Spring, near Pound Lick," Olympian Springs, Bath county, Kentucky.*

One thousand grains of the water left 1.5 grains of dry saline matter, on evaporation.

This water was found to contain,

Carbonic acid gas;

Bi-carbonate of lime;

Bi-carbonate of magnesia;

Bi-carbonate of iron;

Chloride of sodium, (common salt;)

And sulphate of soda.

This is a weak *saline chalybeate* water. All the iron separates from it on standing or boiling. Boiling also causes the deposition of most of the carbonates of lime and magnesia.

No. 561—MINERAL WATER. *Labeled "Chalybeate Spring," Olympian Springs, Bath county, Kentucky.*

One thousand grains of this water left only 0.75 of a grain of dry saline matter on evaporation.

It was found to contain—

Carbonic acid;

Bi-carbonate of lime, magnesia and iron;

Sulphates of magnesia and lime, in small quantities;

And traces of carbonate of soda and chloride of sodium.

This water resembles the preceding in its composition, containing a larger proportion of iron than that. All these *chalybeate* waters must be used *fresh from the spring*, when the full action of the dissolved carbonate of the protoxide of iron is desired, as it is very speedily precipitated when the water is allowed to stand exposed to the air, or when it is boiled. Even the small quantity of air which is usually left in the neck of a bottle, when it is corked, is sufficient to displace all the carbonic acid from the dissolved carbonate, and cause the whole of the iron to fall down as insoluble peroxide. After the iron is precipitated from this water very little saline matter remains dissolved in it.

No. 562—MINERAL WATER. *Labeled "Tea Spring or White Sulphur, Olympian Springs," Bath county, Kentucky.*

One thousand grains of this water, on evaporation to dryness, left 0.5 of a grain of saline matter.

It contains—

Sulphuretted hydrogen gas, in small quantity;

Carbonic acid gas;

Bi-carbonates of lime and magnesia, in small proportions;

Bi-carbonates of iron and soda, in considerable proportions;

Sulphate of soda, in small proportions;

Chloride of sodium, in small proportions.

This is a *good saline alkaline chalybeate*. It is a remarkably soft water after boiling has thrown down the oxide of iron and the earthy carbonates.

No. 563—MINERAL WATER. *Labeled "Salt Sulphur, from the Saloon," Olympian Springs, Bath county, Kentucky.*

One thousand grains of this water, evaporated to dryness, left 5.8 grains of *saline matters*.

It was found to contain—

Sulphuretted hydrogen gas;

Carbonic acid gas;

Bi-carbonates of lime and magnesia, in small proportions;

Chloride of sodium, in large proportion;

Chloride of calcium, in small proportion;

Carbonate of iron, a trace;

Carbonate of soda, a trace;

Iodide of sodium, a small proportion.

This is evidently a very valuable medicinal mineral water, more particularly from the fact that it contains *iodine*, the value of which, in many chronic diseases, is well known to physicians. This water should be thoroughly analyzed, and the relative proportions of its several ingredients, as they exist in the water fresh from the well, should be accurately ascertained. This would require, however, a visit to the spring, and the evaporation of several gallons of the water, for which there has been no time up to the preparation of this report.

No. 564—MINERAL WATER. Labeled "*Black Sulphur*," *Olympian Springs, Bath County, Kentucky*.

One thousand grains of this water were found to contain about one grain of dry saline matter.

The dissolved ingredients of this water, are

Sulphuretted hydrogen gas;

Carbonic acid gas;

Chloride of sodium, } in considerable proportions;

Carbonate of soda, }

Bi-carbonate of lime, } in small proportions;

Sulphate of soda, }

Bi-carbonate of iron, }

Other ingredients could doubtless be found, by operating on larger quantities of the water. This a good *alkaline sulphur water*.

BOONE COUNTY.

No. 565.—SOIL. Labeled "*Soil from a beech-wood pasture, which has never been in cultivation, Sandford farm, near Union, Boone county, Kentucky. Blue limestone, of the Lower Silurian formation.*"

The air-dried soil is of a light mouse-color.

One thousand grains, washed with water, left 855. grains of fine sand, of which all but 40.3 grains passed through the finest bolting-cloth. This coarser portion of the sand is composed of small rounded particles of clear and yellow quartz, and of a ferruginous mineral. One thousand grains, air-dried, digested for a month in water containing carbonic acid, gave up more than four and a half grains of buff-grey extract, dried at 212° F. The composition of which was found to be as follows:

	Grains.
Organic and volatile matters, - - - - -	0.930
Alumina, oxides of iron and manganese, and phosphates, - - -	.563
Carbonate of lime, - - - - -	2.330
Magnesia, - - - - -	.190
Sulphuric acid, - - - - -	.074
Potash, - - - - -	.223
Soda, - - - - -	.026
Silica, - - - - -	.187
Loss, - - - - -	.077
	4.600

The air-dried soil lost 4.635 per cent. of *moisture* when dried at 400° F.; and its composition, thus dried, is as follows:

Organic and volatile matters, - - - - -	7.827
Alumina, - - - - -	2.495
Oxide of iron, - - - - -	2.790
Carbonate of lime, - - - - -	.395
Magnesia, - - - - -	.495
Brown oxide of manganese, - - - - -	.195
Phosphoric acid, - - - - -	.318
Sulphuric acid, - - - - -	.084
Potash, - - - - -	.173
Soda, - - - - -	.040
Sand and insoluble silicates, - - - - -	84.620
Loss, - - - - -	.568
	100.000

No. 566.—SOIL. Labeled "*Same soil (as preceding,) from an old field twenty to thirty years in cultivation, Sandford farm, near Union, Boone county, Kentucky. Blue limestone of the Lower Silurian formation.*"

Color of the dried soil brownish-grey. The sand washed out from a thousand grains of this soil weighed 787.7 grains, and except 30.7 grains, was fine enough to pass through the bolting cloth. The coarser particles are principally rounded ferruginous grains, with some of clear and colored quartz. One thousand grains of the air-dried soil, digested for a month in water containing carbonic acid, gave up more than three grains of *light brown extract*, which had the following composition, dried at 212° F.:

Organic and volatile matters,	0.380
Alumina, oxides of iron and manganese, and phosphates,	.240
Carbonate of lime,	1.947
Magnesia,	.136
Sulphuric acid,	.045
Potash,	.082
Soda,	.005
Silica,	.110
Loss,	.155
	3.100

The air-dried soil lost 3.75 per cent. of moisture, at 400° F.; dried at which temperature it has the following composition, viz :

Organic and volatile matters,	5.506
Alumina,	3.520
Oxide of iron,	3.124
Carbonate of lime,	.495
Magnesia,	.469
Brown oxide of manganese,	.245
Phosphoric acid,	.126
Sulphuric acid,	.187
Potash,	.152
Soda,	.032
Sand and insoluble silicates,	85.595
Loss,	.549
	100.000

No. 567—SUB-SOIL. Labeled "Sub-soil from the old field, twenty to thirty years in cultivation, Sandford farm, near Union, Boone county, Kentucky. Blue limestone of Lower Silurian formation."

Dried sub-soil of a brownish-buff color, having a slightly more reddish tint than the preceding; in cloddy lumps. Washed with water, it gave 76.83 per cent. of sand, &c., of which all but 1.08 per cent. passed through the finest bolting-cloth. This coarser portion was principally composed of small rounded particles of ferruginous matter, with some grains of clear and yellowish quartz. One thousand grains, air-dried, gave to the carbonated water nearly two grains of light grey extract, dried at 212° F., which contained the following ingredients, viz :

Organic and volatile matters,	0.277
Alumina, oxides of iron and manganese, and phosphates,	.063
Carbonate of lime,	1.120
Magnesia,	.139
Sulphuric acid,	.022
Potash,	.066
Soda,	.008
Silica,	.241
	1.936

The air-dried sub-soil lost 3.19 per cent. of moisture at 400° F., and has the following composition, viz :

Organic and volatile matters,	3.455
Alumina,	3.945
Oxide of iron,	3.420
Carbonate of lime,	.265
Magnesia,	.536
Brown oxide of manganese,	.295
Phosphoric acid,	.476
Sulphuric acid,	.067
Potash,	.213
Soda,	.050
Sand and insoluble silicates,	87.645
	100.367

By comparing the several analyses of these soils, it will be seen that the soil from the old field has lost a notable quantity of its organic and volatile matters, its phosphoric acid and alkalies, while it exhibits a larger proportion of alumina and oxide of iron, and of sand and insoluble silicates, than the virgin soil; doubtless owing, in part, to some admixture with it of the sub-soil. The sub-soil is seen to be somewhat richer in phosphoric acid and potash, than even the virgin soil, and hence benefit may result from the use of the sub-soil plough in cultivation.

BOURBON COUNTY.

No. 568—SOIL. Labeled "Virgin soil, from Wm. P. Humes' farm, between the waters of Houston creek and Cooper's run; primitive forest growth, blue and black ash, honey locust, walnut, sugar tree, wild cherry, &c. Blue limestone of Lower Silurian formation. Bourbon county, Kentucky."

The dried soil is of a yellowish-umber color.

Washed with water this soil left 88.13 per cent. of sand, &c., of which all but 18.06 per cent. passed through the finest bolting-cloth. This coarser portion is composed of small rounded ferruginous particles.

One thousand grains of the air-dried soil, digested for twenty days in water containing carbonic acid, gave up *more than six grains* of light brown extract, dried at 212°, of the following *composition*, viz:

	Grains.
Organic and volatile matters, - - - - -	1.133
Alumina, oxides of iron and manganese, and phosphates, - - -	.672
Carbonate of lime, - - - - -	3.630
Magnesia, - - - - -	.194
Sulphuric acid, - - - - -	.039
Potash, - - - - -	.164
Soda, - - - - -	.065
Silica, - - - - -	.181
	6.078

The air-dried soil lost 5.10 per cent. of moisture at 400° F., and has the following *composition*, viz:

Organic and volatile matters, - - - - -	8.406
Alumina, - - - - -	5.745
Oxide of iron, - - - - -	5.185
Carbonate of lime, - - - - -	.945
Magnesia, - - - - -	.170
Brown oxide of manganese, - - - - -	.370
Phosphoric acid, - - - - -	.335
Sulphuric acid, - - - - -	.119
Potash, - - - - -	.227
Soda, - - - - -	.133
Sand and insoluble silicates, - - - - -	79.045
	100.680

No. 569—SOIL. Labeled "Soil from an old field, sixty years in cultivation; for some forty years in grass; same growth, &c., &c., as the preceding virgin soil; from Wm. P. Hume's farm, Bourbon county, Kentucky."

From both of these soils the coarse seive removed irregular fragments of decomposed chert, of limestone, and soft rounded ferrugi-

nous particles. The color of the dried soil is somewhat lighter and browner than that of the preceding.

Washed with water it left 78.56 per cent. of sand, &c., of which all but 6.83 per cent. passed through fine bolting-cloth; this coarser portion consists of small rounded ferruginous particles.

One thousand grains of the air-dried soil, digested for twenty days in water containing carbonic acid, gave up 3.149 grains of brownish *extract*, dried at 212°, which consisted of,

Organic and volatile matters, - - - - -	0.517
Alumina, oxides of iron and manganese, and phosphates, - - -	.422
Carbonate of lime, - - - - -	1.830
Magnesia, - - - - -	.105
Sulphuric acid, - - - - -	.025
Potash, - - - - -	.078
Soda, - - - - -	.075
Silica, - - - - -	.097
	3.149

The air-dried soil lost 3.84 per cent. of *moisture*, at 400° F., and has the following *composition*, viz:

Organic and volatile matters, - - - - -	5.574
Alumina, - - - - -	4.925
Oxide of iron, - - - - -	4.185
Carbonate of lime, - - - - -	.485
Magnesia, - - - - -	.110
Brown oxide of manganese, - - - - -	.395
Phosphoric acid, - - - - -	.330
Sulphuric acid, - - - - -	.085
Potash, - - - - -	.209
Soda, - - - - -	.114
Sand and insoluble silicates, - - - - -	83.310
Loss, - - - - -	.278
	100.000

No. 570—SUB-SOIL. Labeled "Sub-soil from the same old field, Wm. P. Hume's farm, Bourbon county, Kentucky."

The coarse seive removed from this sub-soil fragments of chert and ferruginous particles. The color of the air-dried sub-soil is somewhat lighter than that of the preceding. Washed with water this sub-soil left 79.17 per cent. of sand, &c., of which all but 6.80 per cent. pass-

ed through the finest bolting-cloth. This coarser portion consisted mainly of small rounded ferruginous particles.

One thousand grains of the air-dried sub-soil, digested for twenty days in water containing carbonic acid, gave up 2.263 grains of yellowish-grey *extract*, dried at 212° F., which was composed of

	Grains.
Organic and volatile matters, - - - - -	0.308
Alumina, oxides of iron and manganese, and phosphates, - - -	.205
Carbonate of lime, - - - - -	1.413
Magnesia, - - - - -	.075
Sulphuric acid, - - - - -	.022
Potash, - - - - -	.062
Soda, - - - - -	.062
Silica, - - - - -	.114
	2.263

The air-dried sub-soil lost 3.84 per cent. of moisture at 400° F.; dried at which temperature its *composition* is as follows:

Organic and volatile matters, - - - - -	4.196
Alumina, - - - - -	5.360
Oxide of iron, - - - - -	4.313
Carbonate of lime, - - - - -	.355
Magnesia, - - - - -	.521
Brown oxide of manganese, - - - - -	.420
Phosphoric acid, - - - - -	.440
Sulphuric acid, - - - - -	.085
Potash, - - - - -	.195
Soda, - - - - -	.100
Sand and insoluble silicates, - - - - -	84.070
	100.055

It is interesting to observe, that although the soil of the *old field*, in the preceding soils, has been sixty years under cultivation, it has lost much less of its phosphoric acid, sulphuric acid, and potash than might be expected from the lapse of time. This, doubtless, may be attributed to the fact that for most of this period—about forty years—the land has been in grass.

The immediate sub-soil of the old field does not show a much larger proportion of phosphoric acid than the virgin soil, while it contains less potash; but the red under-clay, next to be described, like most of the red under-clays on the blue limestone formation, exhibits a remarkable richness in this alkali.

No. 571—"RED UNDER-CLAY, with fragments of cherty rock and fossil shells, (*Terebratula capax* and *Orthis testudinaria*,) Capt. Wm. Hume's farm, Bourbon county, Kentucky."

Color, slightly lighter than that of the preceding, and of a purer brownish buff. Washed with water this under-clay left 69.67 per cent. of sand, &c., of which all but 11.93 per cent. was fine enough to pass through the finest bolting-cloth. This coarser portion consists of small rounded ferruginous particles.

One thousand grains of the air-dried clay, digested for twenty days in water containing carbonic acid, gave up 1.834 grains of light-grey *extract*, dried at 212°, which had the following *composition*, viz:

Organic and volatile matters, - - - - -	0.266
Alumina, oxides of iron and manganese, and phosphates, - - -	.063
Carbonate of lime, - - - - -	1.155
Magnesia, - - - - -	.067
Sulphuric acid, - - - - -	.016
Potash, - - - - -	.046
Soda, - - - - -	.040
Silica, - - - - -	.181
	1.834

The air-dried clay lost 6.45 per cent. of moisture at 400° F., and has the following *composition*, viz:

Organic and volatile matters, - - - - -	4.783
Alumina, - - - - -	12.785
Oxide of iron, - - - - -	9.420
Carbonate of lime, - - - - -	6.235
Magnesia, - - - - -	1.946
Brown oxide of manganese, - - - - -	.495
Phosphoric acid, - - - - -	.425
Sulphuric acid, - - - - -	.050
Potash, - - - - -	.840
Soda, - - - - -	.116
Sand and insoluble silicates, - - - - -	63.770
	100.865

Gradually mixed with the exhausted upper soil, by trenching or deep sub-soil plowing, this under-clay would improve it by furnishing a new supply of potash, phosphoric acid, and lime.

No. 572—LIMESTONE. Labeled "*Atrypa capax* limestone, under the soil of Capt. Wm. P. Hume's land, Bourbon county, Kentucky." Lower Silurian.

A crystalline, coarse-granular, light-grey, limestone, containing many shells and corals; very much eroded and cellular on the exterior, where it is of a brown color.

Composition, dried at 212° F.—

Carbonate of lime, - - -	81.340 = 45.645 of Lime.
Carbonate of magnesia, - -	.979
Alumina, and oxides of iron and manganese, - - -	.640
Phosphoric acid, - - -	.221
Sulphuric acid, - - -	.324
Potash, - - -	.104
Soda, - - -	.177
Sand and insoluble silicates, -	16.646
	100.431

No. 573—LIMESTONE. Labeled "*Shell limestone, near the surface, Capt. Wm. P. Hume's farm, Bourbon county, Kentucky. Lower Silurian formation.*"

A grey limestone, full of fossil shells, chætetes, &c., and sparkling with crystalline grains of calcareous spar; weathered surface nearly even, brownish.

Composition, dried at 212° F.—

Carbonate of lime, - - -	94.680 = 53.13 of Lime.
Carbonate of magnesia, - -	.980
Alumina, and oxides of iron and manganese, - - -	1.120
Phosphoric acid, - - -	.196
Sulphuric acid, - - -	.592
Potash, - - -	.166
Soda, - - -	.233
Insoluble silicates, - - -	1.086
Loss, - - -	.947
	100.000

Limestones, so rich in phosphoric acid, sulphuric acid, and the alkalies, and at the same time so easily decomposed under the atmospheric influences, always exert a marked enriching effect on the soil which rests upon them.

No. 574—SOIL. Labeled "*Virgin soil, woods pasture, Wm. Buckner's farm, Cane ridge land; primitive forest growth, large buckeye, oak, honey-locust, sugar-tree, &c. Lower Silurian formation. Bourbon county, Kentucky.*"

The dried soil is of a greyish-brown color. Washed with water this soil left 83.83 per cent. of sand, &c., of which all passed through the finest bolting-cloth except about 5.34 per cent., which was composed of small rounded ferruginous particles.

One thousand grains of the air-dried soil, digested for twenty days in water containing carbonic acid, gave up more than six and a half grains of brown extract, dried at 212° F., which was found to have the following composition, viz:

	Grains.
Organic and volatile matters, - - -	1.975
Alumina, oxides of iron and manganese, and phosphates, - -	1.583
Carbonate of lime, - - -	2.763
Magnesia, - - -	.058
Sulphuric acid, - - -	.065
Potash, - - -	.154
Soda, - - -	.068
Silica, - - -	.089
	6.760

The air-dried soil lost 5.865 per cent. of moisture at 400° F. Thus dried its composition is as follows, viz:

Organic and volatile matters, - - -	7.702
Alumina, - - -	4.620
Oxide of iron, - - -	6.685
Carbonate of lime, - - -	.622
Magnesia, - - -	.508
Brown oxide of manganese, - - -	.720
Phosphoric acid, - - -	.321
Sulphuric acid, - - -	.145
Potash, - - -	.224
Soda, - - -	.077
Sand and insoluble silicates, - - -	78.680
	100.204

No. 575—SOIL. Labeled "*Soil from an old corn-field, forty to fifty years in cultivation, (same locality and primitive forest growth as the*

preceding, Wm. Buckner's farm, &c., &c.) Bourbon county, Kentucky."

The dried soil is slightly lighter colored, and more yellowish than the preceding.

Washed with water it left 71.28 per cent. of sand, &c., of which all but 7.46 per cent. passed through the finest bolting-cloth. This coarser portion consisted of small rounded ferruginous particles.

One thousand grains of the air-dried soil, digested for twenty days in water containing carbonic acid, gave up nearly three grains of light-brownish-grey extract, dried at 212°, which was found to have the following composition, viz :

	Grains.
Organic and volatile matters, - - - - -	0.583
Alumina, oxides of iron and manganese, and phosphates, - - - - -	.496
Carbonate of lime, - - - - -	1.305
Magnesia, - - - - -	.088
Sulphuric acid, - - - - -	.045
Potash, - - - - -	.102
Soda, - - - - -	.076
Silica, - - - - -	.139
	2.834

The air-dried soil lost 4.5 per cent. of moisture, at 400° F., and, thus dried, has the following composition, viz:

Organic and volatile matters, - - - - -	5.837
Alumina, - - - - -	5.195
Oxide of iron, - - - - -	5.910
Carbonate of lime, - - - - -	.446
Magnesia, - - - - -	.416
Brown oxide of manganese, - - - - -	.593
Phosphoric acid, - - - - -	.282
Sulphuric acid, - - - - -	.101
Potash, - - - - -	.248
Soda, - - - - -	.103
Sand and insoluble silicates, - - - - -	81.080
	100.211

No. 576—SUB-SOIL. Labeled "Sub-soil from the same old field, at Wm. Buckner's farm, Cane ridge, Bourbon county, Kentucky."

Cloddy; color lighter and more yellowish than that of the two preceding.

Washed with water this sub-soil left 71.90 per cent. of sand, &c., of which all but 6.97 per cent. passed through the finest bolting-cloth. This coarser portion consists of small rounded ferruginous particles.

One thousand grains of the air-dried sub-soil, digested for twenty days in the water, containing carbonic acid, gave up 2.671 grains of yellowish-grey extract, dried at 212° F., which had the following composition, viz :

	Grains.
Organic and volatile matters, - - - - -	0.442
Alumina, and oxides of iron and manganese, and phosphates, - - - - -	.222
Carbonate of lime, - - - - -	1.530
Magnesia, - - - - -	.136
Sulphuric acid, - - - - -	.045
Potash, - - - - -	.064
Soda, - - - - -	.060
Silica, - - - - -	.172
	2.671

The air-dried sub-soil lost 4.60 per cent. of moisture at 400° F.; thus dried it has the following composition, viz :

Organic and volatile matters, - - - - -	4.785
Alumina, - - - - -	5.295
Oxide of iron, - - - - -	5.660
Carbonate of lime, - - - - -	.421
Magnesia, - - - - -	.517
Brown oxide of manganese, - - - - -	.345
Phosphoric acid, - - - - -	.243
Sulphuric acid, - - - - -	.110
Potash, - - - - -	.217
Soda, - - - - -	.130
Sand and insoluble silicates, - - - - -	82.230
Loss, - - - - -	.047
	100.000

No. 577.—UNDER-CLAY. Labeled "Under-clay, with bog iron ore, from Wm. Buckner's land, Cane ridge, Bourbon county, Kentucky."

Color of the dried clay greyish-buff. Washed with water it left 71.36 per cent. of sand, &c., of which all but 16.96 per cent. passed through the fine bolting cloth; this coarser part was composed of small rounded ferruginous particles.

One thousand grains of the air-dried under-clay, digested for twenty days in water containing carbonic acid, gave up less than two grains

of yellowish grey extract, dried at 212° F., which was found to consist of

	Grains.
Organic and volatile matters,	0.525
Alumina, oxides of iron and manganese, and phosphates,	.063
Carbonate of lime,	.913
Magnesia,	.125
Sulphuric acid,	.022
Potash,	.020
Soda,	.075
Silica,	.106
	1.849

The air-dried under-clay lost 7.085 per cent. of moisture, at 400° F., dried at which temperature its composition was found to be as follows, viz :

Organic and volatile matters,	4.875
Alumina,	8.720
Oxide of iron,	10.015
Carbonate of lime,	.446
Magnesia,	.753
Brown oxide of manganese,	.470
Phosphoric acid,	.221
Sulphuric acid,	.093
Potash,	.347
Soda,	.159
Sand and insoluble silicates,	74.145
	100.000

On comparing the analyses of this series of soils from Bourbon county, the usual fact will be observed of the diminution, in the old soil, of the materials necessary for the nourishment of vegetables, as compared with the original virgin soil. It will be seen that in the soil of the old corn-field, which has been from forty to fifty years in cultivation, there is less organic matter, less carbonate of lime, magnesia, oxide of manganese, phosphoric and sulphuric acids, than in the original soil, and that the former soil, lighter colored because it contains less organic matter, for the same reason, perhaps, is capable of holding a smaller proportion of hygrometric moisture than the latter. But the anomaly appears, which was seldom seen in the course of the examination of the soils of Kentucky, of a slightly larger amount of potash

in the soil of the old field than in the virgin soil. There is a possibility, however, that some undiscovered error may have occurred in the analysis, which, as this series of soils was submitted to examination just before this report was required to be made, could not be rectified by a repetition of the processes; but, on the other hand, there may have been a natural difference of composition in relation to their proportions of potash in the soils of these two neighboring fields. Moreover, the ordinary mode, in Bourbon and the neighboring counties, of feeding down on the same field, with hogs and cattle, the corn which has been raised on it, does not by any means exhaust the soil of the potash, like the removal of the crop from the ground, without the return to it of manure.

It will be seen that the under-clay, containing much more oxide of iron and less alumina than that under Capt. Wm. R. Hume's land, on the waters of Huston creek, contains also less potash, lime, and phosphoric acid. It yet contains enough of these to prove a valuable resource to renew the exhausted upper soil.

No. 578—LIMESTONE. Labeled "*Crystalline lime-rock, quarry below the woods pasture, on Wm. Buckner's land, Cane ridge, Bourbon county, Kentucky. Lower Silurian formation.*"

A limestone which is principally made up of large, pure, crystalline grains, with some little ochreous oxide of iron in spots throughout it; no fossils apparent in the specimen examined; weathered surface brownish.

Composition, dried at 212° F.—

Carbonate of lime,	97.540 = 53.735 per cent. of Lime.
Carbonate of magnesia,	.699
Alumina, and oxides of iron and manganese,	.287
Phosphoric acid,	.093
Sulphuric acid,	.180
Potash,	.065
Soda,	.206
Insoluble silicates,	1.446
	100.516

No. 579—LIMESTONE. Labeled "*Chaetetes limestone, below the woods pasture at Wm. Buckner's, Cane ridge, Bourbon county, Kentucky. Lower Silurian formation.*"

A grey limestone, full of fossil shells and coral, and sparkling with crystalline grains of calcareous spar. Weathered surface irregular, and of a brownish color.

Composition, dried at 212° F.—

Carbonate of lime,	-	-	95.480	= 53.58 per cent. of Lime.
Carbonate of magnesia,	-	-	1.398	
Alumina, and oxides of iron and manganese,	-	-	.797	
Phosphoric acid,	-	-	.183	
Sulphuric acid,	-	-	.180	
Potash,	-	-	.085	
Soda,	-	-	.138	
Insoluble silicates,	-	-	2.326	

100.587

Purer limestones than those under Mr. Hume's land, but not quite so rich as those in the elements of vegetable nourishment.

BOYLE COUNTY.

No. 580—SOIL. Labeled "Virgin soil from Thomas Read's woods pasture, one mile from Danville; primitive forest growth principally sugar-tree, hickory, ash, and walnut. Lower Silurian formation. Boyle county, Kentucky."

The color of the dried soil is yellowish-brown; some ferruginous and cherty gravel was sifted out of it with the coarse seive. Washed with water it left 89.7 per cent. of sand, &c., of which all but 2.78 per cent. was fine enough to pass through the finest bolting-cloth. This coarser part consists of rounded ferruginous and cherty particles.

One thousand grains of the air-dried soil, digested for one month in water charged with carbonic acid, gave up to it more than five and a half grains of chestnut-brown extract, dried at 212°, which contained the following ingredients, viz:

	Grains.
Organic and volatile matters,	2.030
Alumina, oxides of iron and manganese, and phosphates,	.873
Carbonate of lime,	1.907
Magnesia,	.084
Sulphuric acid,	.090
Potash,	.579
Soda,	.087
Silica,	.033

5.683

The air-dried soil lost 3.50 per cent. of moisture at 400° F.; dried at which temperature its composition is as follows, viz:

Organic and volatile matters,	-	-	-	-	-	-	-	5.958
Alumina,	-	-	-	-	-	-	-	3.515
Oxide of iron,	-	-	-	-	-	-	-	3.835
Carbonate of lime,	-	-	-	-	-	-	-	.247
Magnesia,	-	-	-	-	-	-	-	.571
Brown oxide of manganese,	-	-	-	-	-	-	-	.320
Phosphoric acid,	-	-	-	-	-	-	-	.486
Sulphuric acid,	-	-	-	-	-	-	-	.119
Potash,	-	-	-	-	-	-	-	.183
Soda,	-	-	-	-	-	-	-	.071
Sand and insoluble silicates,	-	-	-	-	-	-	-	83.770
Loss,	-	-	-	-	-	-	-	.925

100.000

Rich blue-grass soil, containing, particularly, a large proportion of phosphoric acid, but not quite as much potash as most of the best soils on the blue limestone formation.

BRECKINRIDGE COUNTY.

No. 581—SOIL. Labeled "Virgin soil, from the level table-land near Hardinsburg, from over the sandstone superimposed on the Archimedes limestone, which is some forty or fifty feet below; primitive forest growth black oak, hickory, dogwood, sassafras, and some wild cherry. This soil represents a considerable tract about this place, and between it and the Ohio river. Breckinridge county, Kentucky."

The dried soil is of a dirty grey-cinnamon color; a small quantity of ferruginous and quartzose gravel was sifted out of it with the coarse seive. Washed with water this soil left 82.7 per cent. of sand, &c., of which all but 1.39 per cent. was fine enough to go through the bolting cloth. This coarser portion consisted principally of rounded particles of a soft ferruginous mineral, with very few quartzose grains.

One thousand grains of the air-dried soil, digested for a month in water charged with carbonic acid, gave up to it nearly two grains of brownish extract, dried at 212° F, which was found to consist of,

	Grains.
Organic and volatile matters,	0.630
Alumina, oxides of iron and manganese, and phosphates,	.196
Carbonate of lime,	.170
Magnesia,	.170

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Sulphuric acid, - - - - -	.070
Potash, - - - - -	.210
Soda, - - - - -	.050
Silica, - - - - -	.280
Loss, - - - - -	.051
	1.827

The air-dried soil lost 2.625 per cent. of *moisture* at 400° F.; and, when thus dried, was found to have the following *composition*, viz:

Organic and volatile matters, - - - - -	3.532
Alumina, - - - - -	2.080
Oxide of iron, - - - - -	2.215
Carbonate of lime, - - - - -	.022
Magnesia, - - - - -	.323
Brown oxide of manganese, - - - - -	.220
Phosphoric acid, - - - - -	.108
Sulphuric acid, - - - - -	.059
Potash, - - - - -	.194
Soda, - - - - -	.017
Sand and insoluble silicates, - - - - -	91.145
Loss, - - - - -	.085
	100.000

This soil exhibits a very large proportion of sand and insoluble silicates, and a remarkable deficiency of lime. The application to it of marl containing a considerable quantity of lime would be found to be beneficial. If the marl is rich also in phosphoric acid or phosphates it would be still better, as the proportion of that acid contained in the soil is less than usual.

No. 582—SOIL. *Labeled "Shallow soil, overlying the buff and white Archimedes and Productus beds of the sub-carboniferous limestone of Breckinridge county, Kentucky; taken three and a half miles west of Hardinsburg. This soil supports a small growth of oak and hickory."*

The dried soil is of a light mouse color; the coarse seive removed from it some fragments of ferruginous sandstone. Washed with water it left 84.33 per cent. of sand, &c., of which all but 2.17 per cent. was fine enough to pass through bolting-cloth.

One thousand grains of the air-dried soil, digested for a month in water charged with carbonic acid, gave up nearly two grains of *dark-brown extract*, dried at 212° F. This has the following *composition*:

	<i>Grains.</i>
Organic and volatile matters, - - - - -	0.850
Alumina, oxides of iron and manganese, and phosphates, - - -	.313
Carbonate of lime, - - - - -	.047
Magnesia, - - - - -	.078
Sulphuric acid, - - - - -	.042
Potash, - - - - -	.119
Soda, - - - - -	.039
Silica, - - - - -	.133
Loss, - - - - -	.279
	1.900

The air-dried soil lost 2.60 per cent. of *moisture* at 400° F. Its *composition*, thus dried, is as follows, viz:

Organic and volatile matters, - - - - -	5.030
Alumina, - - - - -	1.640
Oxide of iron, - - - - -	1.490
Carbonate of lime, - - - - -	.147
Magnesia, - - - - -	.285
Brown oxide of manganese, - - - - -	.095
Phosphoric acid, - - - - -	.139
Sulphuric acid, - - - - -	.042
Potash, - - - - -	.198
Soda, - - - - -	.020
Sand and insoluble silicates, - - - - -	90.420
Loss, - - - - -	.494
	100.000

This differs but little, in general composition, from the preceding; it contains, however, rather more carbonate of lime and organic matters; apart from these the proportion of sand and insoluble silicates is fully as large as in that soil, there being a little less of alumina and oxide of iron. The addition of aluminous marl which is rich in lime, phosphates, and potash, would also greatly improve this soil.

BULLITT COUNTY.

No. 583—SOIL. *Labeled "Soil from the flats near Shepherdsville, derived chiefly, from the Black Devonian shale, at the base of the knobs, and the overlying ash-colored shales, which are most probably the lowest sub-carboniferous; considered almost unfit for cultivation, except for grass; too wet and unproductive, and but little cultivated; primitive growth oak, beech, black hickory, &c. Bullitt county, Kentucky."*

The dried soil is of an ash-grey color, and is quite cloddy, so that it was with difficulty passed through the seive. Washed with water it left 54.9 per cent. of sand, &c., of which all but 10.5 per cent. was fine enough to go through the finest bolting cloth. This coarser part consisted of rounded ferruginous and quartzose particles.

One thousand grains, digested for a month in water containing carbonic acid, gave up about two grains of grey-brown extract, dried at 212° F., which had the following composition, viz:

	Grains.
Organic and volatile matters, - - - - -	0.630
Alumina, oxides of iron and manganese, and phosphates, - - -	.598
Carbonate of lime, - - - - -	.223
Magnesia, - - - - -	.050
Sulphuric acid, - - - - -	.226
Potash, - - - - -	.065
Soda, - - - - -	.030
Silica, - - - - -	.200
	2.022

The air-dried soil lost 4.68 per cent of moisture at 380° F.; dried at which temperature it has the following composition, viz:

Organic and volatile matters, - - - - -	5.665
Alumina, - - - - -	2.476
Oxide of iron, - - - - -	4.790
Carbonate of lime, - - - - -	.196
Magnesia, - - - - -	.526
Brown oxide of manganese, - - - - -	.176
Phosphoric acid, - - - - -	.253
Sulphuric acid, - - - - -	.054
Potash, - - - - -	.258
Soda, - - - - -	.058
Sand and insoluble silicates, - - - - -	85.056
Loss, - - - - -	.492
	100.000

Thorough drainage would make this very good soil.

No. 584—SOIL. Labeled "Virgin soil over the magnesian limestone of the Upper Silurian system, Mr. Hall's farm, near Mt. Washington, Bullitt county, Kentucky. Primitive forest growth black, red, and white oak, hickory, dogwood, and some sugar-tree."

The dried soil is of a greyish-brown color. Some fragments of ferruginous sandstone were sifted out with the coarse seive. Washed with water this soil left 70.47 per cent. of sand, &c., of which only 1.7 per cent. was too coarse to pass through the finest bolting cloth; this consisted principally of soft rounded ferruginous particles.

One thousand grains of the air-dried soil, digested for a month in water charged with carbonic acid, gave up less than one and a half grains of brownish extract, dried at 212° F.; this had the following composition, viz:

	Grains.
Organic and volatile matters, - - - - -	0.230
Alumina, oxides of iron and manganese, and phosphates, - - -	.080
Carbonate of lime, - - - - -	.590
Magnesia, - - - - -	.060
Sulphuric acid, - - - - -	.070
Potash, - - - - -	.130
Soda, - - - - -	.080
Silica, - - - - -	.200
	1.390

The air-dried soil lost 2.92 per cent. of moisture at 400°; dried at which temperature its composition was found to be as follows:

Organic and volatile matters, - - - - -	3.120
Alumina, - - - - -	2.390
Oxide of iron, - - - - -	2.740
Carbonate of lime, - - - - -	.182
Magnesia, - - - - -	.348
Brown oxide of manganese, - - - - -	.165
Phosphoric acid, - - - - -	.097
Sulphuric acid, - - - - -	.067
Potash, - - - - -	.145
Soda, - - - - -	.037
Sand and insoluble silicates, - - - - -	90.555
Loss, - - - - -	.154
	100.000

No. 585—SOIL. Labeled "Same soil, which has been from fifty to sixty years in cultivation, from Mr. Hall's farm, near Mt. Washington, Bullitt county, Kentucky. This no longer produces clover."

The dried soil is of a grey-buff color; lighter than that of the preceding soil. Washed with water this soil left 78.2 per cent. of sand,

&c., of which all but 2.87 per cent. passed through the finest bolting-cloth; this portion consisted principally of rounded ferruginous particles, with some quartzose grains.

One thousand grains of the air-dried soil, digested in water containing carbonic acid, for a month, gave up less than a grain of *dark brown extract*, dried at 212° , the composition of which was as follows, viz:

Organic and volatile matters, - - - - -	0.317
Alumina, oxides of iron and manganese, and phosphates, - - - - -	.070
Carbonate of lime, - - - - -	.097
Magnesia, - - - - -	.050
Sulphuric acid, - - - - -	.084
Potash, - - - - -	.089
Soda, - - - - -	.013
Silica, - - - - -	.114
	0.834 of a gr.

The air-dried soil lost 2.725 per cent. of *moisture* at 400° , dried at which temperature it has the following *composition*, viz:

Organic and volatile matters, - - - - -	3.696
Alumina, - - - - -	1.890
Oxide of iron, - - - - -	2.215
Carbonate of lime, - - - - -	.072
Magnesia, - - - - -	.320
Brown oxide of manganese, - - - - -	.145
Phosphoric acid, - - - - -	.070
Sulphuric acid, - - - - -	.055
Potash, - - - - -	.104
Soda, - - - - -	.058
Sand and insoluble silicates, - - - - -	91.695
	100.320

The inability of this soil to produce clover is explained by its very small proportion of lime, and rather small amount of sulphuric and phosphoric acids. The addition of Plaster of Paris, or some of the calcareous marls, would probably restore to it the capability of supporting a clover crop. Sub-soil plowing may have some good effect upon it. The proportion of sand and silicates, however, is quite large, and that of the alkalies also quite moderate. The exhaustive influence, on this soil, of the fifty or sixty years cultivation, is well exhibited in the foregoing analyses.

No. 586—SUB-SOIL. Labeled "*Sub-soil from the same old field, fifty to sixty years in cultivation, Hall's farm, near Mount Washington, Bullitt county, Kentucky.*"

Color of the dried soil darker and more reddish than that of the preceding. Washed with water it left 34.3 per cent. of sand, &c., of which all but 1.43 per cent. passed through the bolting cloth; this portion consisted of round particles of ferruginous mineral, with a few quartzose.

One thousand grains of the air-dried soil, digested for a month in water which was charged with carbonic acid, gave up about a grain and a third of *brownish-grey extract*, dried at 212° ; which had the following composition, viz:

	Grains.
Organic and volatile matters, - - - - -	0.270
Alumina, oxides of iron and manganese, - - - - -	.063
Carbonate of lime, - - - - -	.496
Magnesia, - - - - -	.072
Sulphuric acid, - - - - -	.047
Potash, - - - - -	.140
Soda, (not estimated.)	
Silica, - - - - -	.233
	1.321

The air-dried sub-soil lost 3.25 per cent. of *moisture* at 400° ; dried at which temperature its *composition* is as follows, viz:

Organic and volatile matters, - - - - -	3.229
Alumina, - - - - -	4.345
Oxide of iron, - - - - -	4.495
Carbonate of lime, - - - - -	.197
Magnesia, - - - - -	.289
Brown oxide of manganese, - - - - -	.012
Phosphoric acid, - - - - -	.109
Sulphuric acid, - - - - -	.050
Potash, - - - - -	.235
Soda, - - - - -	.042
Sand and insoluble silicates, - - - - -	86.720
Loss, - - - - -	.277
	100.000

It will be seen, that this sub-soil contains more than twice as much carbonate of lime than the upper soil of the old field; it is also richer in potash and phosphoric acid. The proportion of sulphuric acid in it

is small, however, and although it might improve the fertility of the field somewhat to use the sub-soil plough, yet the addition of Plaster of Paris, and marl, or manures containing phosphates and calcareous matter, would be still more beneficial. The considerable proportion of alumina and oxide of iron of this sub-soil would also be beneficial in its admixture with the surface soil.

No. 587—MARL. Labeled "*Marl from the line between Bullitt and Spencer counties, Kentucky, in the Favosites maximus beds. Lower Silurian formation.*"

In friable lumps of a grey-buff color, containing irregular nodules of porous limestone, and some portions of fossil shells; powder of a light buff color, slightly gritty under the teeth; effervesced strongly with hydrochloric acid.

The air-dried marl lost 2.55 per cent. of moisture, at 212° F.

Composition, dried at 212° F.—	
Carbonate of lime, - - - - -	41.740
Carbonate of magnesia, - - - - -	1.088
Alumina, and oxides of iron and manganese, - - - - -	5.480
Phosphoric acid, - - - - -	.157
Sulphuric acid, - - - - -	.066
Potash, - - - - -	.573
Soda, - - - - -	.152
Sand and insoluble silicates, - - - - -	48.840
Water, organic matters, and loss, - - - - -	1.904
	100.000

This calcareous marl, besides its large proportion of carbonate of lime, contains a considerable amount of potash, which would make it a very valuable addition to some of the light lands of Bullitt county, if the expense of hauling should not prove too great. As it has but a small relative proportion of sulphuric acid, and a moderate quantity of phosphoric acid, the addition of Plaster of Paris and super-phosphate of lime, or the latter alone, would make the application of this marl still more useful.

No. 588—MARL. Labeled "*Marl from the northeast part of Bullitt county, Kentucky.*"

In irregular, soft, friable lumps, of a greenish-grey color. Gritty under the teeth Effervesces with acids.

The air-dried marl lost 3.15 per cent. of moisture at 212° F.; and thus dried had the following composition, viz :

Carbonate of lime, - - - - -	11.190
Carbonate of magnesia, - - - - -	2.147
Alumina, and oxides of iron and manganese, - - - - -	5.230
Phosphoric acid, (only a trace.)	
Sulphuric acid, - - - - -	.066
Potash, - - - - -	.308
Soda, - - - - -	.055
Sand and insoluble silicates, - - - - -	74.790
Water, organic matter and loss, - - - - -	6.214
	100.000

This marl is not so rich in calcareous matter and potash as the preceding, yet it contains these in sufficient amount to make it a useful application to soils which are deficient in these materials. The almost total absence of phosphoric acid, and the small proportion of sulphuric acid which it contains, is a great draw-back on its value. It should, therefore, be mixed with acid phosphate of lime, (bones softened by means of sulphuric acid,) when it is used as a top-dressing to the land.

No. 589—LIMONITE. Labeled "*Iron ore from the knob at Bullitt's Lick. (Sub-carboniferous sandstone formation.) Bullitt county, Kentucky.*"

Portion of a kidney-form mass; in concentric layers of a brown and brownish-yellow color; adhering to the tongue; powder of a brownish-yellow color.

Composition, dried at 212° F.—

Oxide of iron, - - - - -	33.99 = 23.80 per cent. Iron.
Alumina, - - - - -	1.58
Brown oxide of manganese, - - - - -	.48
Lime, a trace.	
Magnesia, - - - - -	.68
Phosphoric acid, not estimated.	
Sulphur, - - - - -	.35
Potash, - - - - -	.44
Soda, - - - - -	.23
Silicious residue, - - - - -	56.13
Combined water, - - - - -	6.75
	100.63

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

A very silicious, and rather poor ore of iron, which could perhaps be used with advantage to mix with richer ores.

CAMPBELL COUNTY.

No. 590—SOIL. Labeled "Virgin soil, from Benj. Beall's land, Alexandria, Campbell county, Kentucky; primitive forest growth beech, walnut, hickory, sugar-tree, and large white oak. Lower Silurian formation."

Dried soil of a light umber color. Washed with water it left 86.13 per cent. of sand, &c., of which 1.50 per cent. would not pass the finest bolting-cloth. This coarser portion consisted of rounded ferruginous particles, with a few of quartz.

One thousand grains of the air-dried soil, digested for twenty days in water containing carbonic acid, gave up nearly three grains of dark brown extract, dried at 212° F., which had the following composition, viz:

	Grains.
Organic and volatile matters, - - - - -	1.000
Alumina, oxides of iron and manganese, and phosphates, - - -	.713
Carbonate of lime, - - - - -	.781
Magnesia, - - - - -	.128
Sulphuric acid, - - - - -	.050
Potash, - - - - -	.079
Soda, - - - - -	.037
Silica, - - - - -	.086
	2.874

The air-dried soil lost 3.35 per cent. at 400° F.; dried at which temperature it has the following composition:

Organic and volatile matters, - - - - -	5.614
Alumina, - - - - -	3.084
Oxide of iron, - - - - -	2.685
Carbonate of lime, - - - - -	.274
Magnesia, - - - - -	.474
Brown oxide of manganese, - - - - -	.110
Phosphoric acid, - - - - -	.245
Sulphuric acid, - - - - -	.101
Potash, - - - - -	.158
Soda, - - - - -	.108
Sand and insoluble silicates, - - - - -	86.730
Loss, - - - - -	.417
	100.000

No. 591—SOIL. Labeled "Soil from an old field, fifty years or more in cultivation, adjoining the "virgin soil," Benj. Beall's farm, Alexandria, Campbell county, Kentucky. Lower Silurian formation."

The dried soil is of a dirty-buff color. Washed with water it left 78.10 per cent. of sand, &c., of which all but 0.90 per cent. passed through the finest bolting-cloth. This coarser portion consisted of small rounded ferruginous particles, with a few of clear and milky quartz.

One thousand grains of the air-dried soil, digested for twenty days in water containing carbonic acid, gave up 1.386 grains of brownish extract, dried at 212° F., which had the following composition, viz:

	Grains.
Organic and volatile matters, - - - - -	0.433
Alumina, oxides of iron and manganese, and phosphates, - - -	.187
Carbonate of lime, - - - - -	.403
Magnesia, - - - - -	.032
Sulphuric acid, - - - - -	.065
Potash, - - - - -	.048
Soda, - - - - -	.054
Silica, - - - - -	.164
	1.386

The air-dried soil lost 1.925 per cent. of moisture, at 400° F.; dried at which temperature it had the following composition, viz:

Organic and volatile matters, - - - - -	3.441
Alumina, - - - - -	2.290
Oxide of iron, - - - - -	2.110
Carbonate of lime, - - - - -	.146
Magnesia, - - - - -	.592
Brown oxide of manganese, a trace, - - - - -	
Phosphoric acid, - - - - -	.177
Sulphuric acid, - - - - -	.119
Potash, - - - - -	.111
Soda, - - - - -	.053
Sand and insoluble silicates, - - - - -	91.095
	100.134

No. 592—SUB-SOIL. Labeled "Sub-soil from the old field fifty years or more in cultivation, Benj. Beall's farm, Alexandria, Campbell county, Kentucky. Lower Silurian formation."

Dried sub-soil of a clearer buff color than the surface soil last described. Washed with water it left 65.40 per cent. of sand, &c., of which all but 0.77 per cent. was fine enough to go through the finest bolting-cloth. This coarser portion consisted of rounded ferruginous and clear quartz particles.

One thousand grains of the air-dried sub-soil, digested for twenty days in water charged with carbonic acid, gave up *less than a grain of yellowish-grey extract*, dried at 212° F., which had the following composition, viz:

	Grains.
Organic and volatile matters, - - - - -	0.283
Alumina, oxides of iron and manganese, and phosphates, - -	.107
Carbonate of lime, - - - - -	.097
Magnesia, - - - - -	.069
Sulphuric acid, - - - - -	.049
Potash, - - - - -	.041
Soda, - - - - -	.067
Silica, - - - - -	.151
	0.864

The air-dried sub-soil lost 2.70 per cent. of *moisture* at 400°; dried at which temperature it has the following *composition*:

Organic and volatile matters, - - - - -	2.826
Alumina, - - - - -	3.740
Oxide of iron, - - - - -	3.270
Carbonate of lime, - - - - -	.072
Magnesia, - - - - -	.430
Brown oxide of manganese, - - - - -	.055
Phosphoric acid, - - - - -	.146
Sulphuric acid, - - - - -	.076
Potash, - - - - -	.159
Soda, - - - - -	.048
Sand and insoluble silicates, - - - - -	88.845
Loss, - - - - -	.333
	100.000

The difference between the composition of the virgin soil and that of the old field, as exhibited by the analyses, is striking and instructive. The sub-soil is not richer in potash than the *original* surface soil, and it contains less phosphoric acid, whilst it exhibits a remarkable deficiency of carbonate of lime. In the renovation of the old field, by

sub-soil plowing, lime or calcareous marl should also be abundantly applied.

CARROLL COUNTY.

No. 593—SOIL. Labeled "*Virgin soil from Walton Craig's farm, half a mile from Ghent; bottom land; primitive forest growth, beech. Lower Silurian formation. Carroll county, Kentucky.*"

The dried soil is of a dark-brownish-grey color. The coarse seive removed from it a few rounded particles, about the size of mustard seed, of ferruginous mineral and milky quartz or chert. Washed with water this soil left 86.46 per cent. of sand, &c., of which all except 2.85 per cent. passed through the finest bolting-cloth. This coarser portion of the soil is composed principally of rounded particles of hyaline quartz, with a few grains of soft ferruginous mineral.

One thousand grains of the air-dried soil, digested for a month in water containing carbonic acid, gave up *nearly five grains of brownish extract*, dried at 212° F., of which the *composition* is as follows:

	Grains.
Organic and volatile matters, - - - - -	1.317
Alumina, oxide of iron, and phosphates, - - - - -	.980
Carbonate of lime, - - - - -	1.730
Magnesia, - - - - -	.183
Brown oxide of manganese, - - - - -	.100
Sulphuric acid, - - - - -	.085
Potash, - - - - -	.228
Soda, - - - - -	.030
Silica, - - - - -	.237
	4.890

The air-dried soil lost 3.80 per cent. of moisture at 400° F., and has the following *composition*, viz:

Organic and volatile matters, - - - - -	5.744
Alumina, - - - - -	3.910
Oxide of iron, - - - - -	3.455
Carbonate of lime, - - - - -	.245
Magnesia, - - - - -	.527
Brown oxide of manganese, - - - - -	.222
Phosphoric acid, - - - - -	.396
Sulphuric acid, - - - - -	.054
Potash, - - - - -	.312
Soda, - - - - -	.022
Sand and insoluble silicates, - - - - -	85.483
	100.370

No. 594—SOIL. Labeled "Soil from an old field; fifty years or more in cultivation, Walton Craig's farm, half a mile northwest of Ghent. Lower Silurian formation. Carroll county, Kentucky."

The color of this dried soil is of a more yellowish tint than that of the preceding—approaching that of the sub-soil, next to be described.

The coarse sieve removed from it a few rounded pebbles and gravel, from the size of a bean down to that of a mustard seed; consisting of sandstone, milky quartz, and other hard quartzose minerals, with some soft ferruginous gravel. Washed with water this soil left 84.76 per cent. of sand, &c., of which all but 2.23 per cent. was fine enough to pass through the finest bolting-cloth; this portion consists principally of clear yellowish and reddish rounded quartz particles with some ferruginous grains.

One thousand grains of the air-dried soil, digested for a month in water charged with carbonic acid, gave up more than four grains of reddish-brown extract, dried at 212° F., which had the following composition, viz:

	Grains.
Organic and volatile matters, - - - - -	1.170
Alumina, oxides of iron and manganese, and phosphates, - -	.963
Carbonate of lime, - - - - -	1.563
Magnesia, - - - - -	.156
Sulphuric acid, - - - - -	.145
Potash, - - - - -	.096
Soda, - - - - -	.042
Silica, - - - - -	.207
	4.342

The air-dried soil lost 2.375 per cent. of moisture when dried at 400° F.; and its composition, thus dried, is as follows:

Organic and volatile matters, - - - - -	3.618
Alumina, - - - - -	2.820
Oxide of iron, - - - - -	2.845
Carbonate of lime, - - - - -	.170
Magnesia, - - - - -	.340
Brown oxide of manganese, - - - - -	.195
Phosphoric acid, - - - - -	.203
Sulphuric acid, - - - - -	.038
Potash, - - - - -	.287
Soda, - - - - -	.064
Sand and insoluble silicates, - - - - -	89.921
	100.505

No. 595—SUB-SOIL. Labeled "Sub-soil from the old field, fifty years or more in cultivation, Mr. Walton Craig's farm, half a mile northwest of Ghent, Carroll county, Kentucky. Lower Silurian formation."

Color of the sub-soil of a more pure yellowish-brown tint than that of the preceding soil. The coarse sieve removed from it a few rounded pebbles of chert, sandstone, and milky quartz, from the size of a coffee-tree bean to that of mustard seed. Washed with water this soil left 87.10 per cent. of sand, &c., of which all but 2.5 per cent. was fine enough to pass through the finest bolting-cloth. This portion consisted principally of rounded grains of hyaline quartz, with a few of yellow milky and reddish quartz.

One thousand grains of the air-dried sub-soil, digested for a month in water charged with carbonic acid, gave up more than two grains of light brown extract, dried at 212° F., which had the following composition, viz:

	Grains.
Organic and volatile matters, - - - - -	0.490
Alumina, oxides of iron and manganese, and phosphates, - -	.297
Carbonate of lime, - - - - -	.830
Magnesia, - - - - -	.066
Sulphuric acid, - - - - -	.050
Potash, - - - - -	.056
Soda, - - - - -	.030
Silica, - - - - -	.200
	2.019

The air-dried sub-soil lost 2.30 per cent. of moisture at 400° F.; dried at which temperature it has the following composition:

Organic and volatile matters, - - - - -	2.814
Alumina, - - - - -	2.470
Oxide of iron, - - - - -	2.630
Carbonate of lime, - - - - -	.280
Magnesia, - - - - -	.300
Brown oxide of manganese, - - - - -	.180
Phosphoric acid, - - - - -	.227
Sulphuric acid, - - - - -	.059
Potash, - - - - -	.256
Soda, - - - - -	.026
Sand and insoluble silicates, - - - - -	90.515
Loss, - - - - -	.243
	100.000

This must be quite a fertile soil. The deterioration caused by fifty years or more of cultivation of the "old field," is well exhibited in the analyses. The sub-soil is hardly equal, in its proportions of phosphoric acid and potash, to the original surface soil. Sub-soil ploughing, or trenching, bringing up the sub-soil to the surface would, therefore, only be beneficial to the very old and exhausted fields, except so far as the mechanical loosening of the sub-stratum would facilitate the growth of vegetables.

CRITTENDEN COUNTY.

No. 596—SUB-SOIL, OR EARTH. Labeled "*Upland, lying immediately above the upper intercalated limestone. Millstone grit formation. Crittenden county, Kentucky.*"

The dried soil is of a buff color. Washed with water it left 83.9 per cent. of sand, &c., of which all but 0.53 per cent. was fine enough to pass through the finest bolting-cloth; this portion consisted of fragments of fossils, quartzose and ferruginous particles.

One thousand grains of the air-dried soil, digested for a month in water containing carbonic acid, gave up a little more than a grain of *light buff-colored extract*, which had the following composition:

Organic and volatile matters,	-	-	-	-	-	-	-	-	0.333
Alumina, oxides of iron and manganese, and phosphates,	-	-	-	-	-	-	-	-	.117
Carbonate of lime,	-	-	-	-	-	-	-	-	.173
Magnesia,	-	-	-	-	-	-	-	-	.086
Sulphuric acid,	-	-	-	-	-	-	-	-	.039
Potash,	-	-	-	-	-	-	-	-	.051
Soda,	-	-	-	-	-	-	-	-	.077
Silica,	-	-	-	-	-	-	-	-	.181
									1.057

The air-dried soil lost 3.415 per cent. of *moisture*, at 400° F., dried at which temperature it has the following *composition*, viz:

Organic and volatile matters,	-	-	-	-	-	-	-	-	4.695
Alumina,	-	-	-	-	-	-	-	-	5.070
Oxide of iron,	-	-	-	-	-	-	-	-	5.285
Carbonate of lime,	-	-	-	-	-	-	-	-	.050
Magnesia,	-	-	-	-	-	-	-	-	.606
Brown oxide of manganese, a trace.									
Phosphoric acid,	-	-	-	-	-	-	-	-	.106
Sulphuric acid,	-	-	-	-	-	-	-	-	.167
Potash,	-	-	-	-	-	-	-	-	.183

Soda,	-	-	-	-	-	-	-	-	-	.067
Sand and insoluble silicates,	-	-	-	-	-	-	-	-	-	83.548
Loss,	-	-	-	-	-	-	-	-	-	.218
										100.000

Although this lies immediately upon a limestone, the proportion of carbonate of lime in it is remarkably small. The application of lime to such land must always be beneficial. The oxide of manganese is also in quantity almost inappreciable.

DAVIESS COUNTY.

No. 597—SOIL. Labeled "*Soil which has never been in cultivation, from slope of ridge at Henry Dugan's farm, near the Coal Measures limestone; one of the best soils of Daviess county; forks of Panther; primitive forest growth, yellow poplar, much sugar-tree, black oak, hickory, sweet and black gum, elm, some beech, and black walnut.*"

The dried soil is of a mouse-color. Washed with water, it left 82.3 per cent. of sand, &c., of which all but 1.6 per cent. was fine enough to pass through the finest bolting-cloth. This portion consisted principally of rounded ferruginous particles, with a few grains of hyaline quartz, and of a black substance like scoria.

One thousand grains of the air-dried soil, digested for a month in water containing carbonic acid, gave up to it *nearly four and a half grains of brownish-grey extract*, dried at 212° F., which had the following composition, viz:

										Grains.
Organic and volatile matters,	-	-	-	-	-	-	-	-	-	1.340
Alumina, oxide of iron, and phosphates,	-	-	-	-	-	-	-	-	-	.218
Carbonate of lime,	-	-	-	-	-	-	-	-	-	1.660
Magnesia,	-	-	-	-	-	-	-	-	-	.266
Brown oxide of manganese,	-	-	-	-	-	-	-	-	-	.497
Sulphuric acid,	-	-	-	-	-	-	-	-	-	.188
Potash,	-	-	-	-	-	-	-	-	-	.142
Soda,	-	-	-	-	-	-	-	-	-	.023
Silica,	-	-	-	-	-	-	-	-	-	.099
										4.433

The air-dried soil lost 4.20 per cent. of *moisture* at 400° F.; dried at which temperature it had the following *composition*:

Organic and volatile matters,	6.972
Alumina,	1.360
Oxide of iron,	1.660
Carbonate of lime,	.536
Magnesia,	.358
Brown oxide of manganese,	.218
Phosphoric acid,	.177
Sulphuric acid,	.103
Potash,	.193
Soda,	.029
Sand and insoluble silicates, and loss,	89.394
	100.000

No. 598—SOIL. *Labeled "Soil from slope of ridge, at Henry Dugan's, near Coal-Measures limestone; in cultivation four years in tobacco, wheat, &c.; same primitive growth as preceding; forks of Panther, Daviess county, Kentucky."*

Color of the dried soil a little lighter than that of the preceding, and of a slight yellowish-tint. Washed with water it left 80.2 per cent. of sand, &c., of which all but 1.4 per cent. was fine enough to pass through the finest bolting-cloth; this portion was principally small rounded ferruginous particles with a few quartzose.

One thousand grains of the air-dried soil, digested for a month in water containing carbonic acid, gave up more than three and a half grains of light brownish-grey extract, which had the following composition, viz:

	Grains.
Organic and volatile matters,	0.800
Alumina, oxide of iron, and phosphates,	.168
Carbonate of lime,	1.798
Magnesia,	.233
Brown oxide of manganese,	.367
Sulphuric acid,	.090
Potash,	.083
Soda,	.042
Silica,	.139
	3.720

The air-dried soil lost 2.88 per cent. of moisture at 400° F.; dried at which temperature it has the following composition:

Organic and volatile matters,	6.301
Alumina,	1.776
Oxide of iron,	2.380
Carbonate of lime,	.416
Magnesia,	.341
Brown oxide of manganese,	.038
Phosphoric acid,	.151
Sulphuric acid,	.098
Potash,	.158
Soda,	.027
Sand and insoluble silicates,	89.236
	100.919

No. 599—SUB-SOIL. *Labeled "Sub-soil, from the field in cultivation, Henry Dugan's land, near Coal Measures limestone, forks of Panther Daviess county, Kentucky."*

Color of the dried sub-soil dirty grey-buff; much lighter than that of the preceding soil. Washed with water this sub-soil left 75.9 per cent. of sand, &c., of which all but 0.9 per cent. was fine enough to pass through the finest bolting-cloth. This portion consisted of rounded ferruginous and quartzose particles, with a few of a dark colored substance like scoria.

One thousand grains of the air-dried sub-soil, digested for a month in water charged with carbonic acid, gave up more than a grain and a half of brownish-grey extract, which had the following composition, viz:

	Grains.
Organic and volatile matters,	0.340
Alumina, oxide of iron and phosphates,	.068
Carbonate of lime,	.498
Magnesia,	.106
Brown oxide of manganese,	.239
Sulphuric acid,	.113
Potash,	.073
Soda,	.001
Silica,	.149
	1.587

The air-dried sub-soil lost 2.40 per cent. of moisture at 400° F.; and thus dried had the following composition:

Organic and volatile matters,	-	-	-	-	-	-	-	-	2.868
Alumina,	-	-	-	-	-	-	-	-	1.756
Oxide of iron,	-	-	-	-	-	-	-	-	2.520
Carbonate of lime,	-	-	-	-	-	-	-	-	.038
Magnesia,	-	-	-	-	-	-	-	-	.156
Brown oxide of manganese,	-	-	-	-	-	-	-	-	.174
Phosphoric acid,	-	-	-	-	-	-	-	-	.177
Sulphuric acid,	-	-	-	-	-	-	-	-	.068
Potash,	-	-	-	-	-	-	-	-	.097
Soda,	-	-	-	-	-	-	-	-	.015
Sand and insoluble silicates,	-	-	-	-	-	-	-	-	92.276
									100.145

The soil of the field which has been in cultivation only four years in tobacco and wheat shows a sensible diminution of organic matters, lime, magnesia, sulphuric and phosphoric acid, and the alkalis; is of a slightly lighter color than the virgin soil; gives less soluble extract to the water containing carbonic acid, (representing atmospheric water,) and holds less of hygrometric moisture; moreover, it contains a somewhat larger proportion of sand and insoluble silicates; the sub-soil of the old field is not as rich as the original surface soil.

ESTILL COUNTY.

No. 600—CARBONATE OF IRON. *Labeled "Iron ore, brought by Dr. E. L. Dudley from Sweet Lick knob, near Irvine, Estill county, Kentucky. Devonian formation."*

A nodule; the interior nucleus is a dark-grey fine-granular carbonate of iron; not adhering to the tongue; the exterior easily separates in dull-brown layers, which adhere to the tongue; powder of a mixture of the exterior and nucleus, of a brownish-yellow color.

Dried at 212° F., it lost 0.50 per cent. of *moisture*. Its composition, thus dried, is as follow, viz:

Oxide of iron,	-	-	52.60	} = 42.72 per cent. of Iron.
Carbonate of iron,	-	-	13.64	
Carbonate of lime,	-	-	1.00	
Carbonate of magnesia,	-	-	3.96	
Carbonate of manganese,	-	-	1.18	
Alumina,	-	-	1.01	
Phosphoric acid,	-	-	0.37	
Sulphur	-	-	.13	
Potash,	-	-	.25	
Soda, a trace.				

Combined water,	-	-	5.70
Silex and insoluble silicates,	-	-	20.78
			100.62

A very good ore of iron, which requires only the addition of limestone to make it smelt well in the high furnace.

No. 601—MINERAL WATER. *Labeled "White Sulphur water from Estill Springs, Irvine, Estill county, Kentucky."*

An opportunity has not yet been afforded for a complete quantitative analysis of the waters of the celebrated Estill mineral springs, at Irvine, but the waters of two of the springs were tested some years since, and the results will be given in this report.

Specific gravity of the "White Sulphur" water, - - - 1.001

One thousand grains gave, by evaporation, about 0.9 of a grain of saline matter, dried at 212° F. The water was found to contain

Sulphuretted hydrogen gas;
Carbonic acid gas;
Bi-carbonate of lime;
Bi-carbonate of magnesia;
Bi-carbonate of iron, a trace;
Bi-carbonate of soda;
Sulphate of lime;
Sulphate of magnesia;
Sulphate of soda;
Chloride of sodium;
And probably sulphate of potash,

Or chloride of potassium, with other chlorides. Whether iodine or bromine is to be found in this can only be ascertained by operating on large quantities of the water, evaporated to a small amount.

No. 602—MINERAL WATER. *Labeled "Red Sulphur water from Estill Springs, Irvine, Estill county, Kentucky."*

The specific gravity of this water is - - - 1.0002

One thousand grains gave only 0.4 of a grain of saline matter on evaporation to dryness.

This water is weaker than the preceding, but contains a larger proportion of chlorides.

It contains the same gases, viz: Sulphuretted hydrogen and carbonic acid; also bi-carbonates of lime, magnesia, and soda, in notable

proportions, with a trace of bi-carbonate of iron, probably more than is contained in the "White Sulphur."

It also contains sulphates of lime, magnesia, and soda, and probably of potash, with chlorides of sodium, calcium, and magnesium.

It is remarkable, in regard to these waters, as well as those of the Olympian Springs, and of several other springs of the state, that bi-carbonate of soda appears to exist, in the recent waters, in solution with bi-carbonates of lime, magnesia, and iron, even in the presence of a trace of sulphuretted hydrogen. These substances being all held in harmonious solution by the excess of carbonic acid present; when that gas escapes, however—as when the water is allowed to stand exposed to the air, or is boiled—the earthy carbonates fall down as insoluble precipitates, along with the iron which is thrown down as peroxide, or, in the presence of alkaline and earthy carbonates and sulphuretted hydrogen, partly as sulphuret of iron. It is probable that the "red" and dark colors noticed in the sediments from sulphur waters, which cause them to be denominated *red sulphur* or *black sulphur*, as the case may be, are due to the presence of iron, in less or greater quantities, whilst the sediment of the white sulphur, so-called, contains little or none of this substance.

FRANKLIN COUNTY.

No. 603—SOIL. Labeled "Soil from an unproductive spot, where a kiln of lime was formerly burnt, about thirty years ago, on Mr. Clarke's farm, two miles from Frankfort. Blue limestone formation. Franklin county, Kentucky."

Some fragments of limestone were found in this soil. The color of the dried soil is dirty-grey-buff. Washed with water it left 67.7 per cent. of grey-buff sand, &c., of which all but 6.3 per cent. passed through the finest bolting-cloth. This coarser portion consisted of rounded ferruginous and quartzose particles.

One thousand grains of the air-dried soil, digested for a month in water charged with carbonic acid, gave up *more than five grains of brownish-grey extract*, dried at 212° F., which had the following composition, viz:

	Grains.
Organic and volatile matters, - - - - -	0.600
Alumina, oxide of iron and phosphates, - - - - -	.068
Carbonate of lime, - - - - -	3.898
Magnesia, - - - - -	.126
Brown oxide of manganese, a trace.	
Sulphuric acid, - - - - -	.185
Potash, - - - - -	.057
Soda, - - - - -	.037
Silica, - - - - -	.099
	5.070

The air-dried soil lost 3.44 per cent. of *moisture* at 400° F.; dried at which temperature it was found to have the following *composition*:

Organic and volatile matters, - - - - -	4.722
Alumina, - - - - -	2.156
Oxide of iron, - - - - -	5.120
Carbonate of lime, - - - - -	1.490
Magnesia, - - - - -	.832
Brown oxide of manganese, - - - - -	.038
Phosphoric acid, - - - - -	.304
Sulphuric acid, - - - - -	.055
Potash, - - - - -	.212
Soda, - - - - -	.065
Sand and insoluble silicates, - - - - -	84.974
Loss, - - - - -	.032
	100.000

There is nothing in the *composition* of this soil which would account for its unproductiveness, all the essential ingredients being in good and sufficient quantities, except perhaps *sulphuric acid*, which is in rather less than the average quantity found in good soils, and *oxide of manganese*, which is decidedly deficient.

Notwithstanding the observations of that praise-worthy German Agricultural Chemist, Sprengel, on the influence exerted by oxide of manganese on the growth of plants, we know too little of its action on organic beings, vegetable and animal, to decide that its absence from the present soil is the cause of its sterility. The probability is, however, that some local accidental cause—as for instance, the escape of carbonic acid gas through some crevice in the rocks beneath the spot, and up through the soil—may be the reason why vegetables do not thrive there. The same remarks would apply to the soil next to be described.

No. 604—SOIL. Labeled "Soil from a 'sick spot,' on the blue limestone formation, near the Kentucky river, two miles from Frankfort, Franklin county, Kentucky. From limited spots where the soil is entirely bare of vegetation, and the grass beyond, for twenty paces, is yellow and sickly."

The soil was found to contain loose fragments of porous limestone. (See number 605.)

The dried soil is of a dirty reddish-grey-brown color. Washed with water it left 68.4 per cent. of sand, &c., of which all but 8.4 per cent. was fine enough to pass through the finest bolting-cloth. This portion consists of rounded ferruginous and quartzose particles.

One thousand grains of the air-dried soil, digested for a month in water charged with carbonic acid, gave up nearly six grains of brownish-grey extract, dried at 212° F., which had the following composition, viz:

	Grains.
Organic and volatile matters, - - - - -	0.340
Alumina, and oxide of iron and phosphates, - - - - -	.093
Carbonate of lime, - - - - -	4.838
Magnesia, - - - - -	.110
Brown oxide of manganese, - - - - -	.029
Sulphuric acid, - - - - -	.157
Potash, - - - - -	.057
Soda, - - - - -	.026
Silica, - - - - -	.118
Loss, - - - - -	.087
	5.860

The air-dried soil lost 3.92 per cent. of moisture at 400° F.; dried at which temperature it was found to have the following composition:

Organic and volatile matters, - - - - -	5.911
Alumina, - - - - -	2.550
Oxide of iron, - - - - -	4.380
Carbonate of lime, - - - - -	1.470
Magnesia, - - - - -	.826
Brown oxide of manganese, - - - - -	.376
Phosphoric acid, - - - - -	.433
Sulphuric acid, - - - - -	.095
Potash, - - - - -	.251
Soda, - - - - -	.007
Sand and insoluble silicates, - - - - -	83.936
	100.235

This has the composition of a fertile soil, and its unproductiveness must doubtless be attributed to local and accidental circumstances, as stated in connection with the analysis of the next preceding soil, No. 603.

No. 605—LIMESTONE. Labeled "Porous limestone, found in the soil from the 'sick spot,' No. 604. Blue limestone of the Lower Silurian formation. Franklin county, Kentucky."

Pores, in some places, lined with red oxide of iron; structure crystalline granular; light-grey color in the interior; dirty-buff on the exterior; contains fossil shells and coral; powder nearly white.

Dried at 212° F. it lost 0.30 per cent. of moisture.

Composition, dried at 212° F.—

Carbonate of lime, - - -	95.15 = 53.39 of Lime.
Carbonate of magnesia, - -	2.55
Alumina, and oxides of iron and manganese, - - -	.87
Phosphoric acid, - - -	.08
Sulphuric acid, - - -	.85
Potash, - - -	.23
Soda, - - -	.23
Silex and insoluble silicates, -	.58
	100.54

A pretty pure limestone, similar in composition to other specimens of blue limestone which have been examined, which contains many of the elements of vegetable nourishment, and hence exerts a beneficial, and not an injurious, effect upon the soil with which it is in contact.

No. 606—SOIL. Labeled "Virgin soil, from a new field for the first time in cultivation in a crop of corn, Alexander Julian's farm, four miles from Frankfort, Franklin county, Kentucky. Primitive forest growth, principally sugar-tree and mulberry. Lower Silurian formation, nearest to the encrinital member of the blue limestone."

Dried soil of a greyish-brown color. The coarse sieve removed from it a few rounded pebbles of yellowish quartz. Washed with water this soil left 81.9 per cent. of sand, &c., of which all but 4.03 per cent. was fine enough to pass through the finest bolting-cloth. This

portion consisted of clear grains of quartz, more or less rounded, with some ferruginous particles.

One thousand grains of the air-dried soil, digested for a month in water containing carbonic acid, gave up *nearly two and a half grains of light-brown extract*, having the following composition, viz:

	Grains.
Organic and volatile matters,	0.580
Alumina, oxides of iron and manganese, and phosphates,	.143
Carbonate of lime,	.997
Magnesia,	.130
Sulphuric acid,	.060
Potash,	.130
Soda,	.080
Silica,	.214
Loss,	.046
	2.380

The air-dried soil lost 3.79 per cent. of *moisture*, at 100° F., dried at which temperature it has the following composition:

Organic and volatile matters,	5.935
Alumina,	2.840
Oxide of iron,	2.370
Carbonate of lime,	.295
Magnesia,	.296
Brown oxide of manganese,	.220
Phosphoric acid,	.182
Sulphuric acid,	.084
Potash,	.198
Soda,	.040
Sand and insoluble silicates,	87.280
Loss,	.260
	100.000

No. 607—SOIL. Labeled "*The same soil, from an adjoining old field, forty years in cultivation; chiefly in corn, oats, wheat, and rye; for the last ten years occasionally in clover; usually pastured down; Alexander Julian's farm, four miles from Frankfort, Franklin county, Kentucky.*"

The color of this soil is intermediate between that of the virgin soil and the sub-soil. The coarse sieve removed from it some milky quartz pebbles, and some smaller fragments of ferruginous mineral.

Washed with water this soil left 73.83 per cent. of sand, &c., of which all but 9.20 per cent. was fine enough to pass through the finest bolting-cloth. This coarser portion consisted of rounded quartz grains, mixed with a few ferruginous particles.

One thousand grains of the air-dried soil, digested for a month in water containing carbonic acid, gave up *more than a grain and a half of light brown extract*, dried at 212° F., which had the following composition, viz:

	Grains.
Organic and volatile matters,	0.240
Alumina, oxides of iron and manganese, and phosphates,	.163
Carbonate of lime,	.697
Magnesia,	.056
Sulphuric acid,	.078
Potash,	.079
Soda,	.012
Silica,	.200
	1.525

The air-dried sub-soil lost 4.125 per cent. of moisture at 400° F.; dried at which temperature it had the following composition:

Organic and volatile matters,	3.911
Alumina,	3.220
Oxide of iron,	4.290
Carbonate of lime,	.305
Magnesia,	.271
Brown oxide of manganese,	.320
Phosphoric acid,	.350
Sulphuric acid,	.050
Potash,	.200
Soda,	.017
Sand and insoluble silicates,	87.280
	100.214

No. 608—SUB-SOIL. Labeled "*Sub-soil from the same old field, (as the preceding,) Alexander Julian's farm, four miles from Frankfort, Franklin county, Kentucky.*"

Dried soil of a dark dirty-buff color. Some small rounded pebbles of yellowish milky quartz, and smaller particles of ferruginous mineral, were sifted out of it with the coarse sieve. Washed with water it left 63.33 per cent. of sand, &c., of which all but 3.83 per cent. was fine

enough to go through the finest bolting-cloth. This coarser portion consisted of clear and colored grains of quartz, more or less rounded, with some of ferruginous mineral.

One thousand grains of the air-dried sub-soil, digested for a month in water containing carbonic acid, gave up *nearly a grain and a half of light brown extract*, which had the following *composition*, dried at 212° F., viz:

	Grains.
Organic and volatile matters, - - - - -	0.282
Alumina, oxides of iron and manganese, and phosphates, - - -	.063
Carbonate of lime, - - - - -	.614
Magnesia, - - - - -	.053
Sulphuric acid, - - - - -	.136
Potash, - - - - -	.047
Soda, - - - - -	.010
Silica, - - - - -	.231
	1.436

The air-dried sub-soil lost 4.815 per cent. of moisture, at 400° F., dried at which temperature it had the following *composition*:

Organic and volatile matters, - - - - -	3.405
Alumina, - - - - -	4.095
Oxide of iron, - - - - -	4.825
Carbonate of lime, - - - - -	.246
Magnesia, - - - - -	.450
Brown oxide of manganese, - - - - -	.335
Phosphoric acid, - - - - -	.359
Sulphuric acid, - - - - -	.081
Potash, - - - - -	.202
Soda, - - - - -	.029
Sand and insoluble silicates, - - - - -	85.810
Loss, - - - - -	.163
	100.000

The results presented by the analyses of the preceding soils are somewhat anomalous in relation to the proportions of potash and phosphoric acid, of which the former appears to be about the same in that of the old field as is found in the virgin soil, and the latter even in larger proportion. If no error has been committed in the labeling, or the labels have not been interchanged, as sometimes inadvertently happens, (one or two cases of which have been corrected by means of the analyses, as previously stated,) the anomaly may be explained by the sup-

position that some of the sub-soil, which has been brought to the surface of the old field by the plough, has been accidentally taken for analysis. By reference to the analysis of the sub-soil a striking similarity will be observed, in regard to the ingredients mentioned, in this and the surface soil of the old field. Not having taken measures to secure new specimens of Mr. Julian's soils for analysis, to verify these conjectures, we let them go, for the present, for as much as they are worth.

No. 609—LIMONITE (IMPURE.) *Labeled "Iron ore from Mr. Alexander Julian's farm, Franklin county, Kentucky."*

A friable cellular limonite; mottled; dark-brown and yellowish, and whitish; powder of a brown color. Dried at 212° F. it lost 6.20 per cent. of *moisture*:

Composition, dried at 212° F.—

Oxide of lime, - - - - -	26.69 = 18.69 per cent. of Iron.
Alumina, - - - - -	7.55
Lime, a small trace.	
Brown oxide of manganese, - - -	3.68
Magnesia, - - - - -	1.14
Phosphoric acid, - - - - -	.63
Sulphur, - - - - -	.05
Potash, - - - - -	.63
Soda, a small trace.	
Combined water, - - - - -	7.50
Silex and insoluble silicates, - -	52.68
	100.56

Rather too poor for profitable smelting by itself, but it might be used in mixture with calcareous ores, or with ores which contained too large a per centage of iron to furnish materials for *cinder*.

No. 610—SANDSTONE. *Labeled "Soft Green Rock, Frankfort, Franklin county, Kentucky. Lower Silurian."*

Rounded fragments of a soft granular rock, of a bluish-green color; adheres strongly to the tongue; powder greenish-white. Dried at 212° F., it lost 4. per cent. of *moisture*.

Composition, dried at 212° F.—

Alumina, and oxides of iron and manganese, - - -	9.47
Carbonate of lime, - - -	.99
Carbonate of magnesia, - - -	2.44
Phosphoric acid, - - -	.18
Sulphuric acid, - - -	2.60 = 1.03 of sulphur.
Potash, - - -	2.37
Soda, - - -	.13
Silex and insoluble silicates, -	80.68
Water and loss, - - -	1.14
	100.000

No. 611—UNDER-CLAY. *Labeled "Clay, one and a half to two feet under the surface soil, waters of Benson, near Hardinsburgh, Franklin county, Kentucky."*

Dried clay of dark greyish-buff color. The coarse seive removed from it some rounded fragments of ferruginous sandstone. Washed thoroughly with water it left 48.10 per cent. of fine sand, of which all but 0.86 per cent. passed through the finest bolting-cloth; this portion consisted of small rounded ferruginous particles.

One thousand grains of the air-dried clay, digested for a month in water containing carbonic acid, gave up *about a grain of nearly white extract*, dried at 212 F., which had the following *composition*, viz:

	Grains.
Organic and volatile matters, - - -	0.200
Alumina, oxides of iron and manganese, and phosphates, - - -	.055
Carbonate of lime, - - -	.214
Magnesia, - - -	.028
Sulphuric acid, - - -	.022
Potash, - - -	.073
Soda, - - -	.079
Silica, - - -	.298
Loss, - - -	.031
	1.000

The air-dried clay lost 4.40 per cent. of moisture at 400° F.; dried at which temperature it had the following *composition*:

	Grains.
Organic and volatile matters, - - -	4.205
Alumina, - - -	6.390
Oxide of iron, - - -	7.240
Carbonate of lime, - - -	.097
Magnesia, - - -	.781
Brown oxide of manganese, - - -	.145
Phosphoric acid, - - -	.182
Sulphuric acid, - - -	.033
Potash, - - -	.444
Soda, - - -	.032
Sand and insoluble silicates, - - -	80.580
	100.129

If this clay contained more carbonate of lime and phosphoric acid, these, with its considerable proportion of potash might make it a valuable application to exhausted land; as it is, it is not likely to prove very valuable for this purpose.

No. 612—SOIL. *Labeled "Virgin soil from woodland pasture on Robt. W. Scott's farm, five miles from Frankfort, near the Versailles and Frankfort turnpike, and the Lexington and Frankfort railroad; primitive forest growth, sugar-tree, white, red and black oak, black walnut, mulberry and honey locust. Lower Silurian formation. Franklin county, Kentucky."*

The dried soil is of a light-umber color. It contained a little soft iron gravel. Washed with water it left 82.90 per cent. of sand, &c., of which all but 6.10 per cent. was fine enough to pass through the finest bolting-cloth. This coarser portion consisted of small rounded ferruginous particles.

One thousand grains of the air-dried soil, digested for twenty days in water containing carbonic acid, gave up *about four grains of reddish-brown extract*, dried at 212°, F., which had the following *composition*:

	Grains.
Organic and volatile matters, - - -	0.692
Alumina, oxides of iron and manganese, and phosphates, - - -	.688
Carbonate of lime, - - -	2.113
Magnesia, - - -	.208
Sulphuric acid, - - -	.028
Potash, - - -	.096
Soda, - - -	.144
Silica, - - -	.114
	4.083

The air-dried soil lost 5.625 per cent. of moisture at 400°, dried at which temperature it had the following *composition*:

Organic and volatile matters,	-	-	-	-	-	-	-	-	7.072
Alumina, -	-	-	-	-	-	-	-	-	3.890
Oxide of iron, -	-	-	-	-	-	-	-	-	4.785
Carbonate of lime, -	-	-	-	-	-	-	-	-	.495
Magnesia, -	-	-	-	-	-	-	-	-	.607
Brown oxide of manganese, -	-	-	-	-	-	-	-	-	.272
Phosphoric acid, -	-	-	-	-	-	-	-	-	.404
Sulphuric acid, -	-	-	-	-	-	-	-	-	.153
Potash, -	-	-	-	-	-	-	-	-	.215
Soda, -	-	-	-	-	-	-	-	-	.084
Sand and insoluble silicates, -	-	-	-	-	-	-	-	-	82.270
									100.247

No. 613—SOIL. Labeled "Soil from an adjoining field, forty to fifty years in cultivation; rotation of crops and grasses, without manure. Robt. W. Scott's farm, near Frankfort, Franklin county, Kentucky."

Color of the dried soil slightly lighter and more yellowish than that of the preceding. It contained about one-twentieth of its weight of soft iron gravel. Washed with water it left 67.37 per cent. of sand, &c., of which all but 6.96 per cent. was fine enough to go through the fine bolting-cloth. This portion consisted of small rounded ferruginous particles.

One thousand grains of the air-dried soil, digested for twenty days in the water containing carbonic acid, gave up to it about *three grains of light-brown extract*, dried at 212° F., which had the following *composition*:

									Grains.
Organic and volatile matters,	-	-	-	-	-	-	-	-	0.783
Alumina, oxides of iron and manganese, and phosphates, -	-	-	-	-	-	-	-	-	.463
Carbonate of lime, -	-	-	-	-	-	-	-	-	1.280
Magnesia, -	-	-	-	-	-	-	-	-	.158
Sulphuric acid, -	-	-	-	-	-	-	-	-	.039
Potash, -	-	-	-	-	-	-	-	-	.094
Soda, -	-	-	-	-	-	-	-	-	.081
Silica, -	-	-	-	-	-	-	-	-	.139
									3.037

The air-dried soil lost 4.25 per cent. of *moisture* at 400°, F.; dried at which temperature it had the following *composition*:

									Grains.
Organic and volatile matters, -	-	-	-	-	-	-	-	-	6.292
Alumina, -	-	-	-	-	-	-	-	-	3.975
Oxide of iron, -	-	-	-	-	-	-	-	-	4.045
Carbonate of lime, -	-	-	-	-	-	-	-	-	.430
Magnesia, -	-	-	-	-	-	-	-	-	.519
Brown oxide of manganese, -	-	-	-	-	-	-	-	-	.197
Phosphoric acid, -	-	-	-	-	-	-	-	-	.305
Sulphuric acid, -	-	-	-	-	-	-	-	-	.093
Potash, -	-	-	-	-	-	-	-	-	.206
Soda, -	-	-	-	-	-	-	-	-	.054
Sand and insoluble silicates, -	-	-	-	-	-	-	-	-	84.120
									100.236

No. 614—SUB-SOIL. Labeled "Sub-soil from the old field, Robt. W. Scott's farm, near Frankfort, Franklin county, Kentucky."

The air-dried sub-soil is of a dirty-buff color. It contained about one-ninth of its weight of soft iron gravel. Washed with water it left about 70.90 per cent. of sand, &c., of which all but 5.40 per cent. was fine enough to go through the finest bolting-cloth. This portion consisted of small rounded ferruginous particles.

One thousand grains of the air-dried sub-soil, digested for twenty days in water containing carbonic acid, gave up *less than a grain of brownish-grey extract*, dried at 212° F., which had the following *composition*, viz:

									0.392
Organic and volatile matters, -	-	-	-	-	-	-	-	-	.055
Alumina, oxides of iron and manganese, and phosphates, -	-	-	-	-	-	-	-	-	.163
Carbonate of lime, -	-	-	-	-	-	-	-	-	.050
Magnesia, -	-	-	-	-	-	-	-	-	.028
Sulphuric acid, -	-	-	-	-	-	-	-	-	.046
Potash, -	-	-	-	-	-	-	-	-	.057
Soda, -	-	-	-	-	-	-	-	-	.106
Silica, -	-	-	-	-	-	-	-	-	
									0.897

The air-dried sub-soil lost 4.475 per cent. of *moisture* at 400° F.; dried at which temperature it had the following *composition*:

	Grains.
Organic and volatile matters, - - - - -	3.611
Alumina, - - - - -	5.740
Oxide of iron, - - - - -	7.085
Carbonate of lime, - - - - -	.445
Magnesia, - - - - -	.383
Brown oxide of manganese, - - - - -	.222
Phosphoric acid, - - - - -	.316
Sulphuric acid, - - - - -	.101
Potash, - - - - -	.173
Soda, - - - - -	.048
Sand and insoluble silicates, - - - - -	82.450
	100.574

By comparing the above analyses it will be seen that there has been a marked change produced in the composition of the soil of the old field, by forty to fifty years cultivation, and that all the materials essential to the constitution of vegetables have been diminished in quantity. Taking for example the phosphoric acid, which is in the proportion of 0.404 per cent. in the virgin soil, and of 0.305 in that of the old field; or, calculating three millions of pounds of soil to the acre to the depth of one foot,

The phosphoric acid in the virgin soil is equal to	- - - 12,120 lbs.
The phosphoric acid in the old field only equal to	- - - 9,150

The quantity removed from the acre by cultivation, is - - - 2,970 lbs.

The potash exhibits a comparatively smaller decrease, probably for the reason that the crops have been most frequently fed to cattle on the ground where they are grown, as this is a very common practice in this grazing country, and is well calculated to prevent much loss of the alkalies of the soil.

The potash in the virgin soil 0.215 per cent., is	- - - 6,450 lbs. to the acre.
That in the soil of the old field 0.206 per cent.,	- - - 6,180

Amount removed by cultivation, - - - 270 lbs.

The sub-soil does not appear to be as rich as the original surface soil; at all events it is not richer.

No. 615—LIMESTONE. Labeled "*Limestone under Robt. W. Scott's land, near Frankfort, Franklin county, Kentucky. Blue limestone of the Lower Silurian formation.*"

A bluish-grey limestone, with blotches of yellowish; full of fossil shells, chaetetes, &c., &c.

Composition, dried at 212° F.—

Carbonate of lime, - - -	95.380 = 53.522 per cent. of Lime.
Carbonate of magnesia, - -	1.510
Alumina, and oxides of iron and manganese, - - -	.769
Phosphoric acid, - - -	.311
Sulphuric acid, - - -	.579
Potash, - - -	.108
Soda, - - -	.003
Silex and insoluble silicates, -	2.080
	100.740

This limestone, which is the sub-stratum of the three preceding soils, is of a composition to renovate the soil above, if, as is generally the case with this kind of limestone, it is easily disintegrated under the action of air and moisture.

FAYETTE COUNTY.

No. 616—LIMESTONE. Labeled "*Magnesian limestone from Harris' quarry, on Elk Lick, about one mile below Clay's ferry, and about a mile and a half, in a straight course, from Grimes' quarry, on the Kentucky river.*"

Supposed to be of the same bed as Grimes'—See Nos. 511, 512 and 513, of the preceding volume—bed about five and a half to six feet thick; and lying about one hundred to a hundred and fifty feet above low water on the Kentucky river, as stated by Mr. Harris. General appearance of the limestone like that from Grimes' quarry. Two specimens were examined, marked A and B; one brought by Mr. Julius Adams, labeled A, and the other by Mr. Harris, proprietor of the quarry, marked B. The latter specimen was slightly lighter colored than the former.

Composition, dried at 212° F.—

	Specimen A.	Specimen B.
Specific gravity, - - -	2.728	2.7678
Carbonate of lime, - - -	59.88	64.40
Carbonate of magnesia, - -	37.05	33.90
Alumina, oxides of iron and manganese, and phosphates, -	1.38	.95
Potash, - - -	.61	} not determ'd.
Soda, - - -	.42	
Silex and insoluble silicates, -	2.63	2.00
	102.02	101.25

Comparative experiments were made with the magnesian limestones from Grimes' and Harris' quarries, and some fine-grained pure white Italian statuary marble from the marble yard in the city of Lexington. Each specimen was dressed and rubbed down, as accurately as possible to the form of a parallelopipedon, one inch and five-eighths long, five-eighths of an inch wide, and five-sixteenths of an inch thick. These blocks were thoroughly dried for eight hours, at the temperature of the boiling point of water; they then were found to weigh as follows:

- No. 1, from Grimes' quarry, weighed 43.0860 grammes.
- No. 2, from Harris' quarry, weighed 45.2135 grammes.
- No. 3, Italian statuary marble, weighed 47.1640 grammes.

The blocks were then immersed in pure water for twenty-four hours, the water being kept hot, and for much of that time at a boiling temperature. They were then taken out and wiped as dry as possible with bibulous paper, and again weighed, with the following results, viz:

- No. 1, Grimes', weighed 44.7450 grammes.
- No. 2, Harris', weighed 46.1185 grammes.
- No. 3, Italian marble, weighed 47.2100 grammes.

Thus:

- No. 1 had absorbed 1.6590 grammes, or 3.85404 per cent. of water.
- No. 2 had absorbed 0.9050 grammes, or 2.00161 per cent. of water.
- No. 3 had absorbed 0.0460 grammes, or 0.09753 per cent. of water.

On allowing the blocks to remain, freely exposed to the dry air, for half an hour, and weighing again,

- No. 1 was found to have lost all the absorbed water except 1.3570 grammes.
- No. 2 was found to have lost all the absorbed water except 0.6125 gramme.
- No. 3 was found to have lost all the absorbed water except 0.0050 gramme.

After an hour's exposure to the air,

- No. 1 still retained, of the absorbed water, 1.1840 grammes.
- No. 2 still retained, of the absorbed water, 0.4565 gramme.
- No. 3 still retained, of the absorbed water, 0.0020 gramme.

After twelve hours exposure to the air the Italian marble weighed 47.156 grammes, or 0.008 gramme less than before immersion in the water, so that it had lost some soluble matter in the water.

The Harris' marble still exhibited an excess over the original weight, (dried at 212°,) of 0.012 grammes, and the Grimes' of 0.839 grammes.

The several blocks were then again dried thoroughly at the boiling temperature of water, and it was found that they each had lost weight

probably by the solution in the water of some soluble matter from the stone, or the separation of loose minute particles, which may have been lodged on the surfaces.

- No. 1, Grimes', had lost 0.0095 gramme.
- No. 2, Harris', had lost 0.0155 gramme.
- No. 3, Italian marble, had lost 0.0130 gramme.

Of course, when we make a compensation for this diminution of weight of the several blocks, after digestion in the water, some difference will be made in the figures representing the relative absorptive power in regard to water, of the three specimens; but yet it is evident, that so far as this test is concerned, the Italian marble exhibits by far the least power of absorbing water, and the Harris' rock less than that from Grimes' quarry. It is believed, however, from the great similarity of composition, and general structure of the limestones from Grimes' and Harris' quarries, that if *similar specimens* be taken from the two they would exhibit nearly corresponding results in experiments like the above described. The cause of the apparent difference in the above experiments is doubtless to be found, not in any natural difference in the nature of the limestones, but in the fact that the specimen from Harris' quarry was probably from near the weather-worn surface of the rock, the pores of which had been partly closed by the action of the atmospheric water, which, by dissolving a small quantity of the carbonate of lime, by means of the carbonic acid which it always contains, and leaving it deposited again on drying, had gradually filled up the interstices between the grains of the limestone, and thus diminished its power of absorbing water. The specimen from Grimes' quarry was from the interior of the bed.

A building stone which absorbs and retains much water is not usually a *durable* material, in regions where it is subject to the action of frost, and the more it absorbs of that fluid the greater is the danger of its speedy disintegration; for the reason that as water always expands, with an immense and uncontrollable force, when it freezes—increasing in volume one-eleventh of its bulk—the more water there is between the particles of the stone the greater is the danger of its disintegration by freezing.

It is to be remarked, however, that the relative power of absorbing water, of a building material, does not, in all cases, seem to measure its relative liability to disintegration under the action of frost, as may be

seen in the familiar examples of the Italian marble and the *well-burnt* brick. The latter having a much greater absorptive power than the former; while the ancient monuments of Europe and Asia demonstrate that nothing exceeds in durability the well-burnt clay.

The application of a solution of *soluble glass* to the surface of this magnesian building stone, according to the process of Fuchs, would fill up its pores and greatly increase its durability, whilst it would also probably prevent or diminish the dark discoloration which appears on the exterior after it has been exposed for some time to the atmosphere, which is no doubt occasioned by the penetration of water—it leaving its impurities on the surface.

No. 617—FOSSIL CHÆTETES LYCOPERDON, from the blue limestone of the Lower Silurian formation. Cut on the Henry's mill turnpike; Big Hill, near Lexington, Fayette county, Ky.

A pure, selected piece of this fossil coral of the blue limestone, was submitted to analysis, to ascertain what elements it contributed to the general composition of the rock, especially in view of its agricultural relationships.

Composition, dried at 212° F.—

Carbonate of lime,	-	-	-	-	-	-	-	-	97.820
Carbonate of magnesia,	-	-	-	-	-	-	-	-	.839
Alumina, and oxides of iron and manganese,	-	-	-	-	-	-	-	-	.480
Phosphoric acid,	-	-	-	-	-	-	-	-	.118
Sulphuric acid,	-	-	-	-	-	-	-	-	.235
Potash,	-	-	-	-	-	-	-	-	.166
Soda,	-	-	-	-	-	-	-	-	.020
Silex and insoluble silicates,	-	-	-	-	-	-	-	-	.527

100.205

Except that it contains less silicious matter it does not differ much in composition from the blue limestone itself—containing, as that does, all the mineral elements necessary to vegetable developement.

No. 618—MINERAL WATER. Sulphur water from the new bored well at Montmollin's mill, on the Elkhorn branch, Lexington, Fayette county, Ky.

This is an agreeable, weak, saline sulphur water, containing Sulphuretted hydrogen gas;
Carbonic acid gas;

Bi-carbonates of lime and magnesia;

Sulphates of lime, magnesia, and probably of potash and soda, with a considerable proportion of chloride of sodium.

It was tested by the writer about two years ago, and found to yield on evaporation *about one grain of dry saline matters* to the thousand grains of water. It was thought, at the time, that it also contained a trace of some phosphate. Complete analysis might show in it small quantities of iodine or bromine.

GALLATIN COUNTY.

No. 619—SOIL. Labeled "*Blue limestone soil, from a field thirty to forty years in cultivation, now in broom corn, near Big Lick creek, Gallatin county, Ky. No woodland near.*"

Dried soil of a greyish or umber-brown color. The coarse seive removed from it a small quantity of rounded particles of quartz and ferruginous mineral, rather larger than mustard seed. Washed with water this soil left 83.93 per cent. of sand, &c., of which 16.7 per cent. was too coarse to pass through fine bolting cloth. This consisted principally of rounded particles of ferruginous mineral, with a few of quartz. The apparent excess of this sand, &c., washed out by water, over the amount of sand and insoluble silicates, as given by the full analysis, is owing to the fact that the ferruginous mineral is mainly soluble in the hydrochloric acid, in which the soil was digested in the analysis.

One thousand grains of the air-dried soil, digested for a month in water containing carbonic acid, gave up *nearly three grains of light buff-grey extract*, dried at 212° F., which had the following composition, viz:

	Grains.
Organic and volatile matters,	0.530
Alumina, oxides of iron and manganese, and phosphates,	.363
Carbonate of lime,	1.530
Magnesia,	.090
Sulphuric acid,	.039
Potash,	.073
Soda,	.047
Silica,	.236
	2.908

The air-dried soil lost 5.575 per cent. of *moisture* at 400° F.; dried at which temperature it had the following *composition*, viz:

Organic and volatile matters,	-	-	-	-	-	-	-	-	7.005
Alumina, -	-	-	-	-	-	-	-	-	5.965
Oxide of iron, -	-	-	-	-	-	-	-	-	6.035
Carbonate of lime, -	-	-	-	-	-	-	-	-	.920
Magnesia, -	-	-	-	-	-	-	-	-	.768
Brown oxide of manganese, -	-	-	-	-	-	-	-	-	.320
Phosphoric acid, -	-	-	-	-	-	-	-	-	.360
Sulphuric acid, -	-	-	-	-	-	-	-	-	.114
Potash, -	-	-	-	-	-	-	-	-	.484
Soda, -	-	-	-	-	-	-	-	-	.013
Sand and insoluble silicates, -	-	-	-	-	-	-	-	-	77.770
Loss, -	-	-	-	-	-	-	-	-	.246
									100.000

This still has the composition of a very rich and fertile soil. It does not yield as much *soluble extract* to water charged with carbonic acid as the virgin soils generally on this formation—an evidence that it does not contain as large a proportion of *immediately available, or soluble*, nourishment for plants as they do. Its large proportions of potash, phosphoric and sulphuric acid, of lime, magnesia, and oxide of manganese, as well as of alumina, and oxide of iron, make it one of the superior soils of Kentucky. The sub-soil next to be described does not differ much from it in composition.

No. 620—SUB-SOIL. *Labeled "Sub-soil from the same field, thirty to forty years in cultivation, near Big Lick creek, Gallatin county, Kentucky."*

Color of the dried sub-soil slightly lighter than that of the preceding. It also contains particles of ferruginous mineral too large to pass through the coarse seive. Washed with water it left 79.83 per cent. of sand, &c., of which all but 17.96 per cent. passed through the finest bolting cloth; this portion is principally composed of rounded ferruginous particles, with very few of quartz.

One thousand grains of the air-dried sub-soil, digested for a month in water charged with carbonic acid, gave up *nearly three and a half grains of grey-buff extract*, dried at 212° F., which had the following *composition*, viz:

Grains.

Organic and volatile matters, -	-	-	-	-	-	-	-	-	0.570
Alumina, oxides of iron and manganese, and phosphates, -	-	-	-	-	-	-	-	-	.530
Carbonate of lime, -	-	-	-	-	-	-	-	-	1.850
Magnesia, -	-	-	-	-	-	-	-	-	.099
Sulphuric acid, -	-	-	-	-	-	-	-	-	.022
Potash, -	-	-	-	-	-	-	-	-	.053
Soda, -	-	-	-	-	-	-	-	-	.053
Silica, -	-	-	-	-	-	-	-	-	.264
									3.441

The air-dried sub-soil lost 6.00 per cent. of *moisture*, at 400° F.; dried at which temperature it had the following *composition*:

Organic and volatile matters, -	-	-	-	-	-	-	-	-	6.543
Alumina, -	-	-	-	-	-	-	-	-	5.715
Oxide of iron, -	-	-	-	-	-	-	-	-	6.170
Carbonate of lime, -	-	-	-	-	-	-	-	-	.970
Magnesia, -	-	-	-	-	-	-	-	-	.818
Brown oxide of manganese, -	-	-	-	-	-	-	-	-	.595
Phosphoric acid, -	-	-	-	-	-	-	-	-	.310
Sulphuric acid, -	-	-	-	-	-	-	-	-	.079
Potash, -	-	-	-	-	-	-	-	-	.354
Soda, -	-	-	-	-	-	-	-	-	.021
Sand and insoluble silicates, -	-	-	-	-	-	-	-	-	77.855
Loss, -	-	-	-	-	-	-	-	-	.570
									100.000

It is somewhat of an anomaly that this sub-soil contains more organic and volatile matters, and less phosphoric acid, sulphuric acid, and potash, than the surface soil, and that it gives more of soluble matter to the water containing carbonic acid than that.

GARRARD COUNTY.

No. 621—SOIL. *Labeled "Virgin soil, from woods pasture, on J. S. Hoskins' farm, forks of the road; some of the best soil in the county. Lower Silurian formation. Garrard county, Kentucky."*

Dried soil of a grey-brown color. The coarse seive removed a few small, irregular, cherty, fragments, a portion of an encrinital stem, and some soft ferruginous particles. Washed with water this soil left 73.77 per cent. of sand, &c., of which all but 4.63 per cent. was fine enough to pass through the finest bolting-cloth. This coarser portion

consisted principally of rounded particles of soft ferruginous mineral, with a few quartzose grains.

One thousand grains of the air-dried soil, digested for a month in water containing carbonic acid, gave up *more than seven and a half grains of chestnut colored extract*, dried at 212°, which had the following composition:

Organic and volatile matters,	1.230
Alumina, oxides of iron and manganese, and phosphates,	.930
Carbonate of lime,	4.413
Magnesia,	.323
Sulphuric acid,	.041
Potash,	.386
Soda,	.080
Silica,	.231
	7.634

The air-dried soil lost 5.825 per cent. of moisture at 400° F.; at which temperature it has the following composition:

Organic and volatile matters,	8.548
Alumina,	6.190
Oxide of iron,	3.920
Carbonate of lime,	1.910
Magnesia,	.763
Brown oxide of manganese,	.520
Phosphoric acid,	.559
Sulphuric acid,	.128
Potash,	.393
Soda,	.081
Sand and insoluble silicates,	77.380
	100.000

No. 622—SOIL. Labeled "Same soil (as the preceding,) from the oldest field in Garrard county; sixty to seventy years in cultivation; overlying cherty beds of blue limestone; Lower Silurian formation. J. S. Hoskins' farm. Garrard county, Kentucky."

Color of the dried soil a little lighter and more yellowish than that of the preceding. It contains a few small rounded fragments of soft ferruginous sandstone. Washed with water it left 81.46 per cent. of sand, &c., of which all but 7.83 per cent. was fine enough to pass through the finest bolting-cloth. This coarser portion consisted of rounded particles of ferruginous mineral, with very few quartz.

One thousand grains of the air-dried soil, digested for a month in water containing carbonic acid, gave up *more than four and a half grains of light chestnut-brown extract*, dried at 212° F., which had the following composition:

	Grains.
Organic and volatile matters,	0.883
Alumina, oxides of iron and manganese, and phosphates,	.913
Carbonate of lime,	2.117
Magnesia,	.140
Sulphuric acid,	.022
Potash,	.152
Soda,	.135
Silica,	.224
	4.586

The air-dried soil lost 4.55 per cent. of moisture, at 400° F., dried at which temperature it has the following composition:

Organic and volatile matters,	5.238
Alumina,	7.805
Oxide of iron,	5.165
Carbonate of lime,	3.270
Magnesia,	1.358
Brown oxide of manganese,	.649
Phosphoric acid,	.484
Sulphuric acid,	.059
Potash,	.386
Soda,	.025
Sand and insoluble silicates,	75.570
	100.000

These are both examples of good blue limestone, or "blue-grass" soil—the soil of the old field being still nearly as rich as the original soil in the neighborhood, notwithstanding the long period during which it has been in cultivation.

No. 623—SUB-SOIL. Labeled "Sub-soil from J. S. Hoskins' old field, sixty to seventy years in cultivation. Lower Silurian formation. Garrard county, Kentucky."

Color of this sub-soil still more yellowish and lighter than the preceding. Washed with water it left 83.9 per cent. of sand, &c., of which all but 12.96 per cent. passed through the finest bolting-cloth. This

coarser portion is principally composed of ferruginous and cherty rounded particles, with very few of quartzose mineral.

One thousand grains of the air-dried sub-soil, digested for a month in water containing carbonic acid, gave up *more than three grains of light-brown extract*, dried at 212° F.; which had the following composition, viz:

	Grains.
Organic and volatile matters, - - - - -	0.600
Alumina, oxides of iron and manganese, and phosphates, - - -	.547
Carbonate of lime, - - - - -	1.580
Magnesia, - - - - -	.090
Sulphuric acid, - - - - -	.025
Potash, - - - - -	.049
Soda, - - - - -	.038
Silica, - - - - -	.257
	3.186

The air-dried sub-soil lost 4.95 per cent. of moisture at 400° F.; dried at which temperature it had the following composition:

Organic and volatile matters, - - - - -	4.234
Alumina, - - - - -	8.577
Oxide of iron, - - - - -	5.745
Carbonate of lime, - - - - -	3.880
Magnesia, - - - - -	1.476
Brown oxide of manganese, - - - - -	.590
Phosphoric acid, - - - - -	.513
Sulphuric acid, - - - - -	.059
Potash, - - - - -	.354
Soda, - - - - -	.059
Sand and insoluble silicates, - - - - -	74.780
	100.267

The sub-soil differs but little in composition from soil on the surface of the field.

No. 624—SOIL. Labeled "*Virgin soil from woodland pasture, W. Smith's farm, Bryantsville, Garrard county, Kentucky. Lower Silurian formation.*"

The dried soil is of a light yellowish-umber color. Washed with water it left 82.75 per cent. of sand, &c., of which all but 5.40 per cent.

was fine enough to go through the finest bolting-cloth. This coarser portion consisted of small rounded soft ferruginous particles.

One thousand grains of the air-dried soil, digested for a month in water containing carbonic acid, gave up *nearly five grains of light chesnut-brown extract*, dried at 212° F., which had the following composition, viz:

	Grains.
Organic and volatile matters, - - - - -	1.070
Alumina, oxides of iron and manganese, and phosphates, - - -	.853
Carbonate of lime, - - - - -	2.488
Magnesia, - - - - -	.111
Sulphuric acid, - - - - -	.056
Potash, - - - - -	.094
Soda, - - - - -	.042
Silex, - - - - -	.218
	4.932

The air-dried soil lost 3.35 per cent. of moisture at 400° F.; dried at which temperature it had the following composition:

Organic and volatile matters, - - - - -	4.640
Alumina, - - - - -	3.140
Oxide of iron, - - - - -	2.875
Carbonate of lime, - - - - -	.420
Magnesia, - - - - -	.692
Brown oxide of manganese, - - - - -	.270
Phosphoric acid, - - - - -	.379
Sulphuric acid, - - - - -	.102
Potash, - - - - -	.121
Soda, - - - - -	.045
Sand and insoluble silicates, - - - - -	88.220
	100.904

No. 625—SOIL. Labeled "*Same soil (as the preceding,) from an adjoining field, which has been thirty to forty years in cultivation, Mr. Smith's farm, Bryantsville, Garrard county, Kentucky. Lower Silurian formation.*"

Color of the dried soil much like that of the preceding, but a very slight shade darker than that. Washed with water this soil left 77.7 per cent. of sand, &c., of which all but 5.30 per cent. was fine enough to go through the finest bolting-cloth. This coarser portion consisted,

principally, of small rounded ferruginous particles, with very few of quartzose.

One thousand grains of the air-dried soil, digested for a month in water charged with carbonic acid, gave up to it *more than three grains of chesnut-brown extract*, dried at 212° F., which had the following composition, viz:

	Grains.
Organic and volatile matters, - - - - -	0.917
Alumina, oxides of iron and manganese, and phosphates, - - -	.407
Carbonate of lime, - - - - -	1.620
Magnesia, - - - - -	.117
Sulphuric acid, - - - - -	.041
Potash, - - - - -	.079
Soda, - - - - -	.031
Silica, - - - - -	.131
	3.343

The air-dried soil lost 3.365 per cent. of moisture at 400° F.; dried at which temperature it has the following composition:

Organic and volatile matters, - - - - -	4.987
Alumina, - - - - -	3.040
Oxide of iron, - - - - -	3.844
Carbonate of lime, - - - - -	.385
Magnesia, - - - - -	.207
Brown oxide of manganese, - - - - -	.110
Phosphoric acid, - - - - -	.335
Sulphuric acid, - - - - -	.067
Potash, - - - - -	.106
Soda, - - - - -	.057
Sand and insoluble silicates, - - - - -	87.170
	100.308

No. 626—SUB-SOIL. Labeled "Sub-soil from the same field, thirty to forty years in cultivation, Mr. Smith's farm, Bryantsville, Garrard county, Kentucky. Lower Silurian formation."

Dried sub-soil of a light greyish-buff color. Washed with water it left 70.77 per cent. of sand, &c., of which all but 3.80 per cent. was fine enough to pass through the finest bolting-cloth. This coarser portion consisted mainly of small rounded ferruginous particles, with very few of quartzose.

One thousand grains of the air-dried sub-soil, digested for a month in water charged with carbonic acid, gave up *less than a grain and a half of greyish-brown extract*, dried at 212° F., which had the following composition:

	Grains.
Organic and volatile matters, - - - - -	0.483
Alumina, oxides of iron and manganese, and phosphates, - - -	.320
Carbonate of lime, - - - - -	.273
Magnesia, - - - - -	.043
Sulphuric acid, - - - - -	.034
Potash, - - - - -	.035
Soda, - - - - -	.071
Silica, - - - - -	.150
	1.409

The air-dried sub-soil lost 2.915 per cent. of moisture at 400° F.; dried at which temperature it has the following composition:

Organic and volatile matters, - - - - -	2.945
Alumina, - - - - -	3.815
Oxide of iron, - - - - -	3.290
Carbonate of lime, - - - - -	.170
Magnesia, - - - - -	.412
Brown oxide of manganese, - - - - -	.210
Phosphoric acid, - - - - -	.251
Sulphuric acid, - - - - -	.042
Potash, - - - - -	.120
Soda, - - - - -	.018
Sand and insoluble silicates, - - - - -	89.095
	100.368

Although the soil of the "old field" is slightly darker colored than the virgin soil, and contains a little more of organic and volatile matters than that, which is rather an unusual circumstance, we yet observe that it has undergone a sensible deterioration, during the thirty to forty years of cultivation to which it has been subjected, having lost not only some of its potash and phosphoric and sulphuric acids, but also of its lime, magnesia, and oxide of manganese. Except in the proportion of potash the sub-soil seems to be less rich than the surface-soil above it.

GRANT COUNTY.

No. 627—SOIL. Labeled "Virgin soil, principally derived from argillaceous rocks. Lower Silurian formation, Hayden Kendall's farm, on the Covington turnpike, seven miles from Williamstown; Grant county, Kentucky. Primitive forest growth, poplar and white oak."

Color of the dried soil brownish-grey. Washed with water it left 81.03 per cent. of sand, &c., of which all but 1.97 per cent. was fine enough to go through the finest bolting-cloth. This coarser portion consisted of fine rounded ferruginous particles, with a very few quartz-ose.

One thousand grains of the air-dried soil, digested for a month in water containing carbonic acid, gave up more than three grains of light brownish-grey extract, dried at 212° F., which had the following composition, viz:

	Grains.
Organic and volatile matters, - - - - -	0.730
Alumina, and oxides of iron and phosphates, - - - - -	.180
Carbonate of lime, - - - - -	1.199
Magnesia, - - - - -	.109
Brown oxide of manganese, - - - - -	.197
Sulphuric acid, - - - - -	.039
Potash, - - - - -	.137
Soda, - - - - -	.027
Silica, - - - - -	.384
Loss, - - - - -	.168
	3.170

The air-dried soil lost 3.15 per cent. of moisture, at 400° F.; dried at which temperature it has the following composition:

Organic and volatile matters, - - - - -	5.212
Alumina, - - - - -	2.530
Oxide of iron, - - - - -	2.595
Carbonate of lime, - - - - -	.247
Magnesia, - - - - -	.472
Brown oxide of manganese, - - - - -	.222
Phosphoric acid, - - - - -	.283
Sulphuric acid, - - - - -	.093
Potash, - - - - -	.186
Soda, - - - - -	.083
Sand and insoluble silicates, - - - - -	87.845
Loss, - - - - -	.232
	100.000

No. 628—SOIL. Labeled "Soil from an old field, forty to fifty years in cultivation, Hayden Kendall's farm, seven miles from Williamstown, on the Covington turnpike. Lower Silurian formation. Grant county, Kentucky."

Color of the dried soil slightly lighter than that of the preceding. Washed with water it left 76.53 per cent. of sand, &c., of which all but 4.93 per cent. was fine enough to go through the finest bolting-cloth. This coarser portion consisted principally of soft rounded ferruginous particles, with a few quartz grains.

One thousand grains of the air-dried soil, digested for a month in water containing carbonic acid, gave up more than two and a half grains of grey-brown extract, dried at 212° F., which had the following composition, viz:

	Grains.
Organic and volatile matters, - - - - -	0.413
Alumina, oxide of iron, and phosphates, - - - - -	.222
Carbonate of lime, - - - - -	1.082
Magnesia, - - - - -	.146
Brown oxide of manganese, - - - - -	.198
Sulphuric acid, - - - - -	.043
Potash, - - - - -	.122
Soda, - - - - -	.047
Silica, - - - - -	.281
Loss, - - - - -	.036
	2.590

The air-dried soil lost 3.135 per cent. of moisture at 400° F.; dried at which temperature it has the following composition:

Organic and volatile matters, - - - - -	4.572
Alumina, - - - - -	3.520
Oxide of iron, - - - - -	3.115
Carbonate of lime, - - - - -	.247
Magnesia, - - - - -	.433
Brown oxide of manganese, - - - - -	.222
Phosphoric acid, - - - - -	.135
Sulphuric acid, - - - - -	.080
Potash, - - - - -	.183
Soda, - - - - -	.071
Sand and insoluble silicates, - - - - -	87.595
	100.173

No. 629—SUB-SOIL. Labeled "Sub-soil, from Hayden Kendall's farm, &c., &c., Grant county, Kentucky." (See the two preceding soils.)

The dried sub-soil is of a slightly lighter color than the preceding, and somewhat more of a reddish tint. It is in the form of cloddy lumps. Washed with water it left 76.5 per cent. of sand, &c., of which all but 2.93 per cent. was fine enough to go through the finest bolting-cloth. This coarser portion consisted of small rounded particles of soft ferruginous mineral.

One thousand grains of the air-dried sub-soil, digested for a month in water charged with carbonic acid, gave up *nearly a grain and a half of light brownish-grey extract*, dried at 212° F., which had the following composition, viz:

	Grains.
Organic and volatile matters, - - - - -	0.237
Alumina, oxides of iron and manganese, and phosphates, - - -	.130
Carbonate of lime, - - - - -	.430
Magnesia, - - - - -	.333
Sulphuric acid, - - - - -	.034
Potash, - - - - -	.071
Soda, - - - - -	.002
Silica, - - - - -	.191
	1.428

The air-dried soil lost 2.415 per cent. of *moisture* at 400° F.; dried at which temperature it has the following composition:

Organic and volatile matters, - - - - -	3.111
Alumina, - - - - -	3.745
Oxide of iron, - - - - -	3.425
Carbonate of lime, - - - - -	.147
Magnesia, - - - - -	.379
Brown oxide of manganese, - - - - -	.212
Phosphoric acid, - - - - -	.244
Sulphuric acid, - - - - -	.045
Potash, - - - - -	.222
Soda, - - - - -	.052
Sand and insoluble silicates, - - - - -	88.650
	100.232

The usual fact of the diminution, by cultivation of the soil, of those ingredients which are essential to the vegetable composition, is to be

observed in these soils also. The sub-soil appears to be somewhat richer in phosphoric acid and potash than the surface-soil.

No. 630—SOIL. Labeled "Soil from the milk-sick region of Grant county, Kentucky, Moses Theobald's farm, five miles north of Williamstown."

The color of the air-dried soil is light greyish-buff. Washed with water it left 78.56 per cent. of sand, &c., of which all but 4.33 per cent. was fine enough to pass through the bolting-cloth. This coarser portion consisted of small rounded ferruginous particles.

One thousand grains of the air-dried soil, digested for twenty days in water charged with carbonic acid, gave up *more than two and a half grains of dark-brown extract*, dried at 212° F., which had the following composition, viz:

	Grains.
Organic and volatile matters, - - - - -	1.380
Alumina, oxides of iron and manganese, and phosphates, - - -	.463
Carbonate of lime, - - - - -	.489
Magnesia, - - - - -	.030
Sulphuric acid, - - - - -	.058
Potash, - - - - -	.089
Soda, - - - - -	.053
Silica, - - - - -	.131
	2.743

The air-dried soil lost 3.225 per cent. of *moisture* at 400° F.; dried at which temperature it had the following composition:

Organic and volatile matters, - - - - -	6.162
Alumina, - - - - -	2.815
Oxide of iron, - - - - -	2.734
Carbonate of lime, - - - - -	.196
Magnesia, - - - - -	.399
Brown oxide of manganese, - - - - -	.170
Phosphoric acid, - - - - -	.203
Sulphuric acid, - - - - -	.072
Potash, - - - - -	.133
Soda, - - - - -	.113
Sand and insoluble silicates, - - - - -	87.045
	100.042

There is nothing peculiar in the composition of this soil, which would tend to explain the cause of this sickness, which sometimes prevails in the region whence it was taken.

No. 631—SANDSTONE. *Labeled "Mud-stone from the milk-sick region of Grant county, Kentucky; at Moses Theobald's, five miles north of Williamstown."*

A dirty-buff colored, friable, impure, shaley sandstone; adheres to the tongue; some thin coatings of dark colored mineral, probably oxide of manganese, on the surfaces of some of the irregular layers.

Dried at 212° F., it lost 1.95 per cent. of moisture.

Composition, dried at 212° F.—

Alumina, oxides of iron and manganese, - - - -	6.202
Carbonate of lime, - - - - -	.563
Magnesia, - - - - -	.766
Phosphoric acid, - - - - -	.378
Sulphuric acid, - - - - -	.117
Potash, - - - - -	.363
Soda, - - - - -	.200
Sand and insoluble silicates, - - - - -	89.620
Water expelled at a red heat, - - - - -	1.950
	100.159

The sand and insoluble silicates contained more than 77. per cent. of silica. Nothing in the composition of this mudstone appears to throw any light on the origin of milk-sickness.

GREENUP COUNTY.

No. 632—CARBONATE OF IRON. *Labeled "Iron ore, (No. 1, the upper part,) from Messrs. Burr, McGrew & Co., Raccoon Furnace, Greenup county, Kentucky. Taken from the hills, just under the hearth-stone rock, placed in Dr. Owens section 215 feet above the level of Raccoon creek. The ore-bed is almost 18 inches thick, and is about three feet below the rock, with dark shale intervening."*

A carbonate of iron ore, varying from yellowish-brown and granular to darker and more compact and cellular; powder, of an average portion, of a brownish-yellow color.

Composition, dried at 212° F.—

Carbonate of iron, - - -	42.26	} = 52.95 per cent. of Iron.
Oxide of iron, - - -	46.45	
Carbonate of lime, - - -	.48	
Carbonate of magnesia, - - -	.38	
Carbonate of manganese, - - -	1.48	
Alumina, - - - - -	.38	
Phosphoric acid, - - -	.76	
Sulphur, - - - - -	.09	
Alkalies, (not estimated.)		
Silex and insoluble silicates, - - -	2.98	
Combined water, - - -	4.00	
Loss, - - - - -	.74	
	100.00	

A very good ore, almost too rich in oxide of iron to be successfully smelted in the high furnace, except in mixture with poorer silicious ores and limestone. (See next numbers.) The proportion of phosphoric acid is considerable, but probably not so great as to injure the quality of the iron produced from it.

No. 633—CARBONATE OF IRON. *Labeled "Iron ore, lower part of same bed as the preceding. Burr, McGrew & Co., Raccoon Furnace, Greenup county, Kentucky."*

General color dark purplish-brown; under the lens it appears to be made up of minute reddish-brown particles, with some intervening whitish material; adheres slightly to the tongue; a few glimmering specks of mica are seen through it.

Dried at 212° F. it lost 1.10 per cent. of moisture.

Composition, dried at 212° F.—

Carbonate of iron, - - -	51.24	} = 31.62 per cent. of Iron.
Oxide of iron, - - -	9.42	
Carbonate of lime, - - -	.68	
Carbonate of magnesia, - - -	2.76	
Carbonate of manganese, - - -	1.31	
Alumina, - - - - -	1.09	
Phosphoric acid, - - -	.64	
Sulphur, - - - - -	.09	
Potash, - - - - -	.15	
Soda, - - - - -	.23	
Silex and insoluble silicates, - - -	32.48	
	100.09	

A very good ore, which requires only limestone to smelt it. It could be advantageously mixed with the preceding ore; but for this purpose the mineral next to be described may perhaps be better, as it contains a larger proportion of silicious matter and a smaller amount of oxide of iron with some combustible matter.

No. 634—LIMONITE (IMPURE.) Labeled "Iron ore? (No. 3,) from Messrs. Burr, McGrew & Co., Raccoon Furnace, Greenup county, Kentucky. (Black band ore?) A bed about 18 inches thick, with 6 inches of coal under it, where it out-crops, about 200 feet above the level of Coal branch, about 3 miles from the Ohio river."

Dried at 212° F., it lost 3.40 per cent. of moisture.

Composition, dried at 212° F.—

Oxide of iron,	- - -	20.87 = 14.61 per cent. Iron.
Alumina,	- - -	.69
Carbonate of lime, a trace.	- - -	
Carbonate of magnesia,	- - -	3.24
Brown oxide of manganese,	- - -	.18
Phosphoric acid,	- - -	.31
Sulphur,	- - -	.25
Potash,	- - -	.38
Soda,	- - -	.10
Bituminous matter,	- - -	9.83
Silex and insoluble silicates,	- - -	60.28
Combined water,	- - -	3.15
Loss,	- - -	.72
		100.00

HANCOCK COUNTY.

No. 635—LIMONITE. Labeled "Iron ore from Mr. Pate's farm, one mile north of the Hardensburg road, Hancock county, Kentucky. Coal Measures."

A cellular, dark-brown limonite; slightly adhering to the tongue; with some of the cavities filled yellow and red ochreous ore; powder of a brownish-yellow color.

Dried at 212° it lost 1.30 per cent. of moisture.

Composition, dried at 212° F.—

Oxide of iron,	- - -	34.60 = 24.23 per cent. of Iron.
Alumina,	- - -	1.38
Lime, a trace.	- - -	
Magnesia,	- - -	.50
Sulphur,	- - -	.06
Potash,	- - -	.67
Soda,	- - -	.17
Combined water,	- - -	6.50
Silex and insoluble silicates,	- - -	55.58
Loss,	- - -	.54
		100.00

A poor silicious ore.

No. 636—SOIL. Labeled "Uncultivated upland soil from Mr. M. E. Pate's farm. Lower Coal Measures, based on ferruginous sandstone; primitive forest growth very large white oak, poplar, ash, some little sugar-tree, cherry, mulberry, chesnut, large dogwood, and black-walnut; undergrowth, pawpaw and spice-bush. Hancock county, Kentucky."

Dried soil mouse-colored. Washed with water it left 81.3 per cent. of sand, &c., of which all but 19.3 per cent. was fine enough to pass through the finest bolting-cloth. This portion consisted mainly of small rounded ferruginous particles, with very few of quartzose.

One thousand grains of the air-dried soil, digested for a month in water charged with carbonic acid, gave up nearly five grains of grey-buff extract, dried at 212° F., which had the following composition, viz:

	Grains.
Organic and volatile matters,	1.530
Alumina, oxide of iron, and phosphates,	.308
Carbonate of lime,	1.679
Magnesia,	.420
Brown oxide of manganese,	.428
Sulphuric acid,	.034
Potash,	.152
Soda,	.047
Silica,	.149
Loss,	.133
	4.890

The air-dried soil lost 3.325 per cent. of moisture at 400° F.; dried at which temperature it has the following composition:

Organic and volatile matters,	6.022
Alumina, - - - - -	2.295
Oxide of iron, - - - - -	2.390
Carbonate of lime, - - - - -	.310
Magnesia, - - - - -	.334
Brown oxide of manganese, - - - - -	.145
Phosphoric acid, - - - - -	.196
Sulphuric acid, - - - - -	.096
Potash, - - - - -	.250
Soda, - - - - -	.054
Sand and insoluble silicates, - - - - -	87.910
	100.002

No. 637—SOIL. Labeled "Same soil as the preceding, from Mr. M. E. Pate's farm, from a field twenty-six years in cultivation, Hancock county, Kentucky."

Dried soil of a dark buff-grey color. Washed with water it left 76.23 per cent. of sand, &c., of which all but 11.2 per cent. was fine enough to pass through the finest bolting-cloth. This portion is principally small rounded ferruginous particles, with a few of clear quartz.

One thousand grains of the air-dried soil, digested for a month in water containing carbonic acid, gave up nearly two grains of light grey extract, dried at 212° F., which had the following composition, viz:

	Grains.
Organic and volatile matters, - - - - -	0.490
Alumina, oxide of iron, and phosphates, - - - - -	.128
Carbonate of lime, - - - - -	.848
Magnesia, - - - - -	.106
Brown oxide of manganese, - - - - -	.089
Sulphuric acid, - - - - -	.016
Potash, - - - - -	.065
Soda, - - - - -	.013
Silex, - - - - -	.039
Loss, - - - - -	.026
	1.820

The air-dried soil lost 3.415 per cent. of moisture, at 400° F., dried at which temperature it has the following composition:

Organic and volatile matters, - - - - -	2.883
Alumina, - - - - -	2.120
Oxide of iron, - - - - -	2.430
Carbonate of lime, - - - - -	.240
Magnesia, - - - - -	.278
Brown oxide of manganese, - - - - -	.260
Phosphoric acid, - - - - -	.063
Sulphuric acid, - - - - -	.067
Potash, - - - - -	.174
Soda, - - - - -	.066
Sand and insoluble silicates, - - - - -	91.070
Loss, - - - - -	.349
	100.000

No. 638—SUB-SOIL. Labeled "Sub-soil from Mr. M. E. Pate's, uncultivated land, &c., Hancock county, Kentucky."

Color of the dried sub-soil dirty reddish-orange. Washed with water it left 78. per cent. of sand, &c., of which all but 0.3 per cent. passed through the finest bolting-cloth. This consisted of rounded ferruginous particles.

One thousand grains of the air-dried soil, digested for a month in water containing carbonic acid, left more than a grain of nearly white extract, dried at 212° F., which had the following composition, viz:

	Grains.
Organic and volatile matters, - - - - -	0.270
Alumina, oxides of iron and manganese, and phosphates, - - - - -	.068
Carbonate of lime, - - - - -	.328
Magnesia, - - - - -	.166
Sulphuric acid, - - - - -	.030
Potash, - - - - -	.071
Soda, - - - - -	.056
Silica, - - - - -	.139
	1.128

The air-dried soil lost 3.175 per cent. of moisture, at 400° F., dried at which temperature it has the following composition:

Organic and volatile matters, - - - - -	3.020
Alumina, - - - - -	4.190
Oxide of iron, - - - - -	4.865
Carbonate of lime, - - - - -	.130
Magnesia, - - - - -	.605

Brown oxide of manganese,	-	-	-	-	-	-	.070
Phosphoric acid,	-	-	-	-	-	-	.107
Sulphuric acid,	-	-	-	-	-	-	.219
Potash,	-	-	-	-	-	-	.055
Soda,	-	-	-	-	-	-	86.645
Sand and insoluble silicates,	-	-	-	-	-	-	100.000

The original virgin soil contains a large proportion of organic and volatile matters, and thus gives up a considerable amount of *extract* to the water charged with carbonic acid; this enables it to sustain very large crops, or causes it to lose much under the washing action of rains, &c., and, just in the same proportion, more speedily exhausts the soil, if it be not sustained by the application of manures. This, probably, is the reason why the soil which has been only twenty-six years in cultivation has lost more of its valuable ingredients than many other soils which have been under the plow for twice that period.

No. 639—CLAY. Labeled "*Fire-clay, on Mr. Miller's land; Lewisport; used for making yellow queensware. Coal Measures. Hancock county, Kentucky.*"

General color of the clay light-grey, mottled, with yellowish and brownish portions, and containing a few small scales of mica; powder of a light buff color; after calcination of a light salmon color.

Dried at 212° F., it lost 2.94 per cent. of *moisture*.

Composition, dried at 212° F.—

Alumina, dissolved out by hydrochloric acid,	-	-	-	-	-	-	3.280
Alumina, combined with silice in insoluble silicates,	-	-	-	-	-	-	20.760
Oxides of iron and manganese,	-	-	-	-	-	-	2.400
Silica, (of which there is 38.79 sand,) -	-	-	-	-	-	-	64.880
Carbonate of lime,	-	-	-	-	-	-	.486
Magnesia,	-	-	-	-	-	-	.500
Potash,	-	-	-	-	-	-	.289
Soda,	-	-	-	-	-	-	.389
Water expelled at a red heat,	-	-	-	-	-	-	6.666
Loss,	-	-	-	-	-	-	.350
							100.000

If it were not for the 2.400 per cent. of oxides of iron and manganese contained in this clay it would burn perfectly white, and would then serve for the basis of an extensive manufacture of queensware.

A manufacture, which in view of the very large consumption of this ware in this country, and the immense capital which is annually transferred to England to purchase it, it would be exceeding desirable to establish here.

If a sufficiently pure clay for this purpose cannot be found in our Coal Measures, it is probable that digestion of this and similar clays in *diluted* hydrochloric acid; which, if the manufacture of soda from common salt is also carried on in the neighborhood, would cost scarcely any thing, might remove most of the objectionable oxides, as well as render the clay less fusible under the action of a very high temperature, by dissolving out also its lime and magnesia.

No. 640—CLAY. Labeled "*Clay used as potter's clay; under the first coal under the Lewisport coal; from George Smith's farm, Hancock county, Kentucky.*"

Light bluish and yellowish-grey plastic clay.

Dried at 212° F., the air-dried clay lost 6.40 per cent. of *moisture*.

Composition, dried at 212° F.—

Alumina, and oxides of iron and manganese, dissolved out by hydrochloric acid,	-	-	-	-	-	-	1.690
Carbonate of lime,	-	-	-	-	-	-	.140
Magnesia,	-	-	-	-	-	-	.466
Potash,	-	-	-	-	-	-	.336
Water expelled at the red heat,	-	-	-	-	-	-	6.400
Silex and insoluble silicates,	-	-	-	-	-	-	91.020
							100.052

The portion insoluble in hydrochloric acid, denominated silex and insoluble silicates, contained the following ingredients, viz:

Silica,	-	-	-	-	-	-	68.150
Alumina,	-	-	-	-	-	-	20.120
Lime, a trace.	-	-	-	-	-	-	.266
Magnesia,	-	-	-	-	-	-	2.484
Loss, &c.	-	-	-	-	-	-	91.020

(See remarks on the preceding clay.)

HARDIN COUNTY.

No. 641—SOIL. Labeled "Virgin soil, from the base of the Salt river hills; near the base of the slope of the encrinital chert limestone, and limestone of the lower sub-carboniferous formation in Hardin county, Kentucky."

Dried soil of buff-grey color. Washed with water it left 68.4 per cent. of sand, &c., of which all but 4.25 per cent. was fine enough to go through the finest bolting-cloth. This coarser part consisted mainly of rounded ferruginous particles, with some hyaline and red quartz grains.

One thousand grains of the air-dried soil, digested for a month in water containing carbonic acid, gave up *more than two grains of greyish-brown extract*, dried at 212° F., which had the following composition, viz:

	Grains.
Organic and volatile matters, - - - - -	0.730
Alumina, oxide of iron, and phosphates, - - - - -	.068
Carbonate of lime, - - - - -	.498
Magnesia, - - - - -	.087
Brown oxide of manganese, - - - - -	.069
Sulphuric acid, - - - - -	.100
Potash, - - - - -	.088
Soda, - - - - -	.058
Silica, - - - - -	.380
	2.078

The air-dried soil lost 3.76 per cent. of moisture at 400° F.; dried at which temperature it has the following composition:

Organic and volatile matters, - - - - -	5.069
Alumina, - - - - -	1.936
Oxide of iron, - - - - -	2.860
Carbonate of lime, - - - - -	.270
Magnesia, - - - - -	.388
Brown oxide of manganese, - - - - -	.236
Phosphoric acid, - - - - -	.396
Sulphuric acid, - - - - -	.054
Potash, - - - - -	.208
Soda, - - - - -	.006
Sand and insoluble silicates, - - - - -	88.096
Loss, - - - - -	.481
	100.000

With the exception of the very small proportion of sulphuric acid which this analysis exhibits, it indicates quite a good quality of soil. The deficiency stated can easily be supplied by the addition of Plaster of Paris to the land.

No. 642—SOIL. Labeled "Virgin soil, from near the top of the Salt river hills. Lower Sub-carboniferous formation. Primitive forest growth black and white oak, hickory, ash, dogwood, &c. (See Dr. Owen's Report.) Hardin county, Kentucky."

Color of the dried soil, dark drab-grey. Washed with water it left 82.8 per cent. of sand, &c., of which all but 0.68 per cent. was fine enough to pass through the finest bolting-cloth. This coarser portion consisted of small rounded particles of clear, milky and red quartz, and of a hard ferruginous mineral.

One thousand grains of the air-dried soil, digested for a month in water containing carbonic acid, gave up *nearly a grain and a half of brown extract*, dried at 212° F., which had the following composition, viz:

	Grains.
Organic and volatile matters, - - - - -	0.600
Alumina, oxides of iron and manganese, and phosphates, - - - - -	.297
Carbonate of lime, - - - - -	.130
Magnesia, - - - - -	.053
Sulphuric acid, - - - - -	.045
Potash, - - - - -	.121
Soda, - - - - -	.020
Silica, - - - - -	.200
	1.466

The air-dried soil lost 1.60 per cent. of moisture at 400° F.; dried at which temperature it has the following composition:

Organic and volatile matters, - - - - -	2.443
Alumina, - - - - -	1.715
Oxide of iron, - - - - -	1.440
Carbonate of lime, - - - - -	.022
Magnesia, - - - - -	.209
Brown oxide of manganese, - - - - -	.095
Phosphoric acid, - - - - -	.079
Sulphuric acid, - - - - -	.016

Potash,	-	-	-	-	-	-	-	-	.167
Soda,	-	-	-	-	-	-	-	-	.032
Sand and insoluble silicates,	-	-	-	-	-	-	-	-	93.020
Loss,	-	-	-	-	-	-	-	-	.762
									100.000

The small proportions of lime, phosphoric acid, and sulphuric acid, as well as of organic matters and alumina and oxide of iron, to the sand and silicates, and the small amount of soluble matter extracted from it by water containing carbonic acid, demonstrate this to be comparatively a sterile soil. The potash exists in it in average proportion, however, and doubtless, by the proper application of lime, (or calcareous marl,) Plaster of Paris, and bone-dust or super-phosphate of lime, guano, or other phosphatic manures, this soil might be made to support the vine or the peach tree; or, with proper management, yield pretty good crops of corn, &c.

No. 643—SOIL. Labeled "Virgin soil from oak woods or upland, at Mr. Howell's farm, eleven miles from Elizabethtown, Hardinsburg road, Hardin county, Kentucky. Sub-carboniferous formation."

Dried soil of a grey-buff color. Washed with water this soil left 76.57 per cent. of sand, &c., of which all but 1.47 per cent. was fine enough to pass through the finest bolting-cloth. This coarser portion consisted mainly of rounded particles of clear, yellowish and reddish quartz, with a few of a ferruginous mineral.

One thousand grains of the air-dried soil, digested in water charged with carbonic acid, gave up more than two and a half grains of dark brown extract, dried at 212° F., which had the following composition, viz:

	Grains.
Organic and volatile matters,	0.827
Alumina, oxides of iron and manganese, and phosphates,	.687
Carbonate of lime,	.830
Magnesia,	.063
Sulphuric acid,	.011
Potash,	.106
Soda,	.041
Silex,	.177
	2.742

The air-dried soil lost 1.965 per cent. of moisture at 400° F.; dried at which temperature it has the following composition:

Organic and volatile matters,	-	-	-	-	-	-	-	-	3.417
Alumina,	-	-	-	-	-	-	-	-	2.245
Oxide of iron,	-	-	-	-	-	-	-	-	2.075
Carbonate of lime,	-	-	-	-	-	-	-	-	.197
Magnesia,	-	-	-	-	-	-	-	-	.203
Brown oxide of manganese,	-	-	-	-	-	-	-	-	.095
Phosphoric acid,	-	-	-	-	-	-	-	-	.177
Sulphuric acid,	-	-	-	-	-	-	-	-	.067
Potash,	-	-	-	-	-	-	-	-	.104
Soda,	-	-	-	-	-	-	-	-	.013
Sand and insoluble silicates,	-	-	-	-	-	-	-	-	91.445
									100.100

No. 644—SOIL. Labeled "Same soil, from Mr. Howard's field, thirty-nine years in cultivation, Hardin county, Kentucky. Sub-carboniferous formation, &c., &c."

Dried soil of a grey-buff color; lighter than the preceding. Washed with water it left 79.07 per cent. of sand, &c., of which all but 1.60 per cent. was fine enough to pass through the finest bolting-cloth. This coarser portion consisted of small rounded particles of clear, yellowish, and reddish quartz, with a few of sandstone, &c.

One thousand grains of the air-dried soil, digested in water containing carbonic acid, gave up nearly two grains of dark-brown extract, dried at 212° F., which had the following composition, viz:

	Grains.
Organic and volatile matters,	0.800
Alumina, oxides of iron and manganese, and phosphates,	.647
Carbonate of lime,	.163
Magnesia,	.072
Sulphuric acid,	.033
Potash,	.083
Soda,	.037
Silica,	.157
	1.992

This air-dried sub-soil lost 1.50 per cent. of moisture at 400° F.; dried at which temperature it has the following composition:

Organic and volatile matters,	-	-	-	-	-	-	-	2.309
Alumina,	-	-	-	-	-	-	-	1.745
Oxide of iron,	-	-	-	-	-	-	-	1.420
Carbonate of lime,	-	-	-	-	-	-	-	.097
Magnesia,	-	-	-	-	-	-	-	.191
Brown oxide of manganese,	-	-	-	-	-	-	-	.040
Phosphoric acid,	-	-	-	-	-	-	-	.078
Sulphuric acid,	-	-	-	-	-	-	-	.021
Potash,	-	-	-	-	-	-	-	.075
Soda,	-	-	-	-	-	-	-	.030
Sand and insoluble silicates,	-	-	-	-	-	-	-	93.495
Loss,	-	-	-	-	-	-	-	.499
								100.000

No. 645—SUB-SOIL. *Labeled "Sub-soil from Mr. Howell's field, thirty-nine years in cultivation, eleven miles from Elizabethtown, Hardinsburg road, Hardin county, Ky. Sub-carboniferous formation, &c."*

Dried sub-soil is of a greyish-buff color; of rather purer and deeper buff than the two preceding soils. Washed with water it left 73.20 per cent. of sand, &c., of which all but 1.57 per cent. passed through the finest bolting-cloth. This coarser portion consisted of rounded particles of clear white and reddish quartz, with some soft ferruginous particles.

One thousand grains of the air-dried sub-soil, digested for a month in water containing carbonic acid, gave up *more than two grains of dark brown extract*, dried at 212° F., which had the following composition, viz:

	Grains.
Organic and volatile matters,	0.750
Alumina, oxides of iron and manganese, and phosphates,	.230
Carbonate of lime,	.713
Magnesia, -	.061
Sulphuric acid, -	.033
Potash, -	.083
Soda, -	.025
Silica, -	.197
	2.093

The air-dried sub-soil lost 1.965 per cent. of *moisture*, at 400° F.; dried at which temperature it had the following composition:

Organic and volatile matters,	-	-	-	-	-	-	-	2.407
Alumina,	-	-	-	-	-	-	-	2.670
Oxide of iron,	-	-	-	-	-	-	-	2.415
Carbonate of lime,	-	-	-	-	-	-	-	.147
Magnesia,	-	-	-	-	-	-	-	.324
Brown oxide of manganese,	-	-	-	-	-	-	-	.070
Phosphoric acid,	-	-	-	-	-	-	-	.096
Sulphuric acid,	-	-	-	-	-	-	-	.028
Potash,	-	-	-	-	-	-	-	.092
Soda,	-	-	-	-	-	-	-	.024
Sand and insoluble silicates,	-	-	-	-	-	-	-	91.395
Loss,	-	-	-	-	-	-	-	.332
								100.000

The soil of the old field, thirty-nine years in cultivation, exhibits considerable exhaustion of its essential elements. The sub-soil does not appear to contain as much of them as the original surface soil. The use of lime or calcareous marl, of Plaster of Paris, and of some phosphatic manure, with ashes, or any other substance containing potash, would much increase the fertility of the cultivated field.

HARRISON COUNTY.

No. 646—SOIL. *Labeled "Virgin soil, James Miller's farm, three miles south of Cynthiana, woods pasture; forest growth large black walnut, sugar-tree, white oak, blue ash, and poplar. Lower Silurian formation. Harrison county, Ky."*

Dried soil of a dark-buff color. Washed with water it left 89.40 per cent. of sand, &c., of which all but 7.40 per cent. was fine enough to go through the finest bolting-cloth. This coarser portion mainly consisted of small rounded ferruginous particles.

One thousand grains of the air-dried soil, digested for twenty days in water charged with carbonic acid, gave up *more than four grains of brown-grey extract*, dried at 212° F., which had the following composition, viz:

	Grains.
Organic and volatile matters,	1.217
Alumina, oxides of iron and manganese, and phosphates,	.563
Carbonate of lime,	2.580
Magnesia,	.072
Sulphuric acid,	.062
Potash,	.185

Soda,	.070
Silica,	.098
	4.847

The air-dried soil lost 3.325 per cent. of *moisture* at 400° F.; dried at which temperature it had the following *composition*:

Organic and volatile matters,	7.721
Alumina, -	3.540
Oxide of iron, -	3.865
Carbonate of lime, -	.466
Magnesia, -	.483
Brown oxide of manganese, -	.420
Phosphoric acid, -	.394
Sulphuric acid, -	.114
Potash, -	.170
Soda, -	.077
Sand and insoluble silicates, -	82.895
	100.145

No. 647—SOIL. *Labeled "Soil from an old field, sixty to seventy years in cultivation, James Miller's farm, three miles south of Cynthiaua, Harrison county, Kentucky. Lower Silurian formation."*

Dried soil of a dirty-buff color; somewhat lighter than that of the preceding soil. Washed with water it left 78.70 per cent. of sand, &c., of which all but 4.43 per cent. was fine enough to pass through the finest bolting-cloth. This latter portion consisted of small rounded ferruginous particles.

One thousand grains of the air-dried soil, digested for twenty days in water charged with carbonic acid, gave up *more than four grains of light-brown extract*, dried at 212° F., which had the following *composition*, viz:

	<i>Grains.</i>
Organic and volatile matters,	0.917
Alumina, oxides of iron and manganese, and phosphates, -	.530
Carbonate of lime, -	2.080
Magnesia, -	.100
Sulphuric acid, -	.067
Potash, -	.168
Soda, -	.084
Silica, -	.131
	4.077

The air-dried soil lost 2.75 per cent. of *moisture*, at 400° F.; dried at which temperature it has the following *composition*:

Organic and volatile matters,	6.051
Alumina, -	3.655
Oxide of iron, -	3.835
Carbonate of lime, -	.296
Magnesia, -	.463
Brown oxide of manganese, -	.480
Phosphoric acid, -	.385
Sulphuric acid, -	.107
Potash, -	.159
Soda, -	.105
Sand and insoluble silicates, -	84.630
	100.166

No. 648—SUB-SOIL. *Labeled "Sub-soil from the old field, sixty to seventy years in cultivation, James Miller's farm, three miles south of Cynthiaua, Harrison county, Kentucky. Lower Silurian formation."*

Color of the dried sub-soil rather purer buff than the preceding. Washed with water it left 74.70 per cent. of sand, &c., of which all but 6.03 per cent. was fine enough to pass through the finest bolting-cloth. This coarser portion consisted of small rounded ferruginous particles, with a few of chert.

One thousand grains of the air-dried sub-soil, digested for twenty days in water containing carbonic acid, gave up *more than three grains of brownish extract*, dried at 212° F., which had the following *composition*, viz:

	<i>Grains.</i>
Organic and volatile matters,	0.550
Alumina, oxides of iron and manganese, and phosphates, -	.230
Carbonate of lime, -	1.831
Magnesia, -	.083
Sulphuric acid, -	.062
Potash, -	.131
Soda, -	.075
Silica, -	.131
	3.093

The air-dried sub-soil lost 2.825 per cent. of *moisture*, at 400° F., dried at which temperature it had the following *composition*:

Organic and volatile matters,	5.119
Alumina, - - - - -	3.565
Oxide of iron, - - - - -	3.660
Carbonate of lime, - - - - -	.313
Magnesia, - - - - -	.491
Brown oxide of manganese, - - - - -	.345
Phosphoric acid, - - - - -	.316
Sulphuric acid, - - - - -	.101
Potash, - - - - -	.151
Soda, - - - - -	.090
Sand and insoluble silicates, - - - - -	85.710
Loss, - - - - -	.139
	100.000

The analyses show the usual influence of exhaustive cultivation upon the soil. The sub-soil of the old field is not quite as rich as the original surface soil, but yet richer than the surface soil of the old field itself.

HENRY COUNTY.

No. 649—SOIL. Labeled "*Virgin soil, from woodland pasture, John Hornback's land, two miles south of New-Castle; primitive forest growth, white oak, sugar tree, blue ash, shell-bark hickory, and pin oak. Lower Silurian formation. Henry county, Kentucky.*"

The dried soil is of a dark greyish-buff color. Washed with water it left 80.96 per cent. of sand, &c., of which all but 2.03 per cent. was fine enough to pass through the finest bolting-cloth. This coarser portion consisted mainly of small rounded ferruginous concretions, with very few of chert.

One thousand grains of the air-dried soil, digested in water charged with carbonic acid, gave up *more than four and a half grains of chesnut-brown extract*, dried at 400° F.; which had the following composition, viz:

	Grains.
Organic and volatile matters, - - - - -	1.383
Alumina, oxides of iron and manganese, and phosphates, - - - - -	.930
Carbonate of lime, - - - - -	1.677
Magnesia, - - - - -	.128
Sulphuric acid, - - - - -	.045
Potash, - - - - -	.185
Soda, - - - - -	.155
Silica, - - - - -	.114
	4.617

The air-dried sub-soil lost 4.075 per cent. of moisture at 400° F.; dried at which temperature it had the following composition:

Organic and volatile matters, - - - - -	5.180
Alumina, - - - - -	2.515
Oxide of iron, - - - - -	3.940
Carbonate of lime, - - - - -	.372
Magnesia, - - - - -	.503
Brown oxide of manganese, - - - - -	.170
Phosphoric acid, - - - - -	.615
Sulphuric acid, - - - - -	.101
Potash, - - - - -	.284
Soda, - - - - -	.132
Sand and insoluble silicates, - - - - -	85.900
Loss, - - - - -	.288
	100.000

No. 650—SOIL. Labeled "*Same soil (as preceding,) from an old field, fifty years or more in cultivation, now in corn, John Hornback's farm, two miles south of New Castle, Henry county, Kentucky.*"

Color of the dried soil dark greyish-buff; a little lighter than that of the virgin soil. Washed with water it left 74.47 per cent. of sand, &c., of which all but 1.93 per cent. was fine enough to pass through the finest bolting-cloth. This portion is principally small rounded ferruginous particles with a few of chert.

One thousand grains of the air-dried soil, digested for a month in the water containing carbonic acid, gave up *nearly two and a half grains of brownish extract*, dried at 212° F., which had the following composition, viz:

	Grains.
Organic and volatile matters, - - - - -	0.250
Alumina, oxides of iron and manganese, and phosphates, - - - - -	.487
Carbonate of lime, - - - - -	1.280
Magnesia, - - - - -	.096
Sulphuric acid, - - - - -	.056
Potash, - - - - -	.058
Soda, - - - - -	.048
Silex, - - - - -	.164
	2.439

The air-dried soil lost 3.935 per cent. of moisture, at 400° F.; dried at which temperature it had the following composition:

Organic and volatile matters,	-	-	-	-	-	-	-	-	5.159
Alumina,	-	-	-	-	-	-	-	-	3.915
Oxide of iron,	-	-	-	-	-	-	-	-	4.115
Carbonate of lime,	-	-	-	-	-	-	-	-	.496
Magnesia,	-	-	-	-	-	-	-	-	.558
Brown oxide of manganese,	-	-	-	-	-	-	-	-	.220
Phosphoric acid,	-	-	-	-	-	-	-	-	.407
Sulphuric acid,	-	-	-	-	-	-	-	-	.101
Potash,	-	-	-	-	-	-	-	-	.298
Soda,	-	-	-	-	-	-	-	-	.133
Sand and insoluble silicates,	-	-	-	-	-	-	-	-	83.760
Loss,	-	-	-	-	-	-	-	-	.038
									100.000

No. 651—SUB-SOIL. *Labeled "Sub-soil from the same old field, fifty years or more in cultivation, John Hornback's land, Henry county, Kentucky, &c."*

Color of the dried sub-soil like that of the preceding, but a little more buff. Washed out about 77.47 per cent. of sand, &c., of which only 2.30 per cent. was too coarse to pass through the finest bolting-cloth. This portion is principally composed of small rounded ferruginous particles, with a few of quartzose.

One thousand grains of the air-dried soil, digested for a month in water charged with carbonic acid, gave up nearly three and a half grains of nearly black extract, dried at 212° F., which had the following composition, viz:

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The air-dried sub-soil lost 4.11 per cent. of moisture at 400° F.; dried at which temperature it has the following composition:

Organic and volatile matters,	-	-	-	-	-	-	-	-	4.918
Alumina,	-	-	-	-	-	-	-	-	4.125
Oxide of iron,	-	-	-	-	-	-	-	-	4.545
Carbonate of lime,	-	-	-	-	-	-	-	-	.396
Magnesia,	-	-	-	-	-	-	-	-	.512
Brown oxide of manganese,	-	-	-	-	-	-	-	-	.160
Phosphoric acid,	-	-	-	-	-	-	-	-	.448
Sulphuric acid,	-	-	-	-	-	-	-	-	.085
Potash,	-	-	-	-	-	-	-	-	.227
Soda,	-	-	-	-	-	-	-	-	.067
Sand and insoluble silicates,	-	-	-	-	-	-	-	-	84.943
									100.426

These soils present almost the only anomaly, in the whole of the soils analyzed, of the existence of larger proportions of lime, magnesia, oxide of manganese, potash, and soda, and a smaller proportion of sand and insoluble silicates, in the soil of the old field than in the virgin soil from the same neighborhood. The organic and volatile matters are in nearly similar quantities in the two soils, but the virgin soil gives up a much larger proportion of soluble extract to the water charged with carbonic acid; and the amount of phosphoric acid, in this latter, is also much the larger. If no error has been committed in putting up and labeling the soils, or no accidental substitution has occurred since, this anomaly can only be explained on the supposition that the soil of the old field was originally much stronger than that of the neighboring one from whence the "virgin soil" was taken—a case which seems to be rare. The sub-soil does not appear to be better than the soil of the old field.

HOPKINS COUNTY.

No. 652—*Labeled "Efflorescence, from a corn field, Steuben's Lick, Hopkins county, Kentucky. Coal Measures."*

A moist powder, of a grey-buff color, having a saline taste, and containing sand, &c.

Five hundred grains of the moist powder gave up, to distilled water, of nearly 88. grains of saline matter, dried at 212° F.—equal to more than seventeen and a half per cent.—which had the following composition:

	In 500 grains.	Per cent. of the moist earth.
Sulphate of soda, - - -	56.82	= 11.364
Sulphate of magnesia, - -	4.92	= .984
Sulphate of lime, - - -	2.19	= .438
Sulphate of potash, - - -	1.38	= .276
Chloride of sodium, - - -	17.25	= 3.450
Chloride of calcium, - -	.72	= .144
Silica, - - - - -	.13	= .026
Organic matter, water, and loss,	4.51	= .902
	87.92	17.584

It contains also traces of nitrates.

Probably some mineral spring sends its waters into the soil or sub-soil, and the efflorescence is caused by the evaporation of the water on the surface of the soil, leaving the salts there; or the saline matters exist in the sub-strata, and are brought up, (by known physical laws,) by the water which moistens the soil.

No. 653—LIMONITE. *Labeled "Iron ore at Jerry Bruce's, Clear creek, south-west of Providence, Hopkins county, Kentucky."*

A cellular limonite; containing some sand grains, and specks of mica, and exhibiting the impression of a fossil shell. The cells are lined with ochreous ore; the general color liver-brown; not adhering to the tongue; the powder of this ore is of a Spanish brown color, changing to black on calcination, although it does not contain any carbonate of the protoxide of iron. The air-dried ore lost 0.90 per cent. of moisture, at 212° F.

Specific gravity - - - - -	2.785
<i>Composition, dried at 212° F.—</i>	
Oxide of iron, - - -	54.080 = 37.87 per cent. of Iron.
Alumina, - - - - -	1.380
Lime, a trace.	
Magnesia, - - - - -	.244
Brown oxide of manganese, -	.720
Phosphoric acid, - - -	1.400
Sulphur - - - - -	.210
Potash, - - - - -	.251
Soda, - - - - -	.055
Silex and insoluble silicates, -	34.480
Combined water and loss, -	7.180
	100.000

A good silicious iron ore, with the only draw-back, that it has more phosphoric acid in its composition than is desirable for the manufacture of tough iron. It would require only the addition of limestone to flux it in the high furnace.

No. 654—LIMONITE. *Labeled "Iron ore, at Benj. Parker's, one and a half miles east of Providence, Hopkins county, Kentucky."*

Dull; adhering to the tongue; presenting various shades of dark red. Powder of a dark Spanish brown color. The air-dried ore lost 2.20 per cent. of moisture, at 212° F.

Composition, dried at 212° F.—

Oxide of iron, - - -	62.250 = 43.593 per cent. of Iron.
Alumina, - - - - -	5.820
Carbonate of lime, - - -	2.040
Magnesia, - - - - -	6.432
Brown oxide of manganese, -	.860
Phosphoric acid, - - -	1.170
Sulphur, - - - - -	.356
Potash, - - - - -	.571
Soda, a trace.	
Silex and insoluble silicates, -	12.180
Combined water, - - -	8.800
	100.479

A richer ore than than the preceding; less silicious, and containing much more lime and magnesia. The phosphoric acid is but little less in this than in the preceding.

No. 655—LIMONITE? *Labeled "Iron ore at Jack Segler's, one mile and a half north-west of Providence, head of Owen and Plover creeks, Hopkins county, Kentucky."*

A dense, fine grained, dark-colored ore, some whitish mineral infiltrated into some of its small cavities; not adhering to the tongue; powder of a purple-brown color. The air-dried ore lost 0.40 per cent. of moisture, at 212° F.

Specific gravity, - - - - -	4.563
<i>Composition, dried at 212° F.—</i>	
Oxide of iron, - - -	91.780 = 64.266 per cent. Iron.
Alumina, - - - - -	1.035
Lime, a trace.	
Magnesia, - - - - -	.221

Brown oxide of manganese, -	.486
Phosphoric acid, - - -	.055
Sulphur, - - - - -	.031
Potash, - - - - -	.154
Soda, - - - - -	.029
Silex and insoluble silicates, -	5.286
Combined water, - - -	1.140
	100.217

Quite a pure, and a very rich ore of iron; too rich, indeed, to be successfully smelted alone in the high furnace, because it does not contain enough silex and alumina to form slag enough, with the limestone used as flux, to protect the reduced iron from the oxidating influence of the blast. It can be very well managed, however, in proper mixture with poorer, more silicious ore—such, for example, as No. 652, or the one next to be described, or even the impure limestone, No. 658, still further on. This ore is remarkable, from the very small proportion of *combined water* which it contains, which makes it doubtful whether it should not be classed with the *specular* iron ores, and not with the *limonites*.

No. 656—CARBONATE OF IRON. *Labeled "Iron ore, seventeen feet below the surface, at Benj. Parker's well, one and a half miles east of Providence, Hopkins county, Kentucky."*

A dull, dark-grey, carbonate of iron; not adhering to the tongue; powder of a grey color. The air-dried ore lost 0.54 per cent. of moisture, at 212° F.

Specific gravity, - - - - - 3.227

Composition, dried at 212° F.—

Carbonate of iron, - -	61.730 = 26.845 per cent. of Iron.
Carbonate of lime, - -	4.890
Carbonate of magnesia, -	1.848
Carbonate of manganese, -	.887
Alumina, - - - - -	.480
Phosphoric acid, - - -	.183
Sulphur, - - - - -	.122
Potash, - - - - -	.201
Soda, - - - - -	.068
Silex and insoluble silicates, -	27.140
Bituminous matter, - -	2.800
	100.339

This may be called a *grey-band ore*. It is rather too poor, perhaps, to be profitably smelted alone, but could be used in mixture with the richer ores, to furnish cinder.

No. 657—CARBONATE OF IRON. *Labeled "Iron ore, twelve feet below the surface at Benj. Parker's, one and a half miles east of Providence, Hopkins county, Kentucky."*

A dull, dark-grey mineral, adhering slightly to the tongue; exterior of a dull yellowish-brown color; powder, grey-buff. The air-dried ore lost 0.8 per cent. of moisture, at 212° F.

Specific gravity, - - - - - 3.148

Composition, dried at 212° F.—

Carbonate of iron, - -	45.119	} = 33.86 per cent. of Iron.
Oxide of iron, - - -	16.457	
Carbonate of lime, - -	4.730	
Carbonate of magnesia, -	5.616	
Carbonate of manganese, -	2.093	
Alumina, - - - - -	.270	
Phosphoric acid, - - -	1.720	
Sulphur, - - - - -	.212	
Potash, - - - - -	.262	
Soda, - - - - -	.097	
Silica, - - - - -	19.920	
Water, bituminous matter and loss, - - - - -	3.454	
	100.000	

Contains rather more phosphoric acid than is desirable in an iron ore; otherwise, a good and sufficiently rich ore, which will require but a small addition of limestone for smelting it.

No. 658—LIMESTONE, (IMPURE) *Labeled "At Benj. Parker's, one mile and a half east of Providence, Hopkins county, Kentucky."*

A grey, fine-grained, ferruginous limestone; containing small scales of mica; rust-brown on the weathered surfaces; powder of a very light-buff color. The air-dried ore lost 0.24 per cent. of moisture, at 212° F.

Specific gravity, - - - - -	2.778
<i>Composition, dried at 212° F.—</i>	
Carbonate of lime, - - - - -	23.790
Carbonate of iron, - - - - -	11.717
Carbonate of magnesia, - - - - -	4.413
Carbonate of manganese, - - - - -	.586
Alumina, - - - - -	1.590
Phosphoric acid, - - - - -	.247
Sulphur, - - - - -	.006
Potash, - - - - -	.270
Soda, - - - - -	.091
Silex and insoluble silicates, - - - - -	55.120
Water, bituminous matter and loss, - - - - -	2.170
	100.000

JEFFERSON COUNTY.

No. 659—SOIL. *Labeled "Soil, ten miles from Louisville, on the Salt river road, thirty or forty years in cultivation; primitive growth, beach, and some poplar and gum; spouty land. Jefferson county, Ky."*

Color of the dried soil, dark yellowish-grey. A few small rounded ferruginous pebbles were removed from it by the coarse seive. Washed with water it left 76.33 per cent. of sand, &c., of which all but 4.37 per cent. was fine enough to go through the finest bolting-cloth. This coarser portion is composed of rounded grains of hyaline and yellow quartz with some ferruginous particles.

One thousand grains of the air-dried soil, digested for a month in water containing carbonic acid, gave up *nearly two grains of light-brown extract*, dried at 212° F., which had the following composition:

	Grains.
Organic and volatile matters, - - - - -	0.370
Alumina, oxides of iron and manganese, and phosphates, - - - - -	.114
Carbonate of lime, - - - - -	.880
Magnesia, - - - - -	.052
Sulphuric acid, - - - - -	.081
Potash, - - - - -	.044
Soda, - - - - -	.081
Silica, - - - - -	.200
	1.822

The air-dried soil lost 3.10 per cent. of *moisture* at 400° F.; dried at which temperature it has the following composition:

Organic and volatile matters, - - - - -	4.231
Alumina, - - - - -	3.580
Oxide of iron, - - - - -	4.421
Carbonate of lime, - - - - -	.230
Magnesia, - - - - -	.359
Brown oxide of manganese, - - - - -	.445
Phosphoric acid, - - - - -	.262
Sulphuric acid, - - - - -	.084
Potash, - - - - -	.167
Soda, - - - - -	.045
Sand and insoluble silicates, - - - - -	86.066
Loss, - - - - -	.110
	100.000

No. 660—SUB-SOIL. *Labeled "Sub-soil, ten miles from Louisville, on the Salt river road, field thirty to forty years in cultivation, (see preceding number.) Jefferson county, Kentucky."*

Color of the dried sub-soil a little lighter than that of the soil above it. The coarse seive removed from it some rounded particles of ferruginous mineral, and a few milky quartz grains about the size of mustard seed. Washed with water, this sub-soil left 70.70 per cent. of sand, &c., of which all but 14.47 per cent. passed through the finest bolting-cloth. This coarser portion consisted principally of clear grains of quartz, more or less rounded, with some rounded ferruginous particles.

One thousand grains of the air-dried soil, digested for a month in water containing carbonic acid, gave up more than five grains of *brown extract*, dried at 212°, which had the following composition:

	Grains.
Organic and volatile matters, - - - - -	2.100
Alumina, oxides of iron and manganese, and phosphates, - - - - -	.663
Carbonate of lime, - - - - -	1.713
Magnesia, - - - - -	.133
Sulphuric acid, - - - - -	.125
Potash, - - - - -	.048
Soda, - - - - -	.012
Silica, - - - - -	.200
	5.194

The air-dried soil lost 3.175 per cent. of *moisture* at 400° F.; dried at which temperature it has the following composition:

Organic and volatile matters,	4.983
Alumina,	3.245
Oxide of iron,	4.130
Carbonate of lime,	.195
Magnesia,	.335
Brown oxide of manganese,	.370
Phosphoric acid,	.295
Sulphuric acid,	.085
Potash,	.213
Soda,	.051
Sand and insoluble silicates,	85.895
Loss,	.203
	100.000

This would be good soil if it were drained. The sub-soil is rather richer than the surface-soil.

JESSAMINE COUNTY.

No. 661—BITUMINOUS SHALE. Brought by Mr. Alexander Headley, from his farm, formerly the "Meade farm," about ten miles from Lexington, Jessamine county, Kentucky."

A soft, friable shale, having a somewhat smooth, or soapy feel; yielding readily to the nail; color brownish-drab, or purplish-grey; burning, when heated, with a smokey flame.

By distillation in an iron retort, gradually raised to dull redness—three receivers and a bell glass for the gas being attached—one thousand grains of this shale gave the following products, viz:

Crude oil,	50.00 grains.
Ammoniacal water,	58.00 grains.
Black residue,	810.00 grains.
Gas, moisture, and loss,	52.00 grains.
	1000.00 grains.

The gas collected from the thousand grains distilled, as above described, measured one hundred and seventy cubic inches.

It is remarkable that so light colored a shale should contain so much bituminous matter. As it yields but five per cent. of crude oil it is doubtful whether the products of its distillation would pay for the trouble, fuel, &c.

No. 622—SOIL. Labeled "Soil, (from woodland,) based on the upper beds of the birds'-eye limestone, two to two and a half miles north of the bridge over the Kentucky river, Jessamine county, Kentucky." Lower Silurian formation.

A considerable quantity of irregular and angular particles and fragments of chert, and some ferruginous mineral, and a small quartz crystal were sifted out of it with the coarse sieve. Washed with water it left 83.90 per cent. of sand, &c., of which all but 6.13 per cent. was fine enough to go through the finest bolting-cloth. This coarser portion consisted mainly of ferruginous particles, with a few of chert and clear quartz.

One thousand grains of the air-dried soil, digested in water charged with carbonic acid, gave up more than four grains of greyish-brown extract, dried at 212° F., which had the following composition, viz:

	Grains.
Organic and volatile matters,	0.817
Alumina, oxides of iron and manganese, and phosphates,	.630
Carbonate of lime,	2.313
Magnesia,	.123
Sulphuric acid,	.017
Potash,	.078
Soda,	.032
Silica,	.200
	4.210

The air-dried soil lost 2.90 per cent. of moisture at 400° F.; dried at which temperature it has the following composition:

Organic and volatile matters,	4.737
Alumina,	2.695
Oxide of iron,	2.890
Carbonate of lime,	.345
Magnesia,	.199
Brown oxide of manganese,	.280
Phosphoric acid,	.133
Sulphuric acid,	.067
Potash,	.121
Soda,	.047
Sand and insoluble silicates,	87.995
Loss,	.491
	100.000

No. 663—SOIL. Labeled "Soil from an adjoining field, immediately overlaying the upper beds of the birds'-eye limestone, two to two and a half miles north of the bridge over the Kentucky river, adjacent to the turnpike, Jessamine county, Kentucky."

Some irregular fragments of chert, and some rounded particles of this and of a ferruginous mineral, were removed from this soil by the coarse seive. Washed with water it left 83.60 per cent. of fine sand, of which all but 7.70 per cent. passed through the finest bolting-cloth. This coarser portion consisted of rounded particles of chert and quartz, &c. Color of the dried soil slightly lighter than that of the preceding.

One thousand grains of the air-dried soil, digested for a month in water charged with carbonic acid, gave up *more than three grains of brownish extract*, dried at 212° F., which had the following composition, viz:

	Grains.
Organic and volatile matters, - - - - -	0.930
Alumina, oxides of iron and manganese, and phosphates, - - -	.330
Carbonate of lime, - - - - -	1.596
Magnesia, - - - - -	.072
Sulphuric acid, - - - - -	.022
Potash, - - - - -	.052
Soda, - - - - -	.010
Silica, - - - - -	.200
	3.212

The air-dried soil lost 2.95 per cent. of *moisture* at 400° F.; dried at which temperature it has the following composition:

Organic and volatile matters, - - - - -	4.250
Alumina, - - - - -	3.695
Oxide of iron, - - - - -	3.240
Carbonate of lime, - - - - -	.295
Magnesia, - - - - -	.366
Brown oxide of manganese, - - - - -	.285
Phosphoric acid, - - - - -	.239
Sulphuric acid, - - - - -	.050
Potash, - - - - -	.185
Soda, - - - - -	.044
Sand and insoluble silicates, - - - - -	87.245
Loss, - - - - -	.106
	100.000

No. 664—SOIL. Labeled "Virgin soil, from Mr. Paton's woodland pasture, near his mill, on Hickman creek; primitive forest growth, over-cup and white oak, black walnut and hickory. Lower Silurian formation. Jessamine county, Kentucky."

The dried soil is of a dirty-buff color. Washed with water it left 77.07 per cent. of sand, &c., of which all but 1.18 per cent. was fine enough to pass through the finest bolting-cloth. This coarser portion consisted of small rounded ferruginous particles.

One thousand grains of the air-dried soil, digested for a month in water charged with carbonic acid, gave up *nearly four grains of chestnut-brown extract*, dried at 212° F., which had the following composition, viz:

	Grains.
Organic and volatile matters, - - - - -	0.783
Alumina, oxides of iron and manganese, and phosphates, - - -	.830
Carbonate of lime, - - - - -	1.947
Magnesia, - - - - -	.094
Sulphuric acid, - - - - -	.062
Potash, - - - - -	.096
Soda, - - - - -	.042
Sand and insoluble silicates, - - - - -	.131
	3.985

The air-dried soil lost 4.20 per cent. of *moisture*, at 400° F., dried at which temperature it has the following composition:

Organic and volatile matters, - - - - -	5.349
Alumina, - - - - -	5.065
Oxide of iron, - - - - -	4.990
Carbonate of lime, - - - - -	.595
Magnesia, - - - - -	.750
Brown oxide of manganese, - - - - -	.220
Phosphoric acid, - - - - -	.666
Sulphuric acid, - - - - -	.106
Potash, - - - - -	.344
Soda, not estimated.	
Sand and insoluble silicates, - - - - -	81.720
Loss, - - - - -	.195
	100.000

No. 665—SOIL. Labeled "Same soil, in a cultivated field, for twelve inches to the underlying rock, (with *Orthis testudinaria*); no sub-soil; near Mr. Paton's mill, on Hickman creek. Lower Silurian formation. Jessamine county, Kentucky."

Dried soil of a light-umber color. It contained irregular worn fragments of limestone, containing portions of small encrinital stems. Washed with water this soil left 83.3 per cent. of sand, &c., of which all but 3.20 per cent. was fine enough to pass through the finest bolting-cloth. This coarser portion consisted of small rounded ferruginous particles.

One thousand grains of the air-dried soil, digested for a month in water charged with carbonic acid, gave up more than eight grains of reddish-brown extract, dried at 212° F., which had the following composition, viz:

	Grains.
Organic and volatile matters, - - - - -	0.990
Alumina, oxide of iron, and phosphates, - - - - -	.953
Carbonate of lime, - - - - -	5.430
Magnesia, - - - - -	.305
Sulphuric acid, - - - - -	.056
Potash, - - - - -	.125
Soda, - - - - -	.043
Silica, - - - - -	.181
	8.083

The air-dried soil lost 6.775 per cent. of moisture at 400° F.; dried at which temperature it has the following composition:

Organic and volatile matters, - - - - -	9.745
Alumina, - - - - -	9.190
Oxide of iron, - - - - -	5.840
Carbonate of lime, - - - - -	3.570
Magnesia, - - - - -	1.290
Brown oxide of manganese, - - - - -	.470
Phosphoric acid, - - - - -	.532
Sulphuric acid, - - - - -	.119
Potash, - - - - -	.569
Soda, - - - - -	.212
Sand and insoluble silicates, - - - - -	69.070
	100.607

Both of these soils contain large proportions of the mineral elements of vegetable food. The latter one is superior in this respect to No. 664, and contains as much alumina and oxide of iron and carbonate of lime as is found in some of the under-clays. The soils based on the harder and more durable beds of the bird's-eye limestone, are much less rich in all these materials.

No. 666—LIMESTONE. Labeled "Limestone, containing *Orthis testudinaria*, &c., found under the soil, near Paton's mill, Hickman creek, Jessamine county, Kentucky. Lower Silurian formation."

Irregular, water-worn fragments, of a very fossiliferous, bluish-grey limestone; exterior surface much and irregularly corroded.

Composition, dried at 212 F.—

Carbonate of lime, - - -	92.980 = 52.176 of Lime.
Carbonate of magnesia, - - -	.839
Alumina, and oxides of iron and manganese, - - -	2.040
Phosphoric acid, - - -	.567
Sulphuric acid, - - -	.133
Potash, - - -	.166
Soda, - - -	.055
Silex and insoluble silicates, - - -	3.146
Loss, - - -	.074
	100.000

A limestone very rich in phosphoric and sulphuric acids and the alkalies, which seems to be easily disintegrated by the action of water, &c., and hence communicates its valuable ingredients to the soil above it.

KENTON COUNTY.

No. 667—SOIL. Labeled "Virgin soil, from the Armstrong farm, five miles south-west of Covington; beech land, over the shell beds of the blue limestone of the Lower Silurian formation, Kenton county, Kentucky."

Dried soil of a dark grey-buff color. Washed by water it left 82.90 per cent. of sand, &c., of which all but 1.02 per cent. was fine enough to pass through the finest bolting-cloth. This coarser portion consisted of clear and colored quartz, with some ferruginous particles.

One thousand grains of the air-dried soil, digested for a month in water containing carbonic acid, gave up nearly two and a half grains of

greyish-brown extract, dried at 212° F., which had the following composition, viz:

	Grains.
Organic and volatile matters, - - - - -	0.770
Alumina, oxide of iron and manganese, and phosphates, - - -	.337
Carbonate of lime, - - - - -	.880
Magnesia, - - - - -	.066
Sulphuric acid, - - - - -	.037
Potash, - - - - -	.125
Soda, - - - - -	.038
Silica, - - - - -	.100
Loss, - - - - -	.107
	2.460

The air-dried soil lost 3.935 per cent. of moisture at 400° F.; dried at which temperature it has the following composition:

Organic and volatile matters, - - - - -	5.429
Alumina, - - - - -	3.225
Oxide of iron, - - - - -	2.520
Carbonate of lime, - - - - -	.197
Magnesia, - - - - -	.461
Brown oxide of manganese, - - - - -	.189
Phosphoric acid, - - - - -	.226
Sulphuric acid, - - - - -	.076
Potash, - - - - -	.272
Soda, a trace, - - - - -	
Sand and insoluble silicates, - - - - -	87.445
	100.070

No. 668—SOIL. Labeled "Same soil, from an old field, forty to fifty years in cultivation, Armstrong farm, five miles south-west of Covington, &c. &c., Kenton county, Kentucky."

The dried soil is of a dark greyish-buff color, slightly lighter than the last. Washed with water it left 77.00 per cent. of sand, &c., of which all but 4.13 per cent. was fine enough to pass through the finest bolting-cloth. This coarser portion is composed of rounded particles of clear and colored quartz, and of ferruginous mineral.

One thousand grains of the air-dried soil, digested for a month in water charged with carbonic acid, gave up more than a grain and a half of brownish-grey extract, dried at 212° F., which had the following composition, viz:

	Grains.
Organic and volatile matters, - - - - -	0.270
Alumina, oxides of iron and manganese, and phosphates, - - -	.160
Carbonate of lime, - - - - -	.780
Magnesia, - - - - -	.113
Sulphuric acid, - - - - -	.022
Potash, - - - - -	.085
Soda, - - - - -	.027
Silica, - - - - -	.200
Loss, - - - - -	.048
	1.705

The air-dried soil lost 3.210 per cent. of moisture at 400° F.; dried at which temperature it has the following composition:

Organic and volatile matters, - - - - -	3.621
Alumina, - - - - -	3.570
Oxide of iron, - - - - -	3.245
Carbonate of lime, - - - - -	.147
Magnesia, - - - - -	.460
Brown oxide of manganese, - - - - -	.345
Phosphoric acid, - - - - -	.206
Sulphuric acid, - - - - -	.074
Potash, - - - - -	.212
Soda, - - - - -	.035
Sand and insoluble silicates, - - - - -	87.495
Loss, - - - - -	.590
	100.000

No. 669—SUB-SOIL. Labeled "Sub-soil from the same old field, forty to fifty years in cultivation, Armstrong farm, &c., &c., Kenton county, Kentucky."

The dried soil is in cloddy lumps, of a lighter color and more buff than the surface-soil. Washed with water it left 68.23 per cent. of sand, &c., of which all but 2.43 per cent. was fine enough to pass through the finest bolting-cloth. This coarser portion consisted of rounded ferruginous particles, with some rounded clear quartz grains.

One thousand grains of the air-dried sub-soil, digested for a month in water charged with carbonic acid, left more than a grain and a half of brownish-grey extract, dried at 212° F., which had the following composition, viz:

	Grains.
Organic and volatile matters, - - - - -	0.370
Alumina, oxides of iron and manganese, and phosphates, - - - - -	.223
Carbonate of lime, - - - - -	.410
Magnesia, - - - - -	.044
Sulphuric acid, - - - - -	.017
Potash, - - - - -	.096
Soda, - - - - -	.030
Silica, - - - - -	.277
Loss, - - - - -	.163
	1.630

The air-dried sub-soil lost 3.165 per cent. of moisture at 400° F.; dried at which temperature it has the following composition:

Organic and volatile matters, - - - - -	2.901
Alumina, - - - - -	3.660
Oxide of iron, - - - - -	3.220
Carbonate of lime, - - - - -	.147
Magnesia, - - - - -	.478
Brown oxide of manganese, - - - - -	.320
Phosphoric acid, - - - - -	.150
Sulphuric acid, - - - - -	.050
Potash, - - - - -	.205
Soda, - - - - -	.060
Sand and insoluble silicates, - - - - -	88.745
Loss, - - - - -	.064
	100.000

The forty to fifty years cultivation of the old field has caused a sensible diminution of its essential ingredients. The sub-soil is not as rich in those as the surface-soil.

LARUE COUNTY.

No. 670—SOIL. Labeled "*Virgin soil, (small black oak and white oak woods,) on the Styliina beds of the sub-carboniferous limestone, Daniel Canady's farm, stone house, two miles north-east of Hodgenville, Larue county, Kentucky.*"

Dried soil of a greyish-buff color. Washed with water it left 81.9 per cent. of sand, &c., of which all but 4.03 per cent. was fine enough to pass through the finest bolting-cloth. This coarser portion consisted of rounded particles of hyaline, yellow, and reddish quartz, with some soft ferruginous mineral.

One thousand grains of the air-dried soil, digested for a month in water containing carbonic acid, gave up *more than one and a half grains of chocolate-brown extract*, dried at 212° F., which had the following composition, viz:

	Grains.
Organic and volatile matters, - - - - -	0.715
Alumina, oxides of iron and manganese, and phosphates, - - - - -	.163
Carbonate of lime, - - - - -	.317
Magnesia, - - - - -	.108
Sulphuric acid, - - - - -	.039
Potash, - - - - -	.074
Soda, - - - - -	.017
Silica, - - - - -	.153
	1.586

The air-dried soil lost 2.625 per cent. of moisture, at 400° F.; dried at which temperature it has the following composition:

Organic and volatile matters, - - - - -	6.428
Alumina, - - - - -	3.175
Oxide of iron, - - - - -	2.715
Carbonate of lime, - - - - -	.072
Magnesia, - - - - -	.290
Brown oxide of manganese, - - - - -	.230
Phosphoric acid, - - - - -	.114
Sulphuric acid, - - - - -	.050
Potash, - - - - -	.135
Soda, - - - - -	.025
Sand and insoluble silicates, - - - - -	88.680
	101.914

No. 671—SOIL. Labeled "*Same soil, from an old field, thirty to forty years in cultivation, Daniel Canady's farm, two miles north east of Hodgenville, Larue county, Kentucky. Styliina beds of sub-carboniferous limestone.*"

Dried soil of a greyish-buff color; slightly lighter than the virgin soil. Washed with water it left 77.13 per cent. of sand, &c., of which all but 2.63 per cent. was fine enough to pass through the finest bolting-cloth. This coarser portion is composed of hyaline, yellowish, and reddish quartz, with a few ferruginous grains.

One thousand grains of the air-dried soil, digested for a month in water charged with carbonic acid, gave up *nearly two grains of brown-*

ish extract, dried at 212° F., which had the following composition, viz:

	Grains.
Organic and volatile matters, - - - - -	0.683
Alumina, oxides of iron and manganese, and phosphates, - - -	.463
Carbonate of lime, - - - - -	.453
Magnesia, - - - - -	.061
Sulphuric acid, - - - - -	.033
Potash, - - - - -	.083
Soda, - - - - -	.021
Silica, - - - - -	.173
	1.970

The air-dried soil lost 2.425 per cent. of moisture, at 400° F., dried at which temperature it has the following composition:

Organic and volatile matters, - - - - -	5.380
Alumina, - - - - -	3.175
Oxide of iron, - - - - -	2.815
Carbonate of lime, - - - - -	.106
Magnesia, - - - - -	.342
Brown oxide of manganese, - - - - -	.245
Phosphoric acid, - - - - -	.113
Sulphuric acid, - - - - -	.055
Potash, - - - - -	.123
Soda, - - - - -	.021
Sand and insoluble silicates, - - - - -	89.340
	101.715

No. 672—SUB-SOIL. Labeled "Sub-soil, from same old field, thirty to forty years in cultivation, Daniel Canady's farm, two miles north-east of Hodgenville, Larue county, Kentucky, &c. &c."

Dried sub-soil of a dirty-buff color; rather lighter than the two preceding. Washed with water it left 79.07 per cent. of sand, &c., of which all but 2.83 per cent. was fine enough to pass through the finest bolting-cloth. This coarser portion consisted of rounded grains of hyaline, yellowish, and reddish quartz, with a few ferruginous particles.

One thousand grains of the air-dried sub-soil, digested for a month in water charged with carbonic acid, gave up more than a grain of light-brown extract, which had the following composition, viz:

	Grains.
Organic and volatile matters, - - - - -	0.450
Alumina, oxides of iron and manganese, and phosphates, - - -	.043
Carbonate of lime, - - - - -	.173
Magnesia, - - - - -	.081
Sulphuric acid, - - - - -	.031
Potash, - - - - -	.096
Soda, - - - - -	.053
Silica, - - - - -	.207
	1.134

The air-dried soil lost 2.725 per cent. of moisture at 400° F.; dried at which temperature it has the following composition:

Organic and volatile matters, - - - - -	2.981
Alumina, - - - - -	3.955
Oxide of iron, - - - - -	3.265
Carbonate of lime, - - - - -	.015
Magnesia, - - - - -	.467
Brown oxide of manganese, - - - - -	.235
Phosphoric acid, - - - - -	.096
Sulphuric acid, - - - - -	.050
Potash, - - - - -	.130
Soda, - - - - -	.023
Sand and insoluble silicates, - - - - -	88.625
Loss, - - - - -	.158
	100.000

The sub-soil is not richer than the original soil. Applications of lime or calcareous marl, gypsum, (Plaster of Paris,) bone dust, or other phosphatic manures, and ashes, would greatly improve this soil.

MARION COUNTY.

No. 673—SOIL. Labeled "Virgin soil, from woods on Daniel Everhart's farm, three miles west of Lebanon, Marion county, Kentucky. Devonian?"

Color of the dried soil, dark-greyish buff. Washed with water it left 83.63 per cent. of sand, &c., of which all but 4.17 per cent. was fine enough to pass through the finest bolting-cloth. This coarser portion consisted of rounded ferruginous particles, with a few of clear quartz.

One thousand grains of the air-dried soil, digested for a month in

water charged with carbonic acid, gave up *more than three grains of buff-brown extract*, dried at 212° F., which had the following composition, viz:

	Grains.
Organic and volatile matters, - - - - -	1.460
Alumina, oxides of iron and manganese, and phosphates, - -	.473
Carbonate of lime, - - - - -	1.063
Magnesia, - - - - -	.133
Sulphuric acid, - - - - -	.036
Potash, - - - - -	.087
Soda, - - - - -	.059
Silica, - - - - -	.098
	3.409

The air-dried soil lost 3.375 per cent. of *moisture* at 400° F.; dried at which temperature it had the following *composition*:

Organic and volatile matters, - - - - -	4.786
Alumina, - - - - -	6.495
Oxide of iron, - - - - -	3.565
Carbonate of lime, - - - - -	.222
Magnesia, - - - - -	.339
Brown oxide of manganese, - - - - -	.271
Phosphoric acid, - - - - -	.262
Sulphuric acid, - - - - -	.042
Potash, - - - - -	.157
Soda, - - - - -	.011
Sand and insoluble silicates, - - - - -	85.040
	101.190

No. 674—SOIL. Labeled "*Soil from a field sixty-five years in cultivation, Daniel Everhart's farm, three miles west of Lebanon, Marion county, Kentucky. Devonian? formation.*"

Color of the dried soil light-brown; darker, and of a more reddish tint than the preceding; and more like the following sub-soil. Washed with water it left 76.07 per cent. of sand, &c., of which all but 2.20 per cent. was fine enough to pass through the finest bolting-cloth. This coarser portion consisted of small rounded ferruginous particles, with very few quartz grains.

One thousand grains of the air-dried soil, digested for a month in water containing carbonic acid, left nearly four and a half grains o

dark-brown extract, dried at 212° F., which had the following *composition*, viz:

	Grains.
Organic and volatile matters, - - - - -	1.800
Alumina, oxides of iron and manganese, and phosphates, - -	.473
Carbonate of lime, - - - - -	1.830
Magnesia, - - - - -	.111
Sulphuric acid, - - - - -	.036
Potash, - - - - -	.053
Soda, - - - - -	.077
Silica, - - - - -	.098
	4.478

The air-dried soil lost 3.40 per cent. of *moisture* at 400° F.; dried at which temperature it has the following *composition*:

Organic and volatile matters, - - - - -	4.748
Alumina, - - - - -	3.940
Oxide of iron, - - - - -	4.970
Carbonate of lime, - - - - -	.222
Magnesia, - - - - -	.302
Brown oxide of manganese, - - - - -	.312
Phosphoric acid, - - - - -	.230
Sulphuric acid, - - - - -	.062
Potash, - - - - -	.181
Soda, - - - - -	.033
Sand and insoluble silicates, - - - - -	84.720
Loss, - - - - -	.230
	100.000

No. 675—SUB-SOIL. Labeled "*Red sub-soil, from the field sixty-five years in cultivation, Daniel Everhart's farm, three miles west of Lebanon, Marion county Kentucky, &c.*"

Color of the dried sub-soil reddish-brown; a shade lighter than that of the preceding. Washed with water it left 72.47 per cent. of sand, &c., of which all but 4.87 per cent. was fine enough to pass through the finest bolting-cloth. This coarser portion consisted of small rounded ferruginous particles.

One thousand grains of the air-dried sub-soil, digested for a month in water charged with carbonic acid, gave up *less than a grain and a half of brownish extract*, dried at 212° F., which had the following *composition*, viz:

	Grains.
Organic and volatile matters, - - - - -	0.110
Alumina, oxides of iron and manganese, and phosphates, - - - - -	.120
Carbonate of lime, - - - - -	.767
Magnesia, - - - - -	.061
Sulphuric acid, - - - - -	.022
Potash, - - - - -	.059
Soda, - - - - -	.067
Silica, - - - - -	.154
	1.360

The air-dried sub-soil lost 3.20 per cent. of moisture at 400° F.; dried at which temperature it has the following composition:

Organic and volatile matters, - - - - -	3.679
Alumina, - - - - -	4.645
Oxide of iron, - - - - -	5.360
Carbonate of lime, - - - - -	.297
Magnesia, - - - - -	.372
Brown oxide of manganese, - - - - -	.172
Phosphoric acid, - - - - -	.279
Sulphuric acid, - - - - -	.042
Potash, - - - - -	.212
Soda, - - - - -	.019
Sand and insoluble silicates, - - - - -	84.720
Loss, - - - - -	.202
	100.000

In these soils also, the apparent anomaly is to be noticed, of somewhat greater strength in the soil of the old field, than in that analyzed as the virgin soil. From appearances, however, it is probable that some of the sub-soil, which contains more potash than even the virgin surface soil, has been turned up by the plough and mixed with the upper soil, in the cultivation of the old field.

MEADE COUNTY.

No. 676—SOIL. Labeled "Virgin soil, from Barren Hill Grove district, Meadville or Good Spring, Meade county, Kentucky. Primitive forest growth, black oak, black gum, hickory, post oak, white oak, black walnut; formerly "barrens," or prairie; produces much better than many blacker soils; best for corn and oats; originally covered with "barren" grass, six to eight feet high."

Dried soil of a dusky-dark-grey color. Washed with water it left 75.6 per cent. of sand, &c., of which all but 1.4 per cent. passed through the finest bolting-cloth. This coarser portion consisted of rounded ferruginous and quartzose particles.

One thousand grains of the air-dried soil, digested for a month in water charged with carbonic acid, gave up more than a grain and a half of brownish-grey extract, dried at 212° F., which had the following composition, viz:

	Grains.
Organic and volatile matters, - - - - -	0.470
Alumina, oxide of iron and phosphates, - - - - -	.419
Carbonate of lime, - - - - -	.233
Magnesia, - - - - -	.066
Brown oxide of manganese, - - - - -	.039
Sulphuric acid, - - - - -	.075
Potash, - - - - -	.071
Soda, - - - - -	.085
Silica, - - - - -	.169
	1.627

The air-dried soil lost 2.84 per cent. of moisture at 400° F.; dried at which temperature it has the following composition:

Organic and volatile matters, - - - - -	3.911
Alumina, - - - - -	1.896
Oxide of iron, - - - - -	2.040
Carbonate of lime, - - - - -	.136
Magnesia, - - - - -	.205
Brown oxide of manganese, - - - - -	.036
Phosphoric acid, - - - - -	.151
Sulphuric acid, - - - - -	.041
Potash, - - - - -	.259
Soda, - - - - -	.042
Sand and insoluble silicates, - - - - -	91.436
	100.153

No. 677—SOIL. Labeled "Same soil as the last, from an adjoining field, fifty years in cultivation in corn and oats, and sometimes wheat. For the last six years in fallow; Meadville, Meade county, Kentucky."

Dried soil of a dirty greyish-buff color. Washed with water it left 65.30 per cent. of sand, &c., of which all but 0.3 per cent. passed through the finest bolting-cloth. This consisted principally of rounded

quartz grains. (It is probable, that in this estimation much of the soft ferruginous particles had been rubbed up, and passed through the seive.)

One thousand grains of the air-dried soil, digested for a month in water charged with carbonic acid, gave up *more than a grain of brownish-grey extract*, dried at 212° F.; which had the following composition, viz :

	Grains.
Organic and volatile matters, - - - - -	0.290
Alumina, oxide of iron and phosphates, - - - - -	.098
Carbonate of lime, - - - - -	.302
Magnesia, - - - - -	.066
Brown oxide of manganese, - - - - -	.219
Sulphuric acid, - - - - -	.048
Potash, - - - - -	.059
Soda, - - - - -	.024
Silica, - - - - -	.099
	1.205

The air-dried soil lost 2.32 per cent. of *moisture*, at 400° F.; dried at which temperature it has the following composition:

Organic and volatile matters, - - - - -	2.620
Alumina, - - - - -	3.136
Oxide of iron, - - - - -	2.580
Carbonate of lime, - - - - -	.236
Magnesia, - - - - -	.298
Brown oxide of manganese, - - - - -	.116
Phosphoric acid, - - - - -	.125
Sulphuric acid, - - - - -	.130
Potash, - - - - -	.154
Soda, - - - - -	.084
Sand and insoluble silicates, - - - - -	91.036
	100.515

The proportion of potash in the virgin soil is quite good, and that of the phosphoric acid nearly as large as the average. Their chemical composition shows why they produce better than could be expected from their comparative light color; for, whilst they contain but a small relative proportion of organic and volatile matters, the *mineral ingredients* generally are not deficient. These soils would be improved by the use of calcareous marls, Plaster of Paris, and the ploughing in of clover, &c.

MERCER COUNTY.

No. 678—SOIL. Labeled "*Virgin soil, from woodland pasture, Col. Wm. Thompson's farm, four and a half miles south-east of Harrodsburg, Mercer county, Kentucky. Lower Silurian formation.*"

Color of the dried soil light greyish-chocolate-brown. The coarse seive removed from it some cherty and ferruginous gravel. Washed with water it left 85.23 per cent. of sand, &c., of which all but 4.67 per cent. passed through the finest bolting-cloth. This coarser portion consisted principally of rounded ferruginous particles with a few of chert and quartz.

One thousand grains of the air-dried soil, digested for a month in water charged with carbonic acid, gave up *more than five grains of yellowish-brown extract*, dried at 212° F., which had the following composition, viz :

	Grains.
Organic and volatile matters, - - - - -	1.230
Alumina, oxides of iron and manganese, and phosphates, - - - - -	.813
Carbonate of lime, - - - - -	2.247
Magnesia, - - - - -	.190
Sulphuric acid, - - - - -	.046
Potash, - - - - -	.166
Soda, - - - - -	.037
Silica, - - - - -	.231
Loss, - - - - -	.240
	5.200

The air-dried soil lost 4.50 per cent. of *moisture*, at 400° F.; dried at which temperature it has the following composition :

Organic and volatile matters, - - - - -	6.361
Alumina, - - - - -	3.955
Oxide of iron, - - - - -	4.050
Carbonate of lime, - - - - -	.495
Magnesia, - - - - -	.341
Brown oxide of manganese, - - - - -	.345
Phosphoric acid, - - - - -	.309
Sulphuric acid, - - - - -	.076
Potash, - - - - -	.144
Soda, - - - - -	.024
Sand and insoluble silicates, - - - - -	83.712
Loss, - - - - -	.188
	100.000

No. 679—SOIL. Labeled "Same soil as the last, Col. Wm. Thompson's farm, from a field, twenty years or more in cultivation; now in oats; Mercer county, Kentucky, &c."

Color of the dried soil a little lighter than that of the last (No. 678.) The coarse sieve removed more cherty fragments from this than from the virgin soil. Washed with water it left 84.05 per cent. of sand, &c., of which all but 6.63 per cent. passed through the finest bolting-cloth. This coarser portion consisted of rounded ferruginous particles, with a few of chert and quartz.

One thousand grains of the air-dried soil, digested for a month in water charged with carbonic acid, gave up *more than five grains of chestnut-brown extract*, dried at 212° F., which had the following composition, viz:

	Grains.
Organic and volatile matters, - - - - -	1.150
Alumina, oxides of iron and manganese, and phosphates, - - -	.963
Carbonate of lime, - - - - -	2.530
Magnesia, - - - - -	.083
Sulphuric acid, - - - - -	.073
Potash, - - - - -	.064
Soda, - - - - -	.084
Silica, - - - - -	.227
Loss, - - - - -	.136
	5.310

The air-dried soil lost 4.00 per cent. of moisture, at 400° F., dried at which temperature it has the following composition:

Organic and volatile matters, - - - - -	5.208
Alumina, - - - - -	3.590
Oxide of iron, - - - - -	3.790
Carbonate of lime, - - - - -	.385
Magnesia, - - - - -	.365
Brown oxide of manganese, - - - - -	.295
Phosphoric acid, - - - - -	.397
Sulphuric acid, - - - - -	.098
Potash, - - - - -	.130
Soda, - - - - -	.036
Sand and insoluble silicates, - - - - -	86.250
	100.544

No. 680—SUB-SOIL. Labeled "Sub-soil from the field, twenty years or more in cultivation, Col. Wm. Thompson's farm, Mercer county, Kentucky, &c."

The dried sub-soil is of a little lighter and more yellowish color than the two preceding soils; it contains larger cherty and ferruginous fragments than they. Washed with water it left 84.7 per cent. of sand, &c., of which all but 7.03 per cent. passed through the finest bolting-cloth. This portion consisted of rounded ferruginous particles, with a few of chert and quartz.

One thousand grains of the air-dried sub-soil, digested for a month in water charged with carbonic acid, gave up *about four grains of yellowish-grey extract*, dried at 212 F., which had the following composition, viz:

	Grains.
Organic and volatile matters, - - - - -	0.817
Alumina, oxides of iron and manganese, and phosphates, - - -	.580
Carbonate of lime, - - - - -	2.047
Magnesia, - - - - -	.094
Sulphuric acid, - - - - -	.039
Potash, - - - - -	.035
Soda, - - - - -	.012
Silica, - - - - -	.264
Loss, - - - - -	.202
	4.090

The air-dried sub-soil, dried at 400° F., lost 3.70 per cent. of moisture, and has the following composition:

Organic and volatile matters, - - - - -	4.389
Alumina, - - - - -	3.750
Oxide of iron, - - - - -	3.415
Carbonate of lime, - - - - -	.395
Magnesia, - - - - -	.390
Brown oxide of manganese, - - - - -	.320
Phosphoric acid, - - - - -	.362
Sulphuric acid, - - - - -	.050
Potash, - - - - -	.114
Soda, - - - - -	.040
Sand and insoluble silicates, - - - - -	86.720
Loss, - - - - -	.055
	100.000

The sub-soil is no richer than the surface-soil.

No. 681—SOIL. Labeled "*Virgin soil, from woods, near Cornishville; lies near the rock, on the Chatetes beds of the blue limestone, overlying the birds'-eye limestone, western part of Mercer county, Kentucky. Characteristic forest growth, white oak. Lower Silurian formation.*"

Dried soil in hard clods, of a light, yellowish-umber color. Washed with water it left 64.43 per cent. of sand, &c., of which all but — per cent. passed through the fine bolting-cloth. This coarser portion consisted mainly of small rounded ferruginous particles.

One thousand grains of the air-dried soil, digested for a month in water containing carbonic acid, gave up *more than eleven grains of brownish extract*, dried at 212° F., which had the following composition, viz:

	Grains.
Organic and volatile matters, - - - - -	1.550
Alumina, oxides of iron and manganese, and phosphates, - -	.980
Carbonate of lime, - - - - -	7.813
Magnesia, - - - - -	.400
Sulphuric acid, - - - - -	.061
Potash, - - - - -	.077
Soda, - - - - -	.100
Silica, - - - - -	.114
	11.095

The air-dried soil lost 4.50 per cent. of *moisture* at 400° F.; dried at which temperature it had the following composition, viz

Organic and volatile matters, - - - - -	10.365
Alumina, - - - - -	5.395
Oxide of iron, - - - - -	7.110
Carbonate of lime, - - - - -	1.995
Magnesia, - - - - -	1.234
Brown oxide of manganese, - - - - -	.620
Phosphoric acid, - - - - -	.333
Sulphuric acid, - - - - -	.093
Potash, - - - - -	.762
Soda, - - - - -	.106
Sand and insoluble silicates, - - - - -	72.035
	100.000

No. 682—SOIL. Labeled "*Same soil from an old adjoining field, fifty years in cultivation; now in corn; western part of Mercer county, near Cornishville, &c., &c.*"

The dried soil is also in cloddy lumps; is of a lighter and more buff color than the last. Washed with water it left 67.47 per cent. of sand, &c., of which all but 8.47 per cent. passed through the finest bolting-cloth. This coarser portion consisted principally of small rounded ferruginous concretions, with a few fragments of fossil shells.

One thousand grains of the air-dried soil, digested for a month in water containing carbonic acid, gave up *nearly four grains of orange-brown extract*, dried at 212° F., which had the following composition, viz:

	Grains.
Organic and volatile matters, - - - - -	0.540
Alumina, oxides of iron and manganese, and phosphates, - -	.280
Carbonate of lime, - - - - -	2.613
Magnesia, - - - - -	.066
Sulphuric acid, - - - - -	.032
Potash, - - - - -	.032
Soda, - - - - -	.060
Silica, - - - - -	.131
	3.754

The air-dried soil lost 4.375 per cent. of *moisture* at 400° F.; dried at which temperature it has the following composition:

Organic and volatile matters, - - - - -	6.980
Alumina, - - - - -	7.495
Oxide of iron, - - - - -	7.270
Carbonate of lime, - - - - -	2.080
Magnesia, - - - - -	1.184
Brown oxide of manganese, - - - - -	.645
Phosphoric acid, - - - - -	.298
Sulphuric acid, - - - - -	.090
Potash, - - - - -	.705
Soda, - - - - -	.106
Sand and insoluble silicates, - - - - -	72.810
Loss, - - - - -	.337
	100.000

No. 683—SUB-SOIL. Labeled "*Sub-soil from the old field, fifty years in cultivation, western part of Mercer county, Ky., near Cornishville. Lower Silurian formation, &c., &c.*"

The dried soil is of a still lighter and more pure buff color than the two preceding; it is also in cloddy lumps; contains more decomposed

fossiliferous limestone than those soils. Washed with water, it left 57.8 per cent. of sand, &c., of which all but 6.30 per cent. passed through the finest bolting-cloth. This coarser part consisted of fragments of fossils, and rounded white and ferruginous particles.

One thousand grains of the air-dried sub-soil, digested for a month in water containing carbonic acid, gave up *more than six grains of orange-brown extract*, dried at 212° F., which had the following composition, viz:

	Grains.
Organic and volatile matters, - - - - -	0.666
Alumina, oxides of iron and manganese, and phosphates, - -	.230
Carbonate of lime, - - - - -	4.870
Magnesia, - - - - -	.076
Sulphuric acid, - - - - -	.032
Potash, - - - - -	.038
Soda, - - - - -	.064
Silica, - - - - -	.181
	6.157

The air-dried soil lost 5.00 per cent. of *moisture* at 400° F.; dried at which temperature it has the following composition:

Organic and volatile matters, - - - - -	7.252
Alumina, - - - - -	8.315
Oxide of iron, - - - - -	7.335
Carbonate of lime, - - - - -	2.850
Magnesia, - - - - -	1.477
Brown oxide of manganese, - - - - -	.769
Phosphoric acid, - - - - -	.459
Sulphuric acid, - - - - -	.058
Potash, - - - - -	.650
Soda, - - - - -	.050
Sand and insoluble silicates, - - - - -	71.395
	100.610

No. 684—SOIL. Labeled "*Stiff under-clay, near Cornishville, western part of Mercer county, Kentucky, &c. Lower Silurian formation.*"

Dried clay in hard clods of a light grey-buff color; effervesces strongly in hydrochloric acid. Washed with water it left 46.57 per cent. of sand, &c., of which all but 1.47 per cent. passed through the finest bolting-cloth. This coarser portion consisted of small fragments of fossil shells, and rounded whitish particles, (concretions?).

One thousand grains of the air-dried under-clay, digested for a month in water containing carbonic acid, gave up *nearly six grains of yellowish-white extract*, dried at 212° F., which had the following composition, viz:

	Grains.
Organic and volatile matters, - - - - -	0.666
Alumina, oxides of iron and manganese, and phosphates, - -	.053
Carbonate of lime, - - - - -	4.630
Magnesia, - - - - -	.061
Sulphuric acid, - - - - -	.055
Potash, - - - - -	.124
Soda, - - - - -	.065
Silica, - - - - -	.164
	5.818

The air-dried under-clay lost 4.45 per cent. of *moisture* at 400° F.; dried at which temperature it had the following composition:

Organic and volatile matters, - - - - -	5.494
Alumina, - - - - -	6.195
Oxide of iron, - - - - -	5.840
Carbonate of lime, - - - - -	14.170
Magnesia, - - - - -	.604
Brown oxide of manganese, - - - - -	.490
Phosphoric acid, - - - - -	.456
Sulphuric acid, - - - - -	.041
Potash, - - - - -	.817
Soda, - - - - -	.123
Sand and insoluble silicates, - - - - -	66.245
	100.455

These soils contain an extraordinary quantity of the mineral elements of vegetable food. The under-clay is a marl of great richness, which could be used as a mineral manure on soils which are deficient in potash, lime, magnesia, the phosphates, &c. The proportions of sulphuric and phosphoric acids, in these soils, however, are not so extraordinary as those of the other essential ingredients.

No. 685—LIMESTONE. Labeled "*Limestone in and under the sub-soil of the old field (No. 683.) Near Cornishville, western part of Mercer county, Kentucky. Lower Silurian formation.*"

Irregular fragments of a very fossiliferous dark-grey limestone.

Composition, dried at 212° F.—

<i>Composition, dried at 212° F.—</i>			
Carbonate of lime,	-	-	88.900 = 49.855 of <i>Lime</i> .
Carbonate of magnesia,	-	-	1.468
Alumina and oxides of iron and			
manganese,	-	-	2.340
Phosphoric acid,	-	-	.631
Sulphuric acid,	-	-	.235
Potash,	-	-	.168
Soda,	-	-	.053
Silex and insoluble silicates,	-	-	7.186
			100.981

A limestone, of the blue limestone formation, which is very rich in the mineral ingredients of vegetable food, and which, doubtless, has furnished much of the large proportions of these materials found in the soil above it.

No. 686—COAL. *Labeled "Cannel coal, brought by the Rev. Jas. C. Crow, from his land on Clay creek, four and a half miles from the Elk fork of Licking river, and seven and a half miles west from West Liberty. Morgan county, Kentucky."*

The bed of coal from whence it was taken is represented to be 36 to 40 inches thick, with about 10 inches of shale above and below; supposed to be the next bed above the bituminous coal, 36 inches thick, found in the bed and banks of Licking river.

Quite a pure looking cannel coal of a dull black appearance, and a somewhat satiny lustre in parts; large conchoidal and laminated fracture; presenting a glimmering appearance under the microscope. Some incrustation of gypsum on the outside layer but no other visible impurities. Quite tough. No fibrous coal between the layers.

Over the spirit lamp it decrepitates a little and burns with a smokey flame, does not soften nor change its form, and leaves a hard coke of a black-lead color.

Specific gravity, 1.365

Moisture, - - - -	0.80	Total volatile matters,	45.80
Volatile combustible matters, -	45.00		
Carbon in the coke, - -	32.70	Dense coke, - - -	54.20
Ashes, nearly white, - -	21.50		
	100.00		100.00

The per centage of *sulphur* is 0.91.

Silica,	-	-	-	-	-	-	-	-	12.48
Alumina, with a little oxide of iron,	.	.	.	.	.	.	.	.	7.70
Lime,	-	-	-	-	-	-	-	-	.54
Magnesia,	-	-	-	-	-	-	-	-	.90
									21.62

One thousand grains of this cannel coal, distilled at a moderate temperature, yielded the following products, viz:

Crude oil,	-	-	-	-	-	-	-	234.00
Ammoniacal water,	-	-	-	-	-	-	-	84.00
Coke,	-	-	-	-	-	-	-	569.00
Gas and loss,	-	-	-	-	-	-	-	123.00
								1000.00

The gas measured five hundred and sixty (560) cubic inches, and possessed pretty good illuminating power.

No. 687—COAL. Labeled "*Bituminous coal, from Maj. D. Payton's land, fifteen feet above low water mark on Licking river, eight miles below West Liberty, Morgan county, Kentucky.*" (Brought by Mr. Crow.)

The bed is said to be 36 inches thick, with ten inches of shale above and below.

A shining, deep black, pure looking coal; not soiling the fingers. Some fibrous coal between the layers. Over the spirit lamp it swelled up, and agglutinated into a bright cellular coke. Probably a coking coal.

Specific gravity,	-	-	-	-	-	-	-	-	1.280
<i>Proximate Analyses:</i>									
Moisture,	-	-	-	3.00	} Total volatile matters,				39.60
Volatile combustible matters,	-	-	-	36.60					
Carbon in the coke,	-	-	-	58.10	} Cellular coke,				60.40
Ashes—grey-purple,	-	-	-	2.30					
				<u>100.00</u>					<u>100.00</u>

The per centage of *sulphur* is 1.15. This is quite a pure coal.

No. 688—COAL. Labeled "*Cannel coal from the Rev. J. C. Crow's land, about four miles from the Elk fork of Licking river, and seven miles from West Liberty, Morgan county, Kentucky.*"

Bed said to be 36 inches thick, with about ten inches of shale above and below it; at about the same level as the first described, probably another portion of the same layer.

Color a little darker than that of the first described cannel coal and with fewer minute glimmering specks; tough but breaking easily in the direction of the layers, presenting no appearance of pyrites. No fibrous coal between the layers. Weathered edges of an earthy appearance.

Over the spirit lamp it burnt with a smokey flame, did not swell up nor soften.

Specific gravity - - - - - 1.360

Proximate Analysis.

Moisture, - - - - - 1.90	Total volatile matters, - - - - - 47.20
Volatile combustible matters, - - - - - 45.30	
Carbon in the coke, - - - - - 31.80	Coke, (dense,) - - - - - 52.80
Ashes, yellowish-grey, - - - - - 21.00	
100.00	100.00

The per-centage of *sulphur* is 0.87.

No. 689—COAL. Labeled "*Cannel coal, from J. Barber's land, half a mile west of Elk fork of Licking river, one a half miles from its mouth, about forty feet above the bed of the branch. Morgan county, Kentucky.*" (Brought by the Rev. J. C. Crow.)

Bed of coal said to be 36 inches thick with eight inches of shale above it.

A dull looking coal, easily separating into thin irregular layers, between which there is much discoloration from oxide of iron. Cross fracture somewhat satiny. The weathered edge has an earthy appearance.

Over the spirit lamp it decrepitates very slightly, burns with a smokey flame, but does not swell up nor soften.

Specific gravity, - - - - - 1.328

Proximate Analysis:

Moisture, - - - - - 3.00	Total volatile matters, - - - - - 43.000
Volatile combustible matters, - - - - - 40.00	
Carbon in the coke, - - - - - 44.00	Dense coke, - - - - - 57.00
Ashes, (orange-grey,) - - - - - 13.00	
100.00	100.00

The per-centage of *sulphur* is 0.82.

No. 690—COAL. Labeled "*Cannel coal, from the Rev. J. C. Crow's land, three miles West of Elk fork of Licking, five miles from the mouth of Elk fork, on Mordecai creek, Morgan county, Kentucky.*" (Brought by Mr. Crow.)

Bed supposed by Mr. Crow to be on the same level as the cannel coal first described, (No. 686,) about forty inches thick, with eight inches of shale above.

Deeper black, and more glossy than No. 686. Weathered end very superficially discolored by oxide of iron.

Over the spirit lamp it did not decrepitate; burnt with a smokey flame; softened and swelled up a little; the fragments cohering somewhat; and left a pretty dense coke.

Specific gravity, - - - - - 1.307

Proximate Analysis:

Moisture, - - - - - 2.50	Total volatile matters, - - - - - 43.00
Volatile combustible matters, - - - - - 40.50	
Carbon in the coke, - - - - - 48.70	Dense coke, - - - - - 57.00
Ashes, (lilac grey,) - - - - - 8.30	
100.00	100.00

The per-centage of *sulphur* is 1.26.

No. 691—COAL. Labeled "*Bituminous coal, from the Rev. J. C. Crow's land, on Clay Lick fork of Licking; three miles from Elk fork, and about six miles from West Liberty, Morgan county, Ky.*" (Brought by Mr. Crow.)

Coal bed represented to be sixteen inches thick, with twenty-four inches of shale below, and eight inches of ferruginous conglomerate (see No. 698,) above. Ten feet below this bed is said to be another of eight inches of coal.

A soft, bright, bituminous coal; some little pyrites between the layers, and a little fibrous coal; not soiling the fingers much; weathered surface with a little ochreous discoloration.

Over the spirit lamp it did not decrepitate; swelled up and agglutinated into a light, cellular coke; a coking coal.

Specific gravity, - - - - - 1.336

Proximate Analysis:

Moisture, - - -	3.30	Total volatile matters, -	39.70
Volatile combustible matters, -	36.40		
Carbon in the coke, - -	55.60	Bright cellular coke, -	60.30
Ashes, (light lilac,) - -	4.70		
	100.00		100.00

The per-centage of sulphur is 0.74.

Composition of the ashes:

Silica, - - - - -	1.49
Alumina, and oxide of iron, &c. - - - - -	2.88
Carbonate of lime, - - - - -	.20
Magnesia, - - - - -	.17
	4.74

No. 692—COAL. Labeled "Cannel coal, from Jesse Barber's land, one and a half miles from the mouth of Elk fork of Licking river, half a mile west of it. Morgan county, Kentucky." (Brought by Mr. Crow.)

Bed said to be twenty-three inches thick, with ten inches of shale above it. About three feet above the level of the branch. This coal resembles No. 686, but is rather darker colored and more glossy; the fracture is splintery, not conchoidal like No. 686.

Over the spirit lamp it does not decrepitate; swells a little, but does not soften much.

Specific gravity, - - - - - 1.327

Proximate Analysis:

Moisture, - - -	5.00	Total volatile matters, -	42.80
Volatile combustible matters, -	37.80		
Carbon in the coke, - -	46.60	Dense coke, - -	57.20
Ashes, (nearly white,) -	10.60		
	100.00		100.00

The per-centage of sulphur is 0.63.

No. 693—COAL. Labeled "Bituminous coal, from Mr. Smedley's land, on the north fork of Licking river, about thirty-five feet above the bed of the creek, and about eight miles from the line of the Lexington and Big Sandy Railroad, Morgan county, Kentucky." (Brought by Mr. Crow.)

The bed is said to be about thirty inches thick. A moderately soft coal, of a glossy, intense black color; breaking easily into thin layers, with much soft fibrous coal between; exterior of the layers of the weathered portion, discolored with a reddish ochreous incrustation, but no pyrites was observed.

Over the spirit lamp it decrepitated, softened, swelled up, and agglutinated into a moderately dense coke.

Specific gravity, - - - - - 1.299

Proximate Analysis:

Moisture, - - -	2.60	Total volatile matters, -	39.60
Volatile combustible matters, -	37.00		
Carbon in the coke, - -	55.40	Moderately dense coke, -	60.40
Ashes, (nearly white,) -	5.00		
	100.00		100.00

The per-centage of sulphur is 0.54.

Analysis of the Ashes:

Silica, - - - - -	2.29
Alumina, oxide of iron, &c., - - - - -	2.48
Lime, - - - - -	.16
Magnesia, - - - - -	.14
	5.07

No. 694—COAL. Labeled "Cannel coal, from the Rev. J. C. Crow's land, about seven miles from West Liberty, on the Big Sandy road, near Wm. Kendall's, Morgan county, Kentucky."

The bed is represented to be about five feet above the Kendall branch of Licking river; nine inches thick, with six inches of black shale above, and twenty-four inches of yellow shale below; resembles No. 686.

Over the spirit-lamp it does not decrepitate; burns with a smokey flame, but does not soften nor change in volume. The coke was as soft as some kinds of charcoal, and may be used for drawing crayons. It is easily incinerated.

Specific gravity, - - - - -	1.542		
<i>Proximate Analysis:</i>			
Moisture, - - - - -	1.00	Total volatile matters, -	38.60
Volatile combustible matters, -	37.60		
Carbon in the coke, - - -	31.40	Coke, - - - - -	61.40
Ashes, (light fawn colored,) -	30.00		
	100.00		100.00

The per centage of sulphur is 1.23.

No. 695—COAL. Labeled "Cannel coal, from John Schoolfield's land, on Mordecai creek, for miles west of West Liberty; two miles west of the Elk fork of Licking, and four miles from the mouth of Elk fork, Morgan county Kentucky." (Brought by Mr. Crow.)

This cannel coal is said to be thirty inches thick, with ten inches of shale and bituminous coal (see No. 696) above it. ("Coal two feet, eight inches thick, with five inches of coal rash on the top, full of impressions of stigmara."—(Dr. Owen's Notes.)

A deep black coal, with but little lustre; breaking in layers, which have no fibrous coal between.

Over the spirit-lamp it does not decrepitate; but softened and swelled a little; the fragments did not agglutinate; left a moderately dense coke.

Specific gravity, - - - - -	1.288		
<i>Proximate Analysis:</i>			
Moisture, - - - - -	1.40	Total volatile matters, -	45.80
Volatile combustible matters, -	44.40		
Carbon in the coke, - - -	48.00	Moderately dense coke, -	54.20
Ashes, (light buff,) - - -	6.20		
	100.00		100.00

The per centage of sulphur is 0.68.

Composition of the ashes:

Insoluble silicates, - - -	3.19
Alumina, oxides of iron and manganese, -	1.99
Carbonate of lime, - - -	.28
Magnesia, - - - - -	.33
Potash, - - - - -	.15
Soda, - - - - -	.07
Loss, - - - - -	.19
	6.20

In order to ascertain the presence of the alkalies in these ashes they were analyzed by digestion in hydrochloric acid, &c., instead of by fusion with the mixed alkaline carbonates, &c., as is usually done. It will be seen that they contain a fair proportion of alkaline matter; they were not tested for the presence of phosphoric acid.

After the above analyses were completed on the small specimens brought to the Laboratory by Mr. Crow, Mr. Schoolfield sent a large piece of this coal, and I was enabled to submit it to the process of distillation.

One thousand grains of this cannel coal, distilled at a low red heat, gave the following products, viz:

Crude oil, thin and dark colored, - - - - -	176.00
Ammoniacal water, (black,) - - - - -	82.00
Slightly coherent coke, - - - - -	642.00
Gas and loss, - - - - -	100.00
	1000.00

The gas measured three hundred and ninety cubic inches, and had moderate illuminating powers. It is therefore not remarkable amongst the oil-producing coals. (See table at the end of the preceding volume.)

No. 696—COAL. Labeled "Bituminous coal, lying on the preceding, Morgan county, Kentucky." Brought by Mr. Crow."

A bright, soft, bituminous coal, a little fibrous coal and pyrites between the layers into which it easily separates. Discolored, on the surface, with clay and oxide of iron.

Over the spirit-lamp it swelled up a good deal, softening and agglutinating.

Specific gravity, - - - - -	1.345		
<i>Proximate Analysis.</i>			
Moisture, - - - - -	3.00	Total volatile matters, -	42.60
Volatile combustible matters, -	39.60		
Carbon in coke, - - - - -	48.20	Cellular coke, - - - - -	57.40
Ashes, (lilac color,) - - -	9.20		
	100.00		100.00

The per centage of sulphur is 4.84.

Composition of the ash:

Silex and insoluble silicates,	-	-	-	-	-	-	-	-	2.19
Alumina, and oxides of iron and manganese,	-	-	-	-	-	-	-	-	6.48
Lime, a trace.	-	-	-	-	-	-	-	-	
Magnesia,	-	-	-	-	-	-	-	-	.33
Potash,	-	-	-	-	-	-	-	-	.17
Soda,	-	-	-	-	-	-	-	-	.13
									9.20

No. 697—COAL. Labeled "Bituminous coal, from Wm. Kendall's land on the Sandy road, 6 miles from West Liberty, Morgan county, Kentucky." Brought by Mr. Crow.

Bed said to be fifteen inches thick. A soft, pure-looking, bright, bituminous coal, with no fibrous coal or pyrites between the layers.

Over the spirit-lamp it softens very much, and swells up into a very cellular coke.

Specific gravity, - - - - - 1.296

Proximate Analysis.

Moisture,	-	-	-	2.70	Total volatile matters,	45.60
Volatile combustible matters,	-	-	-	42.90		
Carbon in the coke,	-	-	-	50.40	Bright cellular coke,	54.40
Ashes, (dull lilac colored,)	-	-	-	4.00		
				100.00		100.00

The per centage of sulphur is 2.42.

No. 698—LIMONITE, (IMPURE.) Labeled "Ferruginous conglomerate, lying above the coal No. 691, on the Rev. J. C. Crow's land, Morgan county, Kentucky."

General color rust-brown and yellowish. A sandy conglomerate of flattened rounded pebbles of ferruginous mineral, united by a sandy ferruginous cement. Powder of a brownish-yellow color.

Composition, dried at 212° F.—

Oxide of iron,	-	-	-	22.04	= 22.10 per cent. of Iron.
Carbonate of iron,	-	-	-	15.34	
Carbonate of lime,	-	-	-	1.64	
Carbonate of magnesia,	-	-	-	2.92	
Carbonate of manganese,	-	-	-	1.02	
Alumina,	-	-	-	.81	
Phosphoric acid,	-	-	-	.37	
Sulphur,	-	-	-	.27	

Potash,	-	-	-	-	.17
Soda,	-	-	-	-	.31
Silex and insoluble silicates,	-	-	-	-	54.48
Water and loss,	-	-	-	-	.63
					100.00

Too poor in iron to be profitably smelted by itself, it yet might be used to mix with richer ores to furnish silicious material for the flux, and the formation of cinder, in the high furnace.

No. 699—SANDSTONE, (FERRUGINOUS.) Labeled "Iron ore? common on the tops of the hills, in the south-western part of Morgan county, Kentucky." Brought by Mr. Crow.

A fine-grained, compact, ferruginous sandstone, showing numerous small scales of mica, color shading from light red to brownish red. Powder of a venetian red color.

Composition:

Sand and insoluble silicates,	-	-	-	-	-	84.38
Oxide of iron, and alumina,	-	-	-	-	-	12.78
Carbonate of lime,	-	-	-	-	-	1.76
Magnesia, water, and loss,	-	-	-	-	-	1.08
						100.00

(See Rowan county for some other minerals of this region.)

MUHLENBURG COUNTY.

No. 700—SHALE, (BITUMINOUS.) Labeled "Bituminous shale on the land of Messrs. Martin. Howe Ridge, one and a half miles north-west of Greenville, waters of Caney creek. Muhlenburg county, Kentucky." Brought by Mr. Martin.

Bed said to be two to four feet thick. Shale of a dull black color, separating into thin layers, which are stained in parts with oxide of iron and covered with small crystals of sulphate of lime. Decrepitates in the fire.

Proximate Analysis.

Total volatile matters,	-	-	-	-	-	25.00
Fixed carbon,	-	-	-	-	-	30.50
Yellowish-grey earthy residue,	-	-	-	-	-	44.50
						100.00

No. 701—SHALE, (BITUMINOUS.) *From same locality as the last. Muhlenburg county, Kentucky.*

Color darker than that of the last, free from ochreous incrustation.

Proximate Analysis.

Total volatile matters,	41.50
Fixed carbon,	38.50
Grey earthy residue,	21.00
	100.00

No. 702—SHALE, (BITUMINOUS.) *From the same locality as the preceding. Muhlenburg county, Kentucky.*

Resembles the preceding.

Proximate Analysis.

Total volatile matters,	40.20
Fixed carbon,	31.80
Grey earthy residue,	28.00
	100.00

These two latter specimens approach cannel coals in composition and properties; whether these could be profitably distilled for the manufacture of the *coal oils*, &c., might be ascertained by calculations based on the relative quantity of these products which they would yield, proximity to market, &c., &c. A sufficient quantity of the shales was not brought to the Laboratory to enable me to institute the necessary experiments.

No. 703—SHALE, (BITUMINOUS.) *From the same locality as the preceding. Muhlenburg county, Kentucky.*

Dull black color, not soiling the fingers.

Proximate Analysis.

Moisture,	4.30
Volatile and combustible matters,	23.10
Fixed carbon,	35.50
Yellowish-grey earthy residue,	37.10
	100.00

No. 704—CARBONATE OF IRON, (BITUMINOUS.) *Labeled "Black Band Iron Ore. Roof of the upper coal. Airdrie Furnace. Muhlenburg county, Kentucky. (Estimate the sulphur.)"*

A dull, fine-granular ore, adhering to the tongue on the cross fractures, separating easily into irregular laminæ, which are nearly black on the exterior, and dark umber-colored on the cross-fracture, which presents parallel lines of darker and lighter color. Powder mouse-colored.

Specific gravity, 2.959

Composition, dried at 212° F.—

Carbonate of iron,	59.344	= 31.598 per cent. of Iron.
Oxide of iron,	4.180	
Alumina,	2.290	
Carbonate of lime,	3.390	
Carbonate of Magnesia,	7.149	
Carbonate of manganese,	2.017	
Phosphoric acid,	.428	
Sulphur,	.246	
Potash,	.286	
Soda,	.322	
Bituminous matter,	4.071	
Silex and insoluble silicates,	16.280	
	100.000	

The air-dried ore lost 0.54 per cent. of moisture at 212° F.

No. 705—LIMESTONE. *Labeled "Limestone, found five feet thick above the six feet coal; used for flux at Airdrie Furnace. Muhlenburg county, Kentucky."*

A dark-grey, compact, fine granular limestone, containing irregular specks and veins of discolored calcareous spar, minute microscopical specks of golden yellow pyrites, and effloresced sulphate of iron in places. Powder of a light-grey color.

Specific gravity, 2.777

Composition, dried at 212° F.—

Carbonate of lime,	82.880	= 46.509 per cent. of Lime.
Carbonate of magnesia,	4.196	
Alumina, and oxides of iron and manganese,	4.333	
Phosphoric acid,	.247	

Sulphuric acid, - - -	4.717 = 1.891 per cent. of Sulphur.
Potash, - - -	.135
Soda, - - -	.150
Silex and insoluble silicates, -	4.280
	100.938

The unusually large proportion of sulphur contained in this limestone, renders it objectionable as a flux for iron ore; and mainly to the use of this limestone at the Airdrie Furnace, may be attributed the singular appearance of a considerable amount of sulphuret of iron, which flows out with the slag, and the too large proportion of sulphur contained in the pig iron, (see No. 707,) notwithstanding the use of a great excess of limestone for the flux. (See next analysis of the slag.) The sulphur in this limestone, although it is stated as sulphuric acid in the account of the analysis above, no doubt exists in the rock principally in combination with iron, as bi-sulphuret of iron, or yellow iron pyrites, minute specks of which can be seen in it by the aid of the microscope. This limestone would answer admirably for agricultural purposes, for the improvement of exhausted soil, or land deficient in phosphoric acid, sulphuric acid, or the alkalies; but could a purer specimen of limestone be found for use as flux at the Airdrie Furnace, the quality of the iron might possibly be improved. The coal, however, which is used in the *raw*, or uncoked condition at this furnace, also contains sulphur, (1.35 per cent. or more,) as does the ore employed, (0.246 per cent.—see preceding analysis.)

No. 706—IRON FURNACE SLAG. *Labeled "Airdrie Furnace slag. Furnace running raw coal, and using the hot blast. Muhlenburg county, Kentucky."*

An opake, dense, slag; free from air-bubbles; drab-colored in the interior; bluish on the exterior; melting easily before the blow-pipe, with intermescence into a white, blebby glass.

Composition:

Silica, - - -	42.080	containing of oxygen,	21.849
Alumina, - - -	23.080	" "	10.788
Lime, - - -	24.230	" "	6.890
Magnesia, - - -	6.103	" "	2.439
Protoxide of manganese, -	1.023	" "	.230
Protoxide of iron, - -	1.044	" "	.231
Potash, - - -	2.066	" "	.345
Soda, - - -	.599	" "	.153
	100.225		21.076 : 21.849

Oxygen on the bases to oxygen in the silica, as 1 : 1.036

It will be seen by comparison of this analysis with those of slags from the iron furnaces where charcoal is used as the fuel, in the first and second volumes of this report, that there it contains nearly twice as much lime as those; and that, moreover, the proportion of the bases generally, to the silica, is nearly twice as great in this slag as in the slags from the charcoal furnaces. The slag, however, seems to be a sufficiently fusible one, especially as the hot blast is used; and the use of a large amount of lime tends to remove much of the sulphur present, and prevents it from combining with the metal, especially when the limestone which is employed as flux, does not itself contain much of that element.

No. 706, (a)—SLAG. *Accompanying this slag, was a specimen labeled "Rough slag. Airdrie Furnace, Muhlenburg county, Kentucky." Is the bright metallic looking substance sulphuret of iron?*

This singular product is a conglomerate, of a bright, light yellow, metallic-like substance, involving a dull, brownish-black, dull, porous material. The bright substance is brittle, and attracted by the magnet; it has a lamellar fracture, and the fresh surfaces are nearly white, and of a high metallic lustre. Before the blow-pipe it melted unchanged at a high temperature, gradually evolving sulphur. It dissolves in hydrochloric acid, with the copious evolution of sulphuretted hydrogen gas.

Specific gravity, - - - - - 6.818

It is therefore a sulphuret of iron, containing much proto-sulphuret, and is a very singular product of the iron furnace. It flows out from the furnace with the ordinary slag, or cinder.

No. 707—PIG IRON. *Labeled "Airdrie Furnace Pig Iron, made with raw stone coal, and hot blast. Muhlenburg county, Kentucky."*

A fine-grained, light-colored iron, which yields readily to the file and is easily crushed to powder under the hammer, when in small fragments.

Specific gravity,	-	-	-	-	7.0067
<i>Composition:</i>					
Iron,	-	-	-	88.428	Total carbon, - 1.550
Graphite	-	-	-	1.360	
Combined carbon,	-	-	-	.190	
Manganese,	-	-	-	.980	
Silica,	-	-	-	6.216	
Slag,	-	-	-	3.090	
Aluminium,	-	-	-	.099	
Magnesium,	-	-	-	.309	
Potassium,	-	-	-	.059	
Sodium,	-	-	-	.091	
Phosphorus,	-	-	-	.209	
Sulphur,	-	-	-	.219	
					101.250

This iron contains more slag and sulphur than any of the pig irons from the charcoal furnaces which have been examined, and a very large proportion of silicon—as large as is to be found in any of them, which, as well as the sulphur, tends to make the iron "hot short." The very large proportion of slag and silicon present, is doubtless owing to the very high temperature produced by the hot blast, and these ingredients are readily removed from the iron, in the operation of puddling, to convert it to malleable iron. The sulphur is not quite so easily separated, but would not be very objectionable in cast iron or railroad iron. The probability is, that the iron smelted with stone coal and the hot blast, can never compete with the best charcoal iron, for the manufacture of the finest and toughest bar iron and steel. Yet it is applicable to castings, and to the manufacture of railroad iron, and to other common purposes. Cheap iron, in short, is of very extensive application, in this and in all civilized countries, and its manufacture in our coal districts, is a great desideratum, especially in view of the large amount of capital annually sent to Europe to procure it.

Since the foregoing analyses were made, a collection of very fine specimens of the black band ore, (upper, middle, and bottom portions,)

some of the roasted ore; pig iron of the first run; limestone used as flux, and of the coal, from Airdrie Furnace, were sent to this laboratory by the enterprising proprietor, Mr. Alexander. They arrived too late, however, for chemical examination before the preparation of this report, and will be deposited at the State Cabinet at Frankfort.

NELSON COUNTY.

No. 708—CARBONATE OF IRON. *Labeled "Kidney iron ore two miles south-east of New Haven, at James Bell's, in the Knobs. Sub-carboniferous sandstone. Nelson county, Kentucky."*

A fine granular, dark brownish-grey mineral, becoming more brown towards the exterior; not adhering to the tongue. Powder of a dark buff-grey color.

Dried at 212°, the air-dried mineral lost 0.50 per cent. of moisture.

Specific gravity, - - - - - 5.201

Composition, dried at 212° F.—

Carbonate of iron,	-	-	53.50	} = 29.69 per cent. of Iron
Oxide of iron,	-	-	5.50	
Carbonate of lime,	-	-	4.58	
Carbonate of magnesia,	-	-	9.82	
Carbonate of manganese,	-	-	.71	
Alumina,	-	-	3.15	
Phosphoric acid,	-	-	.63	
Sulphur,	-	-	.08	
Potash,	-	-	.48	
Soda,	-	-	.23	
Silex and insoluble silicates,	-	-	21.48	
				100.16

No doubt rich enough for profitable smelting. It would require little or no limestone for flux.

No. 709—LIMESTONE, (MAGNESIAN.) *Labeled "Magnesian building stone. Bardstown, Nelson county, Kentucky. Upper Silurian formation."*

A grey-buff, fine-granular rock; not adhering to the tongue. Under the lens appearing to be made up of pretty pure crystalline grains. Powder of a light grey color.

The air-dried powdered stone lost only 0.10 per cent. of moisture at 212° F.

Specific gravity,	-	-	-	-	-	-	2.758
<i>Composition, dried at 212° F.—</i>							
Carbonate of lime,	-	-	62.19	=	34.90	per cent. of <i>Lime</i> .	
Carbonate of magnesia,	-	-	33.90				
Alumina, and oxides of iron and manganese, and trace of phosphates,	-	-					.68
Potash,	-	-					.46
Soda,	-	-					.35
Silex and insoluble silicates,	-	-	3.18				
							100.76

This magnesian limestone was found to contain only a very small trace of *sulphur*. It does not differ greatly in composition from the limestone rocks of the lower strata of the Lower Silurian formation, and will doubtless be found a *very durable* building material.

No. 710—CARBONATE OF IRON. Labeled "*Grey kidney ore. (Sub-carboniferous sandstone formation.) Nelson Furnace, Nelson county, Kentucky.*"

A fine-grained, dull, grey ore; not adhering to the tongue. Exterior layer yellowish-brown; adhering to the tongue. Powder, of the interior portion, buff-grey.

Specific gravity, - - - - - 3.348

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

<i>Composition, dried at 212° F.—</i>							
Carbonate of iron,	-	-	69.96	}	= 35.64 per cent. of <i>Iron</i> .		
Oxide of iron,	-	-	2.64				
Carbonate of lime,	-	-	3.98				
Carbonate of magnesia,	-	-	9.43				
Carbonate of manganese,	-	-	1.32				
Alumina,	-	-	1.55				
Phosphoric acid,	-	-	.63				
Sulphur,	-	-	.09				
Potash,	-	-	.34				
Soda,	-	-	.34				
Silex and insoluble silicates,	-	-	10.48				
							100.76

A good and sufficiently rich ore of iron, which will require little or no limestone to flux it. The proportion of phosphoric acid which it contains, however, is a little greater than is desirable.

No. 711—LIMESTONE. Labeled "*Limestone used as a flux at Nelson Furnace, Devonian formation? Nelson county, Kentucky.*"

A fine-granular, grey-buff limestone; with no appearance of fossils. Weathered surface brownish. Some small cavities in it.

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

<i>Composition, dried at 212° F.—</i>							
Carbonate of lime,	-	-	51.66	=	29.	per cent. <i>Lime</i> .	
Carbonate of Magnesia,	-	-	32.00				
Alumina and oxide of iron, &c.,	-	-	5.55				
Sulphuric acid,	-	-	.09				
Potash,	-	-	.77				
Soda,	-	-	.46				
Silex and insoluble silicates,	-	-	9.78				
							100.31

No. 712—IRON FURNACE SLAG. Labeled "*Green slag. Nelson Furnace, Nelson county, Kentucky.*"

Dull olive-green, at one end of the fragment, passing into dull yellowish at the other. Translucent in the thin pieces and on the thin edges of the yellowish portion.

Before the blow-pipe it melted pretty readily into a blebby globule.

<i>Composition:</i>							
Silica,	-	-	53.524	containing of oxygen,		27.793	
Alumina,	-	-	19.957	"	"	9.328	
Lime,	-	-	14.000	"	"	3.982	
Magnesia	-	-	5.706	"	"	2.280	
Protoxide of iron,	-	-	2.673	"	"	.593	
Protoxide of manganese,	-	-	.059	"	"	.013	
Potash,	-	-	3.244	"	"	.550	
Soda,	-	-	1.401	"	"	.359	
						100.564	17.105 : 27.793

The oxygen in the *bases* is to the oxygen in the *silica* as, 1 : 1.624

The use of a little more limestone for the flux might make the cinder more fusible, and remove from it the nearly two per cent. of protoxide of iron which it contains, and which is so much loss.

No. 713—PIG IRON. *Labeled "Pig iron from Nelson Furnace, Nelson county, Kentucky."*

A moderately fine grained, grey iron. It flattens considerably under the hammer and yields easily to the file.

Specific gravity, - - - - - 7.1493

Composition:	95.173
Iron, - - - - -	2.880
Graphite, - - - - -	.697
Silicon, - - - - -	.190
Slag, - - - - -	.274
Manganese, - - - - -	.101
Aluminium, - - - - -	.025
Calcium, - - - - -	.114
Magnesium, - - - - -	.096
Potassium, - - - - -	.026
Sodium, - - - - -	.339
Sulphur, - - - - -	.096
Phosphorus, - - - - -	
	100.011

This is quite a soft iron, which does not seem to contain any combined carbon. Its proportion of sulphur is considerable, otherwise it is quite a pure specimen of Pig iron.

No. 714—SOIL. *Labeled "Virgin soil, woods pasture; Mr. Beauchamp's land on Chaplin creek. Lower Silurian formation. Primitive forest growth, sugar-tree, beech, and blue ash. (Mr. B. says it will not produce well if sub-soiled.) Nelson county, Kentucky."*

Dried soil of a light umber color. Washed with water it left 86.53 per cent. of sand, &c., of which all but 4.07 per cent. passed through the finest bolting-cloth. This coarser portion consisted of small rounded ferruginous particles or concretions.

One thousand grains of the air-dried soil, digested for a month in water charged with carbonic acid, gave up nearly six grains of chestnut-brown extract, dried at 212° F., which had the following composition, viz:

	Grains.
Organic and volatile matters, - - - - -	1.333
Alumina, oxides of iron and manganese, and phosphates, - - - - -	1.297
Carbonate of lime, - - - - -	2.630
Magnesia, - - - - -	.123
Sulphuric acid, - - - - -	.068
Potash, - - - - -	.150
Soda, - - - - -	.077
Silica, - - - - -	.177
	5.855

The air-dried soil lost 4.985 per cent. of moisture at 400° F.; dried at which temperature it has the following composition:

Organic and volatile matters, - - - - -	6.659
Alumina, - - - - -	4.655
Oxide of iron, - - - - -	4.065
Carbonate of lime, - - - - -	.770
Magnesia, - - - - -	.452
Brown oxide of manganese, - - - - -	.395
Phosphoric acid, - - - - -	.535
Sulphuric acid, - - - - -	.093
Potash, - - - - -	.222
Soda, - - - - -	.026
Sand and insoluble silicates, - - - - -	82.195
	100.067

No. 715—SOIL. *Labeled "Same soil as preceding, from a field thirty-three years in cultivation, that has been injured by sub-soiling. (More beech grew on this than on the preceding soil.) Mr. Beauchamp's farm, &c., Nelson county, Kentucky."*

Dried soil of a lighter color, and more yellowish than the preceding. Washed with water it left 75.40 per cent. of sand, &c., of which all but 3.60 per cent. passed through the fine bolting-cloth. This coarser portion consists of small rounded ferruginous particles, with a few of quartzose.

One thousand grains of the air-dried soil, digested for a month in water containing carbonic acid, gave up not quite two grains and a half of light-brown extract, dried at 212° F., of the following composition, viz:

	Grains.
Organic and volatile matters, - - - - -	0.417
Alumina, oxides of iron and manganese, and phosphates, - - -	.313
Carbonate of lime, - - - - -	1.130
Magnesia, - - - - -	.111
Sulphuric acid, - - - - -	.026
Potash, - - - - -	.149
Soda, - - - - -	.043
Silica, - - - - -	.200
	2.389

The air-dried soil lost 2.70 per cent. of moisture, at 400° F., dried at which temperature it has the following composition:

Organic and volatile matters, - - - - -	3.423
Alumina, - - - - -	3.140
Oxide of iron, - - - - -	2.825
Carbonate of lime, - - - - -	.330
Magnesia, - - - - -	.282
Brown oxide of manganese, - - - - -	.280
Phosphoric acid, - - - - -	.316
Sulphuric acid, - - - - -	.078
Potash, - - - - -	.130
Soda, - - - - -	.036
Sand and insoluble silicates, - - - - -	88.895
Loss, - - - - -	.265
	100.000

No. 716—SUB-SOIL. Labeled "Sub-soil, from the same field, thirty-three years in cultivation; that has never been turned up. Mr. Beauchamp's farm, Chaplin creek, Nelson county, Kentucky."

Dried sub-soil of a greyish-buff color. Washed with water it left 78.93 per cent. of sand, &c., of which all but 2.07 per cent. passed through the finest bolting-cloth. This coarser portion consisted of small rounded ferruginous particles.

One thousand grains of the air-dried sub-soil, digested for a month in water charged with carbonic acid, gave up *rather more than one and a half grains of grey-buff extract*, dried at 212° F., which had the following composition, viz:

	Grains.
Organic and volatile matters, - - - - -	0.340
Alumina, oxides of iron and manganese, and phosphates, - - -	.187
Carbonate of lime, - - - - -	.740
Magnesia, - - - - -	.066
Sulphuric acid, - - - - -	.022
Potash, - - - - -	.074
Soda, - - - - -	.053
Silica, - - - - -	.097
	1.579

The air-dried soil lost 2.85 per cent. of moisture at 400° F.; dried at which temperature it has the following composition:

Organic and volatile matters, - - - - -	2.804
Alumina, - - - - -	3.490
Oxide of iron, - - - - -	3.370
Carbonate of lime, - - - - -	.230
Magnesia, - - - - -	.254
Brown oxide of manganese, - - - - -	.220
Phosphoric acid, - - - - -	.277
Sulphuric acid, - - - - -	.059
Potash, - - - - -	.101
Soda, - - - - -	.034
Sand and insoluble silicates, - - - - -	88.970
Loss, - - - - -	.191
	100.000

The reason why the intermixture of the sub-soil injures the fertility of the surface-soil of these fields is to be readily observed in the smaller proportion of lime, magnesia, oxide of manganese, phosphoric acid, sulphuric acid, and of potash, as well as of alumina and oxide of iron, contained in the sub-soil, and its larger proportion of sand and silicates, and in the much smaller quantity of soluble matter which it gives up to water containing carbonic acid. The organic and volatile matter is also in much smaller amount in it, but this is usually the case with sub-soil as compared with the more superficial stratum.

No. 717—SOIL. Labeled "Under-earth overlying the shell and coral-line beds, (of Lower Silurian formation;) very loose; considered by Mr. Beauchamp injurious to the surface-soil. Mr. Beauchamp's land, on Chaplin creek. Nelson county, Kentucky."

Dried soil of a rather darker grey-buff color than the preceding. The coarse seive removed from it some fragments of rotten sandstone. Washed with water, it left 79.37 per cent. of sand, &c., of which all but 10.5 per cent. was fine enough to go through the finest bolting-cloth. This coarser portion consisted of rounded ferruginous particles.

One thousand grains of the air-dried soil, digested for a month in water containing carbonic acid, gave up *a little more than a grain and a half of light-grey extract*, dried at 212° F., which had the following composition, viz:

	Grains.
Organic and volatile matters, - - - - -	0.583
Alumina, oxides of iron and manganese, and phosphates, - - -	.038
Carbonate of lime, - - - - -	.630
Magnesia, - - - - -	.029
Sulphuric acid, - - - - -	.016
Potash, - - - - -	.037
Soda, - - - - -	.060
Silica, - - - - -	.177
	1.620

The air-dried soil lost 5.575 per cent. of moisture at 400° F.; dried at which temperature it has the following composition:

Organic and volatile matters, - - - - -	4.090
Alumina, - - - - -	8.240
Oxide of iron, - - - - -	7.065
Carbonate of lime, - - - - -	1.725
Magnesia, - - - - -	.731
Brown oxide of manganese, - - - - -	.380
Phosphoric acid, - - - - -	.438
Sulphuric acid, - - - - -	.059
Potash, - - - - -	.334
Soda, - - - - -	.052
Sand and insoluble silicates, - - - - -	77.275
	100.389

A soil containing so much organic and volatile matters, such large proportions of alumina and oxide of iron, of lime, magnesia, and phos-

phoric acid, with more than the average quantity of potash, would be generally considered a *fertile* soil, if there was nothing in its physical (or mechanical) properties unfavorable to vegetable growth. The proportion of sulphuric acid will be seen, however, to be quite small, and it will be observed that, although it contains, in large proportion, most of the elements necessary for vegetable nourishment, especially a large amount of lime and magnesia, which are quite soluble in water charged with carbonic acid, *it gives up but a comparatively small amount of soluble extract, when digested in that fluid*, of which more than a third is carbonate of lime. It seems to contain the mineral elements necessary to vegetable growth in sufficient amount therefore, but not much of them in a *soluble state*. Whether the application of caustic slacked lime to this soil might change this condition of things is well worthy a trial. The use of Plaster of Paris to furnish sulphuric acid might be followed by good results.

No. 718—UNDER-EARTH, "with fragments of *Orth's lynx*; road near Mr. Beauchamp's, on Chaplin creek, Nelson county, Kentucky. Lower Silurian formation."

Dried soil of a dirty-buff color. The coarse seive removed from it a few fragments of fossil shells. Washed with water it left 66.30 per cent. of sand, &c., of which all but 10.03 per cent. passed through the finest bolting-cloth. This coarser portion consisted of small rounded ferruginous particles with a few of chert.

One thousand grains of the air-dried soil, digested for a month in water charged with carbonic acid, gave up *a little more than a grain and a half of yellowish-grey extract*, dried at 212° F., which had the following composition, viz:

	Grains.
Organic and volatile matters, - - - - -	0.283
Alumina, oxides of iron and manganese, and phosphates, - - -	.147
Carbonate of lime, - - - - -	.977
Magnesia, - - - - -	.070
Sulphuric acid, - - - - -	.036
Potash, - - - - -	.041
Soda, - - - - -	.061
Silica, - - - - -	.131
	1.746

The air-dried soil lost 5.05 per cent. of *moisture* at 400° F.; dried at which temperature it has the following *composition*:

Organic and volatile matters,	4.449
Alumina,	7.290
Oxide of iron,	6.015
Carbonate of lime,	.520
Magnesia,	.967
Brown oxide of manganese,	.295
Phosphoric acid,	.368
Sulphuric acid,	.033
Potash,	.283
Soda,	.058
Sand and insoluble silicates,	79.730

100.008

This soil strikingly resembles the next preceding one in properties and composition. Like that it has all the elements of fertility in more than the average proportions, except that the sulphuric acid is deficient, yet gives up but a very small amount, comparatively, of soluble extract, when it is digested in water charged with carbonic acid, indicating that although rich in the nourishing elements it yields them very sparingly to growing crops. (See remarks on the preceding soil.)

No. 719—SOIL. Labeled "*Virgin soil, over the Calymene Blumenbachii bed of magnesian limestone. Five miles south-west of Bardstown; Cedar creek meeting-house, Nelson county, Kentucky. Upper Silurian formation.*"

Dried soil of a greyish-buff color. The coarse seive removed from it some small irregular fragments of a soft ferruginous sandstone. Washed with water it left 79.92 per cent. of sand, &c., of which all but 6.20 per cent. passed through the finest bolting-cloth. This coarser portion consisted of small rounded ferruginous particles with a few of quartzose particles.

One thousand grains of the air-dried soil, digested for a month in water charged with carbonic acid, gave up *nearly five grains of light chesnut-brown extract*, dried at 212° F., which has the following *composition*, viz:

	Grains.
Organic and volatile matters,	1.263
Alumina, oxides of iron and manganese, and phosphates,	.803
Carbonate of lime,	2.177
Magnesia,	.139
Sulphuric acid,	.055
Potash,	.074
Soda,	.035
Silica,	.270
	4.816

The air-dried soil lost 3.75 per cent. of *moisture*, at 400° F.; dried at which temperature it has the following *composition*, viz:

Organic and volatile matters,	5.298
Alumina,	3.890
Oxide of iron,	3.875
Carbonate of lime,	.270
Magnesia,	.416
Brown oxide of manganese,	.420
Phosphoric acid,	.114
Sulphuric acid,	.051
Potash,	.098
Soda,	.036
Sand and insoluble silicates,	85.895
	100.363

This soil gives a striking contrast to the two preceding soils, for although it contains much less of the fertilizing ingredients generally, and but a little more of organic and volatile matters, it gives up about three times as much soluble matter to the water charged with carbonic acid, in which it is digested.

No. 720—SOIL. Labeled "*Virgin soil, Guthry farm, near Bloomfield, Nelson county, Kentucky. Lower Silurian formation. Blue ash land.*"

Dried soil of a brownish-buff color. Washed with water the soil left 84.63 per cent. of sand, &c., of which all but 3.30 per cent. passed through the finest bolting-cloth. This coarser portion consisted of small rounded ferruginous particles with a few of chert.

One thousand grains of the air-dried soil, digested for a month in water charged with carbonic acid, gave up *more than five grains of yel-*

lowish-brown extract, dried at 212° F., which had the following composition, viz:

	Grains.
Organic and volatile matters,	1.450
Alumina, oxides of iron and manganese, and phosphates,	.881
Carbonate of lime,	2.207
Magnesia,	.100
Sulphuric acid,	.048
Potash,	.101
Soda,	.047
Silica,	.198
	5.032

The air-dried soil lost 3.425 per cent. of moisture at 400° F.; dried at which temperature it has the following composition:

Organic and volatile matters,	5.384
Alumina,	4.280
Oxide of iron,	3.905
Carbonate of lime,	.405
Magnesia,	.492
Brown oxide of manganese,	.470
Phosphoric acid,	.228
Sulphuric acid,	.117
Potash,	.193
Soda,	.049
Sand and insoluble silicates,	84.395
Loss,	.082
	100.000

No. 721—SOIL. Labeled "Same soil, from the Guthry farm, forty years in cultivation; blue ash land. Lower Silurian formation. Nelson county, Kentucky."

Color of the dried soil brownish-buff; slightly lighter than that of the preceding; some fragments of fossil shells were removed from it with the coarse sieve. Washed with water it left 82.83 per cent. of sand, &c., of which all but 5.5 per cent. was fine enough to pass through the finest bolting-cloth. This coarser portion consisted of rounded ferruginous and cherty particles.

One thousand grains of the air-dried soil, digested for a month in water containing carbonic acid, gave up nearly four grains of chesnut-

brown extract, dried at 212 F., which had the following composition, viz:

	Grains.
Organic and volatile matters,	1.150
Alumina, oxides of iron and manganese, and phosphates,	.847
Carbonate of lime,	1.473
Magnesia,	.070
Sulphuric acid,	.073
Potash,	.071
Soda,	.058
Silica,	.100
	3.842

The air-dried soil, lost 3.25 per cent. of moisture at 400° F., dried at which temperature it had the following composition:

Organic and volatile matters,	4.858
Alumina,	4.070
Oxide of iron,	3.795
Carbonate of lime,	.222
Magnesia,	.553
Brown oxide of manganese,	.295
Phosphoric acid,	.351
Sulphuric acid,	.067
Potash,	.268
Soda,	.015
Sand and insoluble silicates,	85.585
	100.079

No. 722—SUB-SOIL. Labeled "Sub-soil from the same old field; Guthry farm; Nelson county, Kentucky, &c., &c."

Dried sub-soil of a dirty-buff color; lighter than that of the two preceding soils. Washed with water it left 66.27 per cent. of sand, &c., of which all but 5.82 per cent. passed through the finest bolting-cloth. This coarser portion consisted of ferruginous and cherty particles.

One thousand grains of the air-dried sub-soil, digested for a month in water containing carbonic acid, gave up two grains of umber-brown extract, dried at 212° F., which had the following composition, viz:

	Grains.
Organic and volatile matters, - - - - -	0.666
Alumina, oxides of iron and manganese, and phosphates, - - -	.196
Carbonate of lime, - - - - -	.800
Magnesia, - - - - -	.066
Sulphuric acid, - - - - -	.064
Potash, - - - - -	.044
Soda, - - - - -	.043
Silica, - - - - -	.121
	2.000

The air-dried sub-soil lost 4.00 per cent. of *moisture*, at 400° F.; dried at which temperature it had the following *composition*:

Organic and volatile matters, - - - - -	4.088
Alumina, - - - - -	5.910
Oxide of iron, - - - - -	5.160
Carbonate of lime, - - - - -	.336
Magnesia, - - - - -	.487
Brown oxide of manganese, - - - - -	.320
Phosphoric acid, - - - - -	.345
Sulphuric acid, - - - - -	.085
Potash, - - - - -	.275
Soda, - - - - -	.055
Sand and insoluble silicates, - - - - -	83.210
	100.271

No. 723—SHELL-EARTH. Labeled "*Under Orthis lynx earth, side of the road, on Guthry's farm. Lower Silurian formation. Nelson county, Kentucky.*"

Dried soil of a dirty-buff color; some fragments of fossil shells were removed from it by the coarse seive. Washed with water it left 82.83 per cent. of sand, &c., of as much as 21.43 per cent. was too coarse to pass through the fine bolting-cloth. This portion consisted of small fragments of fossil shells, and rounded ferruginous and cherty particles.

One thousand grains of the air-dried soil, digested for a month in water containing carbonic acid, gave up *less than two grains of brown extract*, dried at 212° F., which had the following *composition*, viz:

	Grains.
Organic and volatile matters, - - - - -	0.830
Alumina, oxides of iron and manganese, and phosphates, - - -	.230
Carbonate of lime, - - - - -	.547
Magnesia, - - - - -	.039
Sulphuric acid, - - - - -	.060
Potash, - - - - -	.039
Soda, - - - - -	.080
Silica, - - - - -	.131
	1.956

The air-dried soil lost 5.275 per cent. of *moisture* at 400° F.; dried at which temperature it has the following *composition*:

Organic and volatile matters, - - - - -	6.281
Alumina, - - - - -	9.325
Oxide of iron, - - - - -	7.885
Carbonate of lime, - - - - -	.645
Magnesia, - - - - -	1.100
Brown oxide of manganese, - - - - -	.295
Phosphoric acid, - - - - -	.773
Sulphuric acid, - - - - -	.062
Potash, - - - - -	.449
Soda, - - - - -	.272
Sand and insoluble silicates, - - - - -	73.095
	100.182

This latter shell earth resembles that previously described, from Mr. Beauchamp's land on Chaplin creek, Nelson county, (Nos. 717 and 718.) They all contain large proportions of alumina and oxide of iron, much organic and volatile matters, and much more than the usual amount of lime, magnesia, phosphoric acid, and potash, but contain a very moderate quantity of sulphuric acid, and *give but a very small amount of soluble matters to the water charged with carbonic acid.*

In the soils from the Guthry farm, that from the old field appears to contain more of these essential mineral elements than the virgin soil, but much less of them in the *soluble form*. The sub-soil, which has probably been mixed with the surface-soil somewhat, during the cultivation of the field, partakes of the same characters.

No. 724—SOIL. Labeled "Virgin soil, from Maj. Minor's woods-pasture. Primitive forest growth, large poplar, blue ash and beech. Near Bloomfield. Lower Silurian formation. Nelson county, Ky."

Color of the dried soil, dirty buff. Washed with water it left 79.41 per cent. of sand, &c., of which all but 3.47 per cent. passed through the fine bolting-cloth. This portion consisted of small rounded ferruginous particles, with a few of chert.

One thousand grains of the air-dried soil, digested for a month in water containing carbonic acid, gave up nearly six grains of brownish extract, dried at 212° F.; which had the following composition, viz:

	Grains.
Organic and volatile matters, - - - - -	1.700
Alumina, oxides of iron and manganese, and phosphates, - - -	.964
Carbonate of lime, - - - - -	2.563
Magnesia, - - - - -	.013
Sulphuric acid, - - - - -	.164
Potash, - - - - -	.170
Soda, - - - - -	.054
Silex, - - - - -	.264
	5.892

The air-dried soil lost 2.575 per cent. of moisture, at 400° F.; dried at which temperature it had the following composition:

Organic and volatile matters, - - - - -	7.196
Alumina, - - - - -	3.295
Oxide of iron, - - - - -	3.110
Carbonate of lime, - - - - -	.445
Magnesia, - - - - -	.522
Brown oxide of manganese, - - - - -	.195
Phosphoric acid, - - - - -	.342
Sulphuric acid, - - - - -	.096
Potash, - - - - -	.154
Soda, - - - - -	.021
Sand and insoluble silicates, - - - - -	84.595
Loss, - - - - -	.030
	100.000

No. 725—SOIL. Labeled "Soil from Maj. Miner's field, fourteen years in cultivation. Near Bloomfield, Nelson county, Ky. Lower Silurian formation, &c., &c."

Dried soil of a dirty-buff color. Washed with water it left 84.80 per cent. of sand, &c., of which all but 5.77 per cent. passed through the fine bolting-cloth. This coarser portion consisted of rounded ferruginous particles, pieces of fossils and chert.

One thousand grains of the air-dried soil, digested for a month in water charged with carbonic acid, gave up nearly five grains of chestnut-brown extract, dried at 212° F., which had the following composition, viz:

	Grains.
Organic and volatile matters, - - - - -	1.660
Alumina, oxides of iron and manganese, and phosphates, - - -	.847
Carbonate of lime, - - - - -	3.040
Magnesia, - - - - -	.083
Sulphuric acid, - - - - -	.045
Potash, - - - - -	.054
Soda, - - - - -	.027
Silica, - - - - -	.139
	4.895

The air-dried soil lost 2.64 per cent. of moisture at 400° F.; dried at which temperature it has the following composition:

Organic and volatile matters, - - - - -	7.164
Alumina, - - - - -	3.495
Oxide of iron, - - - - -	3.535
Carbonate of lime, - - - - -	.520
Magnesia, - - - - -	.656
Brown oxide of manganese, - - - - -	.220
Phosphoric acid, - - - - -	.343
Sulphuric acid, - - - - -	.067
Potash, - - - - -	.125
Soda, - - - - -	.027
Sand and insoluble silicates, - - - - -	83.770
Loss, - - - - -	.078
	100.000

The fourteen years cultivation of this field, has not caused much deterioration. The quantities of organic and volatile matters, lime,

magnesia, and phosphoric acid, are pretty much the same in this and in the virgin soil. The soil of this cultivated field gives less soluble matter to the water charged with carbonic acid, however, and contains a smaller quantity of potash and sulphuric acid.

No. 726—MARL. Labeled "*Mathers marl, or ash colored clay, containing carbonate of lime; from the deep cut in the Bardstown turnpike; two and a half to three miles from New Haven, Nelson county, Kentucky. Sub-carboniferous formation.*"

A yellowish-grey, stratified indurated clay, or soft shale. Powder of a light olive-grey color.

Composition, dried at 212° F.—

Alumina, oxides of iron, and manganese,	11.850
Carbonate of lime,	.393
Magnesia,	.966
Phosphoric acid,	.121
Sulphuric acid,	.463
Potash,	.749
Soda,	.482
Sand and insoluble silicates,	84.990
	100.014

This marl contains valuable proportions of potash, sulphuric acid, magnesia, lime and soda, and but a moderate quantity of phosphoric acid. It would be a useful application to exhausted land, especially with the addition of bone dust, or other phosphatic manures.

No. 727—LIMONITE. Labeled "*Iron ore in the preceding clay, &c., &c. Nelson county, Kentucky.*"

Layers of dull yellowish-brown iron ore; adheres to the tongue.

Composition, dried at 212° F.—

Oxide of iron,	39.340 = 27.55 per cent. of Iron.
Alumina,	2.560
Carbonate of lime,	.886
Carbonate of magnesia,	4.827
Brown oxide of manganese,	1.180
Phosphoric acid,	.315
Sulphuric acid,	.201

Potash,	.668
Soda,	.342
Silex and insoluble silicates,	44.720
Water and loss,	4.961
	100.000

No. 728—MARL. Labeled "*Ash-colored shale, (Marl?) Big Lick, near Bell's and New Haven, Nelson county, Kentucky. Sub-carboniferous formation.*"

Composition dried at 212° F.—

Alumina, and oxides of iron and manganese,	9.430
Carbonate of lime,	.843
Magnesia,	1.533
Phosphoric acid,	.114
Sulphuric acid,	.227
Potash,	.657
Soda,	.229
Sand and insoluble silicates,	85.840
Water and loss,	1.127
	100.000

As this contains a considerable proportion of potash and lime and magnesia it may be entitled to the denomination of marl. Like the preceding, its quantity of phosphoric acid is small.

No. 729—SOIL. Labeled "*Shell-earth, underlying the blue ash land at R. B. Grigsby's, three miles from Bloomfield; Nelson county, Kentucky. Lower Silurian formation.*"

A dirty-buff colored earth, containing silicified fragments of shells, and some fragments of chert and ferruginous sandstone.

Composition, dried at 212° F.—

Organic and volatile matters,	4.200
Alumina,	5.190
Oxide of iron,	4.650
Carbonate of lime,	.396
Magnesia,	.613
Brown oxide of manganese,	.230
Phosphoric acid,	.172

Sulphuric acid, - - - - -	.085
Potash, - - - - -	.282
Soda, - - - - -	.095
Sand and insoluble silicates, - - - - -	84.495
	100.408

NICHOLAS COUNTY.

No. 730—SANDSTONE. *Labeled "Rock from the Blue Lick battle ground, Nicholas county, Kentucky. Lower Silurian."*

A fine-grained sandstone, containing a few specks of mica. Color dirty-buff; with thin bands of brownish and dirty-orange color. Adheres to the tongue.

Composition, dried at 212° F.—

Alumina, and oxides of iron and manganese, - - -	4.140
Carbonate of lime, - - - - -	.113
Magnesia, - - - - -	.199
Phosphoric acid, - - - - -	.092
Sulphuric acid, - - - - -	.076
Potash, - - - - -	.202
Soda, - - - - -	.121
Sand and insoluble silicates, - - - - -	93.390
Water and loss, - - - - -	1.667
	100.000

The presence of this sandstone as a sub-stratum at the Blue Lick Springs is the reason of that sterility and paucity of soil, which has generally been attributed, by early observers, to the trampling of the herds of buffaloes, which formerly frequented the licks.

No. 731—SANDSTONE. *Labeled "Mudstone, from a pasture near Carlisle; (where cattle die of milk sickness;) Nicholas county, Kentucky."*

A friable argillaceous sandstone, of a dirty-buff color and imperfectly laminated structure. Exterior of the laminæ of a dark iron-rust-brown color, and covered with impressions of shells, entrochites, &c.

Composition, dried at 212° F.—

Alumina, - - - - -	3.880
Oxide of iron, - - - - -	4.680
Carbonate of lime, - - - - -	.743
Magnesia, - - - - -	.322
Brown oxide of manganese, - - - - -	.290
Phosphoric acid, - - - - -	.572
Sulphuric acid, - - - - -	.100
Potash, - - - - -	.473
Soda, - - - - -	.233
Sand and insoluble silicates, - - - - -	88.440
Loss, - - - - -	.267
	100.000

Nothing in the composition of this rock explains the origin of milk sickness in this region.

No. 732—LIMESTONE. *Labeled "Modesta limestone. Cut of the Railroad, near Carlisle, Nicholas county, Kentucky."*

An olive-grey, impure limestone, full of fossil shells—weathered surface of a dirty-buff color.

Composition, dried at 212° F.—

Carbonate of lime, - - -	78.680 = 44.150 per cent. of Lime.
Carbonate of magnesia, - -	1.566
Alumina, oxides of iron and manganese, - - -	2.480
Phosphoric acid, - - -	.247
Sulphuric acid, - - -	.270
Potash, - - -	.173
Soda, - - -	.172
Silex and insoluble silicates, -	16.640
	100.228

A good limestone for agricultural purposes, containing considerable proportions of phosphoric and sulphuric acids and alkalies. By its gradual disintegration it tends to renovate the soil which may rest upon it.

No. 733—MINERAL WATER. *Water of the Lower Blue Lick Spring. Nicholas county, Kentucky.*

The water of this celebrated spring has not been analyzed at this laboratory during the progress of this survey. But some years ago,

the writer submitted it to a full quantitative examination, and published the results as follows:

Although this celebrated water has, at various times, been *qualitatively tested*, and the nature of its principal larger ingredients ascertained, yet it has never been fully analyzed *quantitatively*, and the presence and proportions of its minuter constituents made out. To ascertain the exact weights and proportions of these several ingredients, and to detect and estimate the more minute, yet not less valuable medicinal agents of this water, was the object of the new investigation.

Nor is this object devoid of interest to the physician or the man of science. Chemical analyses frequently owe all their value to the minute ingredients which are detected. For example; the analysis of a soil is of very minor importance when it does not develop the proportions of the potash or phosphate of lime, and mineral waters frequently present medicinal virtues, in their use, which cannot be accounted for in the properties of the ingredients which are shown by a rough and imperfect analysis. Thus, the salt-sulphur water of Leamington, England, possesses virtues in the cure of scrofula, &c., which were unaccountable to physicians, until by the minute analysis of Prof. Daubeny, iodine and bromine were detected in it in small quantities.

The water of the Lower Blue Lick Springs, has an extensive reputation in Kentucky, and in the South generally; this being one of the oldest and best known watering places in the valley of the Ohio and Mississippi. Hundreds of invalids, as well as of seekers for recreation and pleasure, visit this pleasant locality every season, and thousands of barrels and of bottles of the water are annually put up for distant places in this and other States.*

This remarkable spring, it is well known, attracted the attention of the earliest settlers of Kentucky, by its strong odor of sulphuretted hydrogen, and the saltiness of its waters. It was, indeed, from this source, that Boone and other pioneers obtained the salt with which to flavor their venison. Here, while engaged in procuring this necessary condiment, was he surprised and captured by the Indians; and here was fought one of the most disastrous, to the whites, of the early battles with the savages. The historian of Kentucky will always connect the name of this place with some of the most interesting events of its early annals. * * *

At the Blue Licks, beside the main spring, there are a number of minor ones, on the two sides of the Licking river and in its bed, the water of some of which has been examined by the author, and found to be very much like that of the principal spring in composition. Johnson's well, in Scott county, Ky., also presents a composition some-

* Put up in tight vessels it bears transportation very well; but as it is speedily altered after exposure to the air, it should be bottled, and corked and sealed very perfectly, for distant use.

what analogous to that of the Blue Lick water, but it is much weaker, and contains more magnesian salts.

While the water of the superficial wells and springs, on the blue limestone formation, are generally what is denominated *hard*, or *limestone water*—containing bi-carbonates of lime and magnesia, with a little iron, and some phosphate of lime, held in solution by carbonic acid; these salt wells, or “licks,” so called, contain chlorides of sodium and potassium, chlorides of calcium and magnesium, sulphate and carbonate of lime, &c., and are frequently impregnated, to a greater or less degree, with sulphuretted hydrogen. Saline water of this character, as above intimated, has been frequently obtained on the blue limestone formation, by boring. For example, in the little town of Keene, in Jessamine county, Kentucky, a water was obtained in this manner, in 1848, by Mr. Wm. R. Dean, which is a very good salt sulphur water, and has been considerably employed for its medicinal properties. It contains sulphuretted hydrogen and carbonic acid gases; bi-carbonates of lime and magnesia, with a trace of bi-carbonate of soda; chlorides of sodium, calcium, magnesium, and doubtless of potassium, with a trace of iron; but this is much weaker than the Blue Lick water, containing only 1.6 grains of saline in the 1000 grains of the water; being only about one sixth the strength of the former. In a later testing, in May, 1850, it was found to be yet weaker, probably because of the then extremely wet season. This water has not been fully analyzed to detect the presence of iodine and bromine.

In Scott county, of this State, in a well bored to the depth of 176 feet in this limestone, Mr. W. Roszell obtained a water which contains a notable proportion of chlorides of sodium, calcium, and magnesium, &c., &c, and smells strongly of sulphuretted hydrogen. The water of another bored well, 105 feet deep, obtained in 1848, by Maj. B. Roberts, in Harrison county, also on the blue limestone formation, has a very slight bituminous or sulphurous odor, but contains as much as sixteen parts in the thousand of saline matters, principally chloride of sodium, with chlorides of potassium, calcium and magnesium; sulphate of lime, bi-carbonates of lime, magnesia and iron, and a trace of iodine. This is rather stronger in salts than the Blue Lick water, and differs from it also in its deficiency in sulphuretted hydrogen, but in other respects they resemble each other very much in composition.

Another well, 81½ feet deep, was made by boring, in Scott county, near Georgetown, on the property of Mr. R. Ford, the water of which contains as much as 4. per cent. of saline matter, principally common salt, with sulphates of lime and potash, chlorides of calcium and magnesium, &c., &c. Some of the wells in Lexington yield a water smelling slightly of sulphuretted hydrogen, and while penning these remarks, a

bottle of water was brought to me from a boring in progress, forty-five feet deep, in this city, which is a weak sulphur water.*

Saline, and saline sulphur-waters, therefore are quite frequent, comparatively, in our Blue Limestone strata; but amongst all the springs of this nature, known at present on this formation, in Kentucky, none are as valuable, and as remarkable, in many respects, as those of the lower Blue Licks.

The principal spring, of this locality, from which the water submitted to analysis was taken, is situated near the banks of the Licking river, flowing out about twenty feet above low water in that stream. It rises in a hexagonal basin of stone, which has been built for it, which is six feet two inches in diameter from one side to the opposite parallel one, and about five or six feet in depth. The quantity of water which flows out varies in different seasons. When the water for the present examination was obtained, June 6, 1850, it was low in the spring and not running. The water in this basin was lowered about one foot by pumping out seventy-six barrels† in the course of three hours; and in the winter time the stream which flows out from it would probably fill a pipe three inches in diameter.

The temperature of this spring was observed by Major Richard Owen, Professor in the Western Military Institute located at the Blue Licks; who was kind enough also to procure and pack up for me with great care, the water, sediment and gas, from the spring, in the various bottles which had been prepared for the purpose. In six observations, at different times on June 4th and 5th, the external air varying from 60° to 76° F., the temperature of the water stood very constantly at 62°. This is about seven degrees above the mean temperature of this region, which is about 55°; and it is probable that the temperature of the water in the basin had been somewhat raised by the external heat of the atmosphere. When flowing rapidly it may perhaps be found to approximate more nearly to the mean annual temperature.

The mass of water in the spring presents a light yellowish-green color; partly owing, perhaps, to the reflection from the yellowish-grey sediment; for when it is taken up in a clear vessel it appears perfectly colorless and beautifully transparent. On standing exposed to the air, however, it becomes of a yellowish-green color, very perceptible in a white pitcher, or even in a white glass bottle. This color deepens on

*Associated with the water thus obtained by boring, in our blue limestone, is sometimes found a large quantity of light carburetted hydrogen gas. One remarkable instance occurred in Franklin county, at the mills of the Messrs. Steadman, where, as I am informed, this gas, in large quantities is poured out from the boring; the stream lasting for some time and perhaps existing at the present moment. The origin of this gas in the coal formations, where it is more abundant, is doubtless from the vegetable matters which formed the coal, but in this formation it is more difficult to explain. Unless we suppose it to be derived, like the fluid bitumen sometimes discovered in this rock, from the decomposition of the marine, vegetable, and animal remains in the strata, no other probable cause can be given for its production.

†These barrels will not contain more than twenty-five gallons.

boiling the water, but boiling does not cause it to appear in the recent water. This color, to which the spring probably owes its name of *Blue Licks*, is due to the decomposition of some of the dissolved ingredients. On exposure to the air, the hydrogen, of the sulphuretted hydrogen, becomes converted into water by combining with oxygen from the atmosphere, while the sulphur, with the trace of iron, &c., are deposited as a light yellowish-green precipitate; at the same time, in consequence of the escape of some of the free carbonic acid, carbonate of lime is thrown down, which mixes with the sulphur precipitate. The minute portion of iron which exists in the recent water, probably as carbonate of the protoxide, losing its carbonic acid and oxygen, becomes a sulphuret by taking some of the sulphur of the decomposed sulphuretted hydrogen, and gives the greenish tinge to the water and its sediment.

In the water which has been bottled or brought in barrels* from the spring, this change of color and consequent deposition, occur a few hours after it has been brought in contact with the air by uncorking and withdrawing a portion out of the vessel. It changes in a marked manner in flavor owing to the decomposition of the sulphuretted hydrogen; and after a few days exposure loses all smell and taste of this gas; as might be expected from its decomposable nature. To preserve its virtues in exportation, therefore, it should be bottled like a sparkling wine and used as soon as it is opened. In this manner, if but little air be left in the neck of the bottle and the cork is very tight and secured by sealing wax, it may be preserved unchanged for a considerable time. In the spring and its channel this decomposition and escape of gas continually takes place, causing the formation of sediment. Less decomposition would probably take place in the spring were its basin smaller, so that the water would be more rapidly renewed and it would expose less surface to the air.

Some of the *sediment* collected from the bottom of the spring, was found by analysis to contain the following ingredients, viz:

- Sand, in considerable proportion;
- Carbonates of lime and magnesia;
- Sulphur;
- Oxide and sulphuret of iron;
- Alumina;
- A trace of oxide of manganese;
- Apocrenic acid;
- A trace of crenic acid.

All these ingredients, except the sand, which is probably brought out mechanically suspended, were doubtless dissolved in the recent water, and were deposited on its exposure to the air.

In addition to the gases, sulphuretted hydrogen and carbonic acid, which are thus gradually decomposed in the water, or which escape insensibly from its surface, streams of bubbles of gas are continually rising through the spring and breaking into the atmosphere. Some of this gas, carefully collected for me by Maj. Owen, in bottles prepared for the purpose, was submitted to analysis, and found to consist mainly of nitrogen, mixed with about 4.5 per cent. of carbonic acid gas, containing only a trace of sulphuretted hydrogen.

The analysis of the water was performed in the chemical laboratory of the Medical Department of Transylvania University, at Lexington, with the assistance of Mr. A. Schue, of the Western Military Institute, and required at least ten days constant labor. I will not give the detail of the various processes, as this would be uninteresting to the general reader. Let it suffice to say that the amount of free sulphuretted hydrogen and carbonic acid was ascertained by placing, by means of a proper pipette, a measured quantity of the recent water, at the spring, in bottles containing, severally, solution of arsenious acid in hydrochloric acid, and an ammoniacal solution of chloride of calcium. The precipitates in these bottles were examined in the laboratory, and the proportion of these gases accurately ascertained.

The estimation of the saline ingredients was made in the most careful manner, in some of the water which had been brought from the spring in tight glass-stoppered bottles. The quantity used in each estimation was not less than one thousand grains, and was sometimes as much as twelve thousand grains.

To estimate the bromine and iodine, a demijohn which would hold about one hundred pounds, was sent to the springs to be filled; intending to evaporate this quantity for the purpose, but by some accident it did not come to hand in time, and to avoid delay the estimation of these minute ingredients was made by operating on the residue obtained by evaporating $5\frac{1}{2}$ lbs, troy, of the water, all that was left, of two gallons, from the other experiments. The iodine was estimated as iodide of palladium, and the bromine, precipitated as bromide of silver was estimated by the *indirect* method, as described in the recent works on chemical analysis.

The proportions of the alkalies were also separately estimated. In consequence of the failure to obtain the carboy of water, the *separate* proportions of the alumina, phosphate of lime, and oxide or proto-carbonate of iron, were not made out; this, however, is a matter of minor importance.

The *composition* of the Blue Lick water, according to this analysis, is as follows: calculated both in 1000 grains of the water, and in the wine pint of 7,680 grains, viz:

	Specific gravity, - - - - -		1.007	
	<i>Gases in the 1000 Grains:</i>		<i>In the wine pint.</i>	
	Grains.	Cubic inch.	Grains.	Cubic inch.
Sulphuretted hydrogen gas,	0.03947	0.1086	0.303129	0.834048
Free carbonic acid gas,	0.3547	0.7600	2.724096	5.836800

The former is in the proportion of about 1.36th the volume of the water, and the latter about 1.5th the volume.

	<i>Saline Contents in the 1000 Grains:</i>		<i>In the wine pint.</i>	
	Grains.	Grains.	Grains.	Grains.
Carbonate of lime,	- - - - -	0.3850000	2.9568000	
Carbonate of Magnesia,	- - - - -	0.0022065	.0169459	
Alumina, phosphate of lime and oxide of iron,	- - - - -	0.0058330	0.0447974	
Chloride of sodium,	- - - - -	8.3472930	64.1072102	
Chloride of potassium,	- - - - -	0.0226690	0.1740979	
Chloride of magnesium,	- - - - -	0.5272000	4.0488960	
Bromide of magnesium,	- - - - -	0.0039394	0.0302546	
Iodine of magnesium,	- - - - -	0.0007340	0.0056371	
Sulphate of lime,	- - - - -	0.5533300	4.2495744	
Sulphate of potash,	- - - - -	0.1519190	1.1166738	
Silicic acid,	- - - - -	0.0179400	0.1377792	
Loss,	- - - - -	0.2819861	2.2158335	
		10.3000000	79.1040000	

The water also contains traces of oxide of manganese, and apocrenic and crenic acids.*

As it respects the medicinal virtues of this water, it is not necessary for me to say much. Knowing the nature and proportions of the ingredients, any well educated physician will understand its medicinal virtues and applications. It is undoubtedly a highly valuable saline sulphur water, and consequently acts as a nervous stimulant, diaphoretic, diuretic and emmenagogue; proving purgative only to some persons. Such waters are described by authors to be useful in chronic disorders of the liver, dyspepsia, chronic cutaneous diseases, chronic rheumatism and gout, secondary syphilis, dismenorrhœa, &c., &c.; and this water would doubtless be valuable in some scrofulous affections, more especially from the iodine and bromine which it contains.

The discovery of these ingredients in this water is a matter of great interest in a medical point of view. Although they exist in it in very small proportions, yet experience has demonstrated that they are

*The quantity of saline and other matters brought out from the interior by this and other similar springs is immense, and sets at defiance all efforts to find out their source.

Taking the data above given as to the quantity of water which flows out at this spring, we find that it emits 678 gallons per hour, equal to 26,272 gallons in the day of twenty-four hours. Supposing the saline matters to constitute but one per cent. of the water, the amount brought out in one hour would be more than 58 lbs, avoirdupois. But say that 50 lbs an hour is the proportion, and the quantity will amount to 438,000 lbs per annum. The specific gravity of common salt being 2.257, this quantity in a solid lump would contain about 310 cubic feet, or be enough to form a cube of salt nearly 7 feet on a side! And yet the water flows on without any sensible diminution of its saltiness. Whence is all this saline matter obtained.

in sufficient amount to be active when the use of the water is continued for a length of time, in the quantities usually drank at the springs.

The use of the water as a bath, is a valuable adjuvant to its internal use in many cases. Its application to the cure of disease should, however, always be made under the directions of a physician."

It is not necessary to add any thing to these remarks at present.

OLDHAM COUNTY.

No. 734—SOIL. Labeled "*Virgin soil, woodland pasture, Mr. A. Hawley's farm, adjoining the field from which the cultivated soil was collected. Primitive forest growth, beech, sugar-tree, walnut, poplar, hickory, and large burr oak. Favistella bed, junction of the Upper and Lower Silurian formations. Oldham county, Kentucky.*"

Color of the dried soil dark buff-grey. Washed with water it left 83. per cent. of sand, &c., of which all but 1.30 per cent. was fine enough to pass through the finest bolting-cloth. This coarser portion consisted of very small rounded ferruginous particles, with a few of quartzose.

One thousand grains of the air-dried soil, digested for a month in water charged with carbonic acid, gave up *more than two grains of light brownish-grey extract*, dried at 212° F., which had the following composition, viz:

	Grains.
Organic and volatile matters, - - - - -	0.677
Alumina, oxides of iron and manganese, and phosphates, - - -	.113
Carbonate of lime, - - - - -	.557
Magnesia, - - - - -	.133
Sulphuric acid, - - - - -	.253
Potash, - - - - -	.091
Soda, - - - - -	.014
Silica, - - - - -	.164
Loss, - - - - -	.098
	2.100

The air-dried soil lost 3.00 per cent. of moisture at 400° F.; dried at which temperature it has the following composition:

Organic and volatile matters, - - - - -	4.778
Alumina, - - - - -	2.214
Oxide of iron, - - - - -	2.240
Carbonate of lime, - - - - -	.340
Magnesia, - - - - -	.328
Brown oxide of manganese, - - - - -	.172
Phosphoric acid, - - - - -	.251
Sulphuric acid, - - - - -	.067
Potash, - - - - -	.125
Soda, - - - - -	.027
Sand and insoluble silicates, - - - - -	89.420
Loss, - - - - -	.038
	100.000

No. 735—SOIL. Labeled "*Soil twenty years in cultivation; Mr. A. Hawley's farm. Astrea favosites beds; junction of the Upper and Lower Silurian formations. Oldham county, Kentucky.*"

Color of the dried soil lighter than that of the last. Washed with water it left 76.9 per cent. of fine sand, &c., of which all but 1.37 per cent. was fine enough to pass through the finest bolting-cloth. This portion consisted of very small particles of ferruginous mineral, with very few of quartzose.

One thousand grains of the air-dried soil, digested for a month in water charged with carbonic acid, gave up *rather more than a grain and a half of umber-brown extract*, dried at 212° F., which has the following composition, viz:

	Grains.
Organic and volatile matters, - - - - -	0.340
Alumina, oxides of iron and manganese, and phosphates, - - -	.063
Carbonate of lime, - - - - -	.700
Magnesia, - - - - -	.100
Sulphuric acid, - - - - -	.062
Potash, - - - - -	.069
Soda, - - - - -	.016
Silica, - - - - -	.197
	1.547

The air-dried soil lost 2.20 per cent. of moisture at 400° F.; dried at which temperature it has the following composition:

Organic and volatile matters,	3.001
Alumina,	2.270
Oxide of iron,	2.020
Carbonate of lime,	.170
Magnesia,	.275
Brown oxide of manganese,	.145
Phosphoric acid,	.128
Sulphuric acid,	.076
Potash,	.111
Soda,	.039
Sand and insoluble silicates,	91.295
Loss,	.470
	100.000

No. 736—SUB-SOIL. Labeled "Sub-soil from the field twenty years in cultivation. Mr. A. Hawley's farm, Oldham county, Kentucky."

Color of the dried sub-soil, which was in cloddy lumps, is grey-buff. Washed with water it left 72.43 per cent. of fine sand, &c., of which all but 2.83 per cent. was fine enough to pass through the finest bolting-cloth. This portion consisted of rounded reddish ferruginous particles, with a few quartzose.

One thousand grains of the air-dried sub-soil, digested for a month in water charged with carbonic acid, gave up *nearly a grain and a half of light brownish-grey extract*, dried at 212° F., which had the following composition, viz:

	Grains.
Organic and volatile matters,	0.420
Alumina, oxides of iron and manganese, and phosphates,	.063
Carbonate of lime,	.263
Magnesia,	.090
Sulphuric acid,	.053
Potash,	.085
Soda,	.002
Silica,	.261
	1.237

The air-dried sub-soil lost 2.575 per cent. of moisture at 400° F.; dried at which temperature it has the following composition:

Organic and volatile matters,	2.643
Alumina,	3.355
Oxide of iron,	2.540
Carbonate of lime,	.125
Magnesia,	.365
Brown oxide of manganese,	.145
Phosphoric acid,	.112
Sulphuric acid,	.050
Potash,	.130
Soda, a trace.	
Sand and insoluble silicates,	89.620
Loss,	.715
	100.000

The *sub-soil* does not differ much in composition from the surface soil. The soil of the old field shows the usual evidences of deterioration by cultivation.

No. 737—SOIL. Labeled "Ashy white soil, one mile north-east of Lagrange, in a hollow; derived from a mudstone, near the base of the Upper Silurian formation, under the magnesian limestone. Oldham county, Kentucky."

The dried soil is of a light yellowish-grey color. The coarse seive removed from it some small cherty fragments. Washed with water, it left 75.10 per cent. of fine sand, &c., of which all but 2.77 per cent. passed through the finest bolting-cloth. This coarser portion consisted of hard rounded particles of a ferruginous mineral, with a few clear grains and crystals of quartz and particles of chert.

One thousand grains of the air-dried soil, digested for a month in water containing carbonic acid, gave up *a little more than three grains of light-buff extract*, dried at 212° F., which had the following composition, viz:

	Grains.
Organic and volatile matters,	0.800
Alumina, oxides of iron and manganese, and phosphates,	.597
Carbonate of lime,	1.117
Magnesia,	.209
Sulphuric acid,	.039

Potash,	.061
Soda,	.045
Silica,	.226
Loss,	.006
	3.100

The air-dried soil lost 1.475 per cent. of moisture at 400° F.; dried at which temperature it has the following composition:

Organic and volatile matters,	2.537
Alumina,	1.120
Oxide of iron,	2.265
Carbonate of lime,	.239
Magnesia,	.233
Brown oxide of manganese,	.072
Phosphoric acid,	.107
Sulphuric acid,	.079
Potash,	.075
Soda,	.056
Silica,	92.746
Loss,	.112
	100.000

Rather a poor soil.

OWEN COUNTY.

No. 738—SOIL. Labeled "Virgin soil, from Green Threlkeld's farm, four miles from Owenton. Primitive forest growth, beech, oak, and poplar. Lower Silurian formation. Owen county, Kentucky."

Dried soil of a dark greyish-buff color. Washed with water it left 76.5 per cent. of fine sand, &c., of which all but 3.73 per cent. passed through the bolting-cloth. This coarser portion consisted of small rounded ferruginous particles, with very few quartzose grains.

One thousand grains of the air-dried soil, digested for a month in water containing carbonic acid, gave up nearly two grains of yellowish-brown extract, dried at 212° F., which had the following composition, viz:

	Grains.
Organic and volatile matters,	0.450
Alumina, oxides of iron and manganese, and phosphates,	.237
Carbonate of lime,	.763
Magnesia,	.061
Sulphuric acid,	.022
Potash,	.082
Soda,	.021
Silica,	.168
Loss,	.046
	1.850

The air-dried soil lost 3.225 per cent. of moisture, at 400° F., dried at which temperature it has the following composition:

Organic and volatile matters,	3.978
Alumina,	3.970
Oxide of iron,	3.290
Carbonate of lime,	.180
Magnesia,	.444
Brown oxide of manganese,	.335
Phosphoric acid,	.179
Sulphuric acid,	.054
Potash,	.256
Soda,	.024
Sand and insoluble silicates,	87.195
Loss,	.095
	100.000

No. 739—SOIL. Labeled "Same soil, from an old field forty years in cultivation; never manured; now in grass; Green Threlkeld's farm, four miles from Owenton, &c. Owen county, Kentucky."

The dried soil is in cloddy lumps of a dark grey-buff color; a little lighter than that of the virgin soil. Washed with water it left 76.00 per cent. of fine sand, &c., of which all but 3.40 per cent. passed through the fine bolting-cloth. This coarser portion consisted of small rounded ferruginous particles with a few quartzose grains.

One thousand grains of the air-dried soil, digested for a month in water charged with carbonic acid, gave up less than one grain of greyish-brown extract, dried at 212° F., which had the following composition, viz:

	Grains.
Organic and volatile matters, - - - - -	0.370
Alumina, oxides of iron and manganese, and phosphates, - - -	.080
Carbonate of lime, - - - - -	.347
Magnesia, - - - - -	.026
Sulphuric acid, - - - - -	.022
Potash, - - - - -	.079
Soda, - - - - -	.012
Silica, - - - - -	.013
Loss, - - - - -	.031
	0.980

The air-dried soil lost 3.25 per cent. of moisture at 400° F.; dried at which temperature it has the following composition:

Organic and volatile matters, - - - - -	3.256
Alumina, - - - - -	3.995
Oxide of iron, - - - - -	3.290
Carbonate of lime, - - - - -	.145
Magnesia, - - - - -	.388
Brown oxide of manganese, - - - - -	.180
Phosphoric acid, - - - - -	.163
Sulphuric acid, - - - - -	.050
Potash, - - - - -	.179
Soda, - - - - -	.017
Sand and insoluble silicates, - - - - -	88.170
Loss, - - - - -	.167
	100.000

No. 740—SUB-SOIL. Labeled "*Sub-soil from the same old field; Green Threlkeld's farm, four miles from Owenton, &c., &c. Owen county, Kentucky.*"

Color of the dried sub-soil rather more reddish than that of the two preceding soils. Washed with water it left 71.86 per cent. of fine sand, &c., of which all but 2.60 per cent. passed through the fine bolting-cloth. This coarser portion consisted of small rounded particles of ferruginous matter.

One thousand grains of the air-dried soil, digested for a month in water charged with carbonic acid, gave up *about a grain and a half of greyish-brown extract*, dried at 212° F., which had the following composition, viz:

	Grains.
Organic and volatile matters, - - - - -	0.317
Alumina, oxides of iron, and phosphates, - - - - -	.063
Carbonate of lime, - - - - -	.570
Magnesia, - - - - -	.013
Brown oxide of manganese, - - - - -	.080
Sulphuric acid, - - - - -	.033
Potash, - - - - -	.122
Soda, - - - - -	.056
Silica, - - - - -	.247
	1.501

The air-dried soil lost 3.05 per cent. of moisture at 400° F.; dried at which temperature it had the following composition:

Organic and volatile matters, - - - - -	3.146
Alumina, - - - - -	4.343
Oxide of iron, - - - - -	3.515
Carbonate of lime, - - - - -	.195
Magnesia, - - - - -	.441
Brown oxide of manganese, - - - - -	.265
Phosphoric acid, - - - - -	.163
Sulphuric acid, - - - - -	.044
Potash, - - - - -	.262
Soda, - - - - -	.006
Sand and insoluble silicates, - - - - -	87.380
Loss, - - - - -	.240
	100.000

The sub-soil is not richer than the original surface-soil. The soil of the old field shows the usual evidence of the gradual loss of its essential elements, by cultivation without the return of manures. The sub-soil is richer in potash and lime than the surface-soil.

No. 741—SANDSTONE. Labeled "*Argillaceous sandstone; near Benj. Hardin's; Owen county, Kentucky. Lower Silurian formation.*"

A dirty-buff, dull-looking sandstone; adhering somewhat to the tongue.

Composition, dried at 212° F.—

Alumina,	1.280
Oxide of iron,	5.040
Carbonate of lime,	1.193
Magnesia,	1.600
Brown oxide of manganese,	.240
Phosphoric acid,	.860
Sulphuric acid,	.184
Potash,	.602
Soda,	.212
Silex and insoluble silicates,	88.090
Water and loss,	.699
	100.000

Contains large proportions of phosphoric acid, potash, and lime.

No. 742—LIMESTONE. Labeled "*Nucula (sp?) bed; headwaters of Cedar creek; near Harmony, Owen county, Kentucky.*" Lower Silurian formation."

A dull, grey, granular limestone, full of fossil shells, which are of a lighter color than the body of the stone, which is also dotted with small ochreous spots.

Composition, dried at 212° F.—

Carbonate of lime,	92.920 = 52.139 per cent. of Lime.
Carbonate of magnesia,	.559
Alumina, and oxides of iron and manganese,	3.580
Phosphoric acid,	.349
Sulphuric acid,	.338
Potash,	.162
Soda,	.160
Silex and insoluble silicates,	1.720
Loss,	.212

100.000

Like most of the Lower Silurian limestones, this is rich in phosphoric acid, sulphuric acid, and the alkalis, &c., &c.

PENDLETON COUNTY.

No. 743—SOIL. Labeled "*Virgin soil from Wm. Ellis' land, six and a half miles north of Falmouth. Primitive forest growth large white and red oak, sugar-tree, black walnut, hickory, some black locust, and wild cherry. Under-growth small oaks. Lower Silurian formation. Pendleton county, Kentucky.*"

Dried soil of a dark grey-buff color. Washed with water it left 78.17 per cent. of fine sand, &c., of which all but 1.37 per cent. passed through the finest bolting-cloth. This coarser portion was composed of rounded ferruginous particles, with a few of clear and yellow quartz.

One thousand grains of the air-dried soil, digested for a month in water charged with carbonic acid, gave up *nearly three and a half grains of chestnut-brown extract*, dried at 212° F., which had the following composition:

	Grains.
Organic and volatile matters,	1.370
Alumina, oxides of iron and manganese, and phosphates,	.430
Carbonate of lime,	1.080
Magnesia,	.083
Sulphuric acid,	.051
Potash,	.031
Soda,	.145
Silica,	.164
	3.354

The air-dried soil lost 2.45 per cent. of moisture, at 400° F.; dried at which temperature it has the following composition viz:

Organic and volatile matters,	4.766
Alumina,	2.290
Oxide of iron,	2.685
Carbonate of lime,	.296
Magnesia,	.157
Brown oxide of manganese,	.145
Phosphoric acid,	.227
Sulphuric acid,	.107

Potash,	.207
Soda,	.078
Sand and insoluble silicates,	88.010
Loss,	.032
	100.000

No. 744—SOIL. Labeled "Soil from a field forty to fifty years in cultivation; Wm. Ellis' farm, six and a half miles north of Falmouth, &c., &c. Pendleton county, Kentucky."

Dried soil of a grey-buff color, rather lighter than that of the last. Washed with water it gave up 82.30 per cent. of fine sand, of which all but 1.53 per cent. passed through the finest bolting-cloth. This coarser portion consisted of rounded ferruginous particles principally.

One thousand grains of the air-dried soil, digested for a month in water containing carbonic acid, gave up a little more than two and a half grains of dark-brown extract, dried at 212° F.; which had the following composition, viz:

	Grains.
Organic and volatile matters,	1.240
Alumina, oxides of iron and manganese, and phosphates,	.480
Carbonate of lime,	.430
Magnesia,	.059
Sulphuric acid,	.131
Potash,	.058
Soda,	.074
Silica,	.177
	2.649

The air-dried soil lost 2.675 per cent. of moisture, at 400° F.; dried at which temperature it has the following composition:

Organic and volatile matters,	4.906
Alumina,	2.565
Oxide of iron,	2.510
Carbonate of lime,	.275
Magnesia,	.341
Brown oxide of manganese,	.145
Phosphoric acid,	.178
Sulphuric acid,	.055

Potash,	.140
Soda,	.037
Sand and insoluble silicates,	88.570
Loss,	.278
	100.000

No. 745—SUB-SOIL. Labeled "Sub-soil from Wm. Ellis' old field, forty to fifty years in cultivation, &c., &c. Pendleton county, Kentucky." (See preceding analyses.)

The air-dried sub-soil is of a greyish-buff color, more yellowish than that of the preceding soils. Washed with water it left 69.73 per cent. of fine sand, &c., of which all but 1.77 per cent. was fine enough to go through the finest bolting-cloth. This coarser portion is composed of small rounded ferruginous particles, with a very few of quartzose.

One thousand grains of the air-dried soil, digested for a month in water containing carbonic acid, gave up a little more than two grains of grey-buff extract, dried at 212° F., which had the following composition, viz:

	Grains.
Organic and volatile matters,	1.017
Alumina, oxides of iron and manganese, and phosphates,	.430
Carbonate of lime,	.347
Magnesia,	.083
Sulphuric acid,	.033
Potash,	.055
Soda,	.054
Silica,	.164
	2.183

The air-dried soil, lost 2.45 per cent. of moisture at 400° F., dried at which temperature it has the following composition:

Organic and volatile matters,	3.459
Alumina,	3.500
Oxide of iron,	3.200
Carbonate of lime,	.162
Magnesia,	.685
Brown oxide of manganese,	.146
Phosphoric acid,	.135
Sulphuric acid,	.090

Potash, - - - - -	.188
Soda, - - - - -	.068
Sand and insoluble silicates, - - - - -	88.010
Loss, - - - - -	.298
	100.000

The sub-soil is not richer than the soil of the surface.

ROWAN COUNTY.

No. 746—LIMONITE, (IMPURE.) *Labeled "Iron ore, from Mr. Smedley's land, on the dividing ridge between Triplett creek and the north fork of Licking. On the surface of the ground, four miles from the railroad line. Rowan county, Kentucky. (Brought by Mr. Crow.)"*

A portion of a thin layer of a purple-brown color; dense and hard; and appearing under the lens, to be composed of rounded particles of silicious sand, united by a ferruginous cement.

Specific gravity, - - - - -	2.868
Composition, dried at 212° F.—	
Oxide of iron, - - - - -	26.68
Alumina, - - - - -	.98
Magnesia, - - - - -	.33
Brown oxide of manganese, - - - - -	.26
Sulphur, - - - - -	.05
Potash, - - - - -	.57
Combined water, - - - - -	2.80
Sand and insoluble silicates, - - - - -	68.92
	100.59

Too poor to be smelted alone for iron. It may be useful to mix with very rich ores which are deficient in silicious matter.

No. 747—LIMONITE. *Labeled "Iron ore, from S. Smedley's land, on the north fork of Licking river, about six miles from the railroad line. Picked up on the top of a ridge. Rowan county, Kentucky. (Brought by Mr. Crow.)"*

A dense, compact mineral, of a dark reddish-brown color, with irregular cavities, lined with ochreous ore, and containing adhering and embedded small, rounded pebbles of milky quartz.

Specific gravity, - - - - -	3.261
Composition, dried at 212° F.—	
Oxide of iron, - - - - -	56.14 = 39.31 per cent. of Iron.
Alumina, - - - - -	.96
Magnesia, - - - - -	.18
Brown oxide of manganese, - - - - -	.38
Potash, - - - - -	.21
Soda, - - - - -	.11
Combined water, - - - - -	8.64
Silex and insoluble silicates, - - - - -	31.78
Lime, phosphoric acid, &c. and loss, - - - - -	1.60
	100.00

A silicious ore, sufficiently rich to be profitably smelted.

SCOTT COUNTY.

No. 748—SOIL. *Labeled "Virgin soil, from woodland-pasture; James F. Robinson's farm, three quarters of a mile from Georgetown, on Elkhorn creek. Primitive forest growth, sugar-tree, white oak, black walnut, wild cherry, and black locust. Lower Silurian formation. Scott county, Kentucky."*

Dried soil of an umber color. Washed with water it left 86.03 per cent. of fine sand, &c., of which all but 6.53 per cent. passed through the finest bolting-cloth. This is composed of small rounded ferruginous particles, mostly soluble in hydrochloric acid.

One thousand grains of the air-dried soil, digested for a month in water containing carbonic acid, gave up more than six grains of orange-brown extract, dried at 212° F., which had the following composition:

	Grains.
Organic and volatile matters, - - - - -	1.540
Alumina, oxides of iron and manganese, and phosphates, - - - - -	.494
Carbonate of lime, - - - - -	3.663
Magnesia, - - - - -	.101
Sulphuric acid, - - - - -	.045
Potash, - - - - -	.071
Soda, - - - - -	.113
Silica, - - - - -	.087

6.114

The air-dried soil gave up 5.45 per cent. of *moisture* when dried at 400° F.; and had the following *composition*:

Organic and volatile matters,	9.042
Alumina,	5.015
Oxide of iron,	5.310
Carbonate of lime,	1.020
Magnesia,	.293
Brown oxide of manganese,	.565
Phosphoric acid,	.438
Sulphuric acid,	.141
Potash,	.214
Soda,	.106
Sand and insoluble silicates,	78.145
	100.289

No. 749—SOIL. Labeled "Same soil, from an old adjoining field, forty-five years or more in cultivation; now in wheat; James F. Robinson's farm, near Georgetown, Scott county, Kentucky, &c., &c."

Dried soil of a dirty-buff color, lighter colored than the preceding. Washed with water it left 76.13 per cent. of fine sand, &c., of which all but 5.87 per cent. passed through the finest bolting-cloth. This coarser portion consisted mainly of small rounded ferruginous particles, with a few of chert.

One thousand grains of the air-dried soil, digested for a month in water containing carbonic acid, gave up to it *about six and a half grains of brownish-yellow extract*, dried at 212° F., which had the following *composition*, viz:

	Grains.
Organic and volatile matters,	1.470
Alumina, oxides of iron and manganese, and phosphates,	.253
Carbonate of lime,	4.497
Magnesia,	.076
Sulphuric acid,	.045
Potash,	.058
Soda,	.049
Silica,	.130
	6.578

The air-dried soil lost 3.40 per cent. of *moisture* at 400° F.; dried at which temperature it has the following *composition*:

Organic and volatile matters,	5.197
Alumina,	5.425
Oxide of iron,	5.110
Carbonate of lime,	1.195
Magnesia,	.504
Brown oxide of manganese,	.502
Phosphoric acid,	.319
Sulphuric acid,	.179
Potash,	.197
Soda,	.125
Sand and insoluble silicates,	81.260
	100.013

No. 750—SUB-SOIL. Labeled "Sub-soil from the old field forty-five years or more in cultivation; James F. Robinson's farm, near Georgetown, Scott county, Kentucky, etc., etc."

The dried sub-soil is of a dirty-buff color; rather clearer in color than the preceding. The coarse sieve removed from it a few cherty fragments, (also an old rusty shingle nail and a percussion cap.) Washed with water it left 75.17 per cent. of fine sand, &c., of which all but 5.70 per cent. passed through the finest bolting-cloth. This coarser portion consisted of small rounded ferruginous particles, with very few of quartzose.

One thousand grains of the air-dried sub-soil, digested for a month in water charged with carbonic acid, gave up to it *about three and a half grains of grey extract*, dried at 212° F., which had the following *composition*, viz:

	Grains.
Organic and volatile matters,	0.550
Alumina, oxides of iron and manganese, and phosphates,	.230
Carbonate of lime,	2.383
Magnesia,	.139
Sulphuric acid,	.023
Potash,	.035
Soda,	.036
Silica,	.143
	3.599

The air-dried soil lost 3.415 per cent. of *moisture* at 400° F.; dried at which temperature it has the following *composition*:

Organic and volatile matters,	4.669
Alumina,	6.740
Oxide of iron,	5.735
Carbonate of lime,	.595
Magnesia,	.581
Brown oxide of manganese,	.397
Phosphoric acid,	.323
Sulphuric acid,	.136
Potash,	.183
Soda,	.031
Sand and insoluble silicates,	81.880
	101.270

The comparison, with each other, of the composition of these several fertile soils of the blue limestone formation, is highly interesting. It can be made in detail by any one who is interested in the subject. It will be seen in particular that a marked change has been produced, in the soil of the old field, by forty-five years of cultivation, most probably without manuring as is the general practice in Kentucky. The sub-soil is not as rich as the original virgin soil of the surface.

SHELBY COUNTY.

No. 751—MARL. Labeled "*Marl, associated with the Chætetes bed of the blue limestone of the Lower Silurian formation. Shelby county, Kentucky.*"

Friable lumps of a dirty-buff color. A little gritty under the teeth. Did not effervesce with hydrochloric acid.

Dried at 212° F., the air-dried marl lost 3.70 per cent. of moisture.

Composition dried at 212° F.—

Alumina, and oxides of iron and manganese,	13.130
Carbonate of lime,	1.290
Carbonate of magnesia,	.914
Phosphoric acid,	.284
Sulphuric acid,	.066
Potash,	.395
Soda,	.033
Sand and insoluble silicates,	80.690
Water, organic matter, and loss,	3.193

100.000

Not very rich in phosphoric and sulphuric acids and the alkalies, and containing only a moderate quantity of carbonate of lime. It is not much better than many specimens of the soil from this formation.

No. 752—SOIL. Labeled "*Virgin upland soil, from Addison Jesse's farm. Overlies the Chætetes and Leptæna beds of the blue limestone of the Lower Silurian formation. Primitive forest growth, principally beech, with some elm, oak, poplar, sugar-tree, and locust. Shelby county, Kentucky.*"

Dried soil of a grey-brown color. Washed with water it left 75.30 per cent. of fine sand, &c., of which all but 4.37 per cent. passed through the fine bolting-cloth. This coarser portion consisted principally of rounded ferruginous particles.

One thousand grains of the air-dried soil, digested for a month in water charged with carbonic acid, gave up more than two grains of brownish extract, dried at 212° F., which had the following composition:

	Grains.
Organic and volatile matters,	0.477
Alumina, oxides of iron and manganese, and phosphates,	.130
Carbonate of lime,	.714
Magnesia,	.166
Sulphuric acid,	.045
Potash,	.159
Soda,	.011
Silica,	.200
Loss,	.108
	2.010

The air-dried soil lost 3.565 per cent. of moisture, at 400° F.; dried at which temperature it has the following composition:

Organic and volatile matters,	4.648
Alumina,	2.895
Oxide of iron,	3.280
Carbonate of lime,	.320
Magnesia,	.406
Brown oxide of manganese,	.170
Phosphoric acid,	.249
Sulphuric acid,	.064

Potash,	.159
Soda,	.026
Sand and insoluble silicates,	87.220
Loss,	.563
	100.000

No. 753—SOIL. Labeled "Soil from a field which has been twenty-five years or more in cultivation; for ten years almost successively in corn; for the last six years in small grain, with clover and blue grass, in succession, to restore it. Addison Jessee's farm, &c., Shelby county, Kentucky."

Color of the dried soil like that of the preceding. Washed with water it left 75.63 per cent. of fine sand, &c., of which all but 3.80 per cent. passed through the finest bolting-cloth. This coarser portion consisted principally of small rounded ferruginous particles.

One thousand grains of the air-dried soil, digested for a month in water containing carbonic acid, gave up *nearly two grains of brownish extract*, dried at 212° F., which had the following composition, viz:

	Grains.
Organic and volatile matters,	0.486
Alumina, oxides of iron and manganese, and phosphates,	.213
Carbonate of lime,	.747
Magnesia,	.056
Sulphuric acid,	.048
Potash,	.085
Soda,	.045
Silica,	.171
	1.851

Dried at 400° F.; the air-dried soil lost 3.40 per cent. of moisture, and has the following composition:

Organic and volatile matters,	4.530
Alumina,	3.070
Oxide of iron,	3.190
Carbonate of lime,	.495
Magnesia,	.366
Brown oxide of manganese, a trace.	
Phosphoric acid,	.152
Sulphuric acid,	.050
Potash,	.128
Soda,	.051
Sand and insoluble silicates,	88.050
	100.055

No. 754—SUB-SOIL. Labeled "Sub-soil from the same field, twenty-five years in cultivation, &c., &c. Addison Jessee's farm, Shelby county, Kentucky."

Color of the dried sub-soil, like that of the preceding. Washed with water it left 73.80 per cent. of fine sand, &c., of which all but 0.63 per cent. was fine enough to pass through the fine bolting-cloth. This coarser portion consisted principally of small rounded ferruginous particles.

One thousand grains of the air-dried soil, digested for a month in water containing carbonic acid, gave up *more than one grain of light-brown extract*, dried at 212° F., which had the following composition, viz:

	Grains.
Organic and volatile matters,	0.280
Alumina, oxides of iron and manganese, and phosphates,	.120
Carbonate of lime,	.270
Magnesia,	.060
Sulphuric acid,	.120
Potash,	.070
Soda,	.020
Silica,	.177
	1.117

The air-dried soil lost 3.35 per cent. of moisture at 400° F.; dried at which temperature it has the following composition:

Organic and volatile matters,	3.336
Alumina,	3.174
Oxide of iron,	4.080
Carbonate of lime,	.235
Magnesia,	.354
Brown oxide of manganese,	.045
Phosphoric acid,	.196
Sulphuric acid,	.059
Potash,	.214
Soda,	.014
Sand and insoluble silicates,	88.445
	100.152

The effects of cultivation on the soil are made manifest by the analyses. The sub-soil is richer in potash than the virgin soil above, and also richer in phosphoric acid than the soil of the cultivated field.

No. 755—SOIL. Labeled "Virgin soil, from woods pasture, four and half miles from Shelbyville, on the Louisville turnpike; primitive forest growth, beech, white oak, and shell-bark hickory. Lower Silurian formation. Shelby county, Kentucky."

The dried soil is of a dark brownish-buff color. Washed with water it left 81.27 per cent. of fine sand, &c., of which all but 3.90 per cent. passed through the finest bolting-cloth. This coarser portion consisted mainly of small rounded ferruginous particles.

One thousand grains of the air-dried soil, digested for twenty days in water containing carbonic acid, gave up more than three grains of light-brown extract, dried at 212° F., which had the following composition, viz:

	Grains.
Organic and volatile matters,	0.650
Alumina, oxides of iron and manganese, and phosphates,	.322
Carbonate of lime,	1.813
Magnesia,	.072
Sulphuric acid,	.062
Potash,	.112
Soda,	.050
Silica,	.047
	3.128

The air-dried soil lost 3.575 per cent. of moisture, at 400° F., dried at which temperature it has the following composition:

Organic and volatile matters,	4.734
Alumina,	4.590
Oxide of iron,	3.585
Carbonate of lime,	.445
Magnesia,	.533
Brown oxide of manganese,	.270
Phosphoric acid,	.479
Sulphuric acid,	.128
Potash,	.120
Soda,	.097
Sand and insoluble silicates,	85.670
	100.651

No. 756—SOIL. Labeled "Soil from an old turned-out field; four and a half miles from Shelbyville, on the Louisville turnpike, &c, &c. Shelby county, Kentucky."

Color of the dried soil a very slight, but perceptible shade darker than of the preceding. Washed with water it left 77.50 per cent. of fine sand, of which all but 2.37 per cent. passed through the finest bolting-cloth. This coarser portion consisted of small rounded ferruginous particles.

One thousand grains of the air-dried soil, digested for twenty days in water charged with carbonic acid, gave up more than four grains of grey-brown extract, dried at 212° F., which had the following composition, viz:

	Grains.
Organic and volatile matters,	0.666
Alumina, oxides of iron and manganese, and phosphates,	.380
Carbonate of lime,	2.820
Magnesia,	.094
Sulphuric acid,	.062
Potash,	.133
Soda,	.070
Silica,	.074
	4.279

The air-dried soil lost 3.225 per cent. of moisture at 400° F.; dried at which temperature it has the following composition:

Organic and volatile matters,	4.970
Alumina,	4.115
Oxide of iron,	3.660
Carbonate of lime,	.546
Magnesia,	.497
Brown oxide of manganese,	.515
Phosphoric acid,	.259
Sulphuric acid,	.067
Potash,	.173
Soda,	.093
Sand and insoluble silicates,	84.970
Loss,	.135
	100.000

No. 757—SUB-SOIL. Labeled "Sub-soil from the same old turned-out field; four miles and a half from Shelbyville, on the Louisville turn-pike, &c., &c. Shelby county, Kentucky."

The air-dried soil is lighter and more yellowish colored than the preceding. Washed with water it left 77.93 per cent. of fine sand, &c., of which all but 2.40 per cent. was fine enough to pass through the finest bolting-cloth. This coarser portion consisted of small rounded ferruginous particles.

One thousand grains of the air-dried soil, digested for twenty days in water charged with carbonic acid, gave up *less than two grains of yellowish-grey extract*, dried at 212° F., which had the following composition:

Organic and volatile matters,	0.500
Alumina, oxides of iron and manganese, and phosphates,	.063
Carbonate of lime,	.753
Magnesia,	.027
Sulphuric acid,	.036
Potash,	.043
Soda,	.056
Silica,	.131
	1.614

The air-dried soil lost 2.925 per cent. of moisture at 400° F.; dried at which temperature it has the following composition:

Organic and volatile matters,	3.245
Alumina,	4.690
Oxide of iron,	3.865
Carbonate of lime,	.246
Magnesia,	.553
Brown oxide of manganese,	.395
Phosphoric acid,	.393
Sulphuric acid,	.050
Potash,	.208
Soda,	.051
Sand and insoluble silicates,	86.320
	100.021

The soil of the old turned-out field, contains rather more organic matter than that from the woods-pasture, as is indicated also by its slightly darker color. The proportions of carbonate of lime, of oxide of manganese, and of potash, are also larger than those in the so-called

virgin soil. It gives up also a larger amount of soluble extract to the water which is charged with carbonic acid; but it will be seen that the excess is due to a larger proportion of carbonate of lime only. The soil of the old field has less of sand and insoluble silicates than the virgin soil. As it regards phosphoric and sulphuric acids, however, the latter soil contains the larger proportions. But it is probable, from these analyses, that the soil of the old field, after its season of fallow, would now be as fertile and productive as that of the woodland pasture, if brought again into cultivation—more especially, if some phosphatic manure, as bone dust, with a little Plaster of Paris, be used as a top dressing to it. Super-phosphate of lime would perhaps be still better. The sub-soil is about as rich as the surface soil, being richer in potash than that; to which circumstance, and the admixture of some of the sub-soil with that of the surface, in the course of the former cultivation of this field, may probably be attributed the fact, that its soil contains more of that alkali than the virgin soil from the woods pasture in the neighborhood.

SPENCER COUNTY.

No. 758—SOIL. Labeled "Virgin soil, from George Beam's farm; primitive growth, mostly beech, with some ash and poplar. Blue limestone, of the Lower Silurian formation. Spencer county, Kentucky."

Color of the dried soil buff-grey. The coarse sieve removed from it a few cherty fragments. Washed with water, it left 69.66 per cent. of fine sand, &c., of which all but 15.30 per cent. passed through the fine bolting-cloth. This coarser portion consisted principally of rounded particles of ferruginous mineral, with some rounded and angular grains of chert and milky quartz.

One thousand grains of the air-dried soil, digested for a month in water containing carbonic acid, gave up *more than two grains and a half of yellowish-grey extract*, dried at 212° F., which had the following composition, viz:

Organic and volatile matters,	0.520
Alumina, oxide of iron, and phosphates,	.498
Carbonate of lime,	1.169
Magnesia,	.066
Brown oxide of manganese,	.258

Sulphuric acid,	.020
Potash,	.077
Soda,	.021
Silica,	.149
	2.798

The air-dried soil lost 3.35 per cent. of moisture at 400° F.; dried at which temperature it has the following composition:

Organic and volatile matters,	4.317
Alumina,	3.096
Oxide of iron,	2.590
Carbonate of lime,	.345
Magnesia,	.493
Brown oxide of manganese,	.515
Phosphoric acid,	.187
Sulphuric acid,	.059
Potash,	.236
Soda,	.014
Sand and insoluble silicates,	\$7.970
Loss,	.178
	100.000

No. 759—SOIL. Labeled "Soil from an old field fifty to sixty years in cultivation; generally in corn, oats, and clover; never manured; Geo. Beam's farm; Spencer county, Kentucky."

Dried soil of a dirty buff-grey color. The coarse sieve removed from it some fragments of ferruginous sandstone. Washed with water it left 63.51 per cent. of fine sand, of which all but 16.90 per cent. passed through the fine bolting-cloth. Thir coarser portion consisted principally of small rounded ferruginous particles, with a few rounded and angular grains of chert and milky quartz.

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

	Grains.
Organic and volatile matters,	0.440
Alumina, oxides of iron, and phosphates,	.348
Carbonate of lime,	.678
Magnesia,	.086
Brown oxide of manganese,	.059
Sulphuric acid,	.020
Potash,	.081
Soda,	.021
Silica,	.291
Loss,	.087
	2.111

The air-dried soil lost 2.425 per cent. of moisture, at 400° F., dried at which temperature it has the following composition, viz:

Organic and volatile matters,	2.973
Alumina,	2.496
Oxide of iron,	2.640
Carbonate of lime,	.245
Magnesia,	.241
Brown oxide of manganese,	.170
Phosphoric acid,	.144
Sulphuric acid,	.041
Potash,	.183
Soda,	.047
Sand and insoluble silicates,	90.095
Loss,	.725
	100.000

No. 760—SUB-SOIL. Labeled "Sub-soil from the same old field, fifty to sixty years in cultivation; Geo. Beam's farm, &c. Spencer county, Kentucky."

Dried sub-soil of grey-buff color. Washed with water it left 65.50 per cent. of fine sand, of which all but 1.40 per cent. passed through the fine bolting-cloth. This coarser portion consisted of small rounded ferruginous particles, with a few rounded and angular ones of milky and reddish quartz.

One thousand grains of the air-dried sub-soil, digested for a month in water charged with carbonic acid, gave up rather more than a grain of light yellowish-grey extract, dried at 212° F., which had the following composition, viz:

	Grains.
Organic and volatile matters, - - - - -	0.120
Alumina, oxides of iron and manganese, and phosphates, - - - - -	.058
Carbonate of lime, - - - - -	.558
Magnesia, - - - - -	.033
Sulphuric acid, - - - - -	.013
Potash, - - - - -	.067
Soda, - - - - -	.012
Silica, - - - - -	.139
Loss, - - - - -	.050
	1.050

The air-dried sub-soil gave up 3.075 per cent. of moisture at 400° F.; dried at which temperature it has the following composition:

Organic and volatile matters, - - - - -	2.347
Alumina, - - - - -	2.665
Oxide of iron, - - - - -	3.175
Carbonate of lime, - - - - -	.220
Magnesia, - - - - -	.454
Brown oxide of manganese, - - - - -	.164
Phosphoric acid, - - - - -	.106
Sulphuric acid, - - - - -	.062
Potash, - - - - -	.154
Soda, - - - - -	.030
Sand and insoluble silicates, - - - - -	90.320
Loss, - - - - -	.313
	100.000

The change of composition, produced by the cultivation of the soil of the old field, is shown in a marked manner by the analyses, and is apparently the greater because the sub-soil is not naturally as rich as the surface-soil, and has doubtless been mixed more or less with it in the operations of ploughing, &c.

No. 761—MARL. Labeled "Marl, interstratified with the blue limestone; near Taylorsville; Spencer county, Kentucky."

Bluish-grey, soft friable, irregular porous lumps. Effervesces with acids; very little grittiness under the teeth.

Dried at 212° F., it lost 1.40 per cent. of moisture.

Composition, dried at 212° F.—

Alumina, and oxides of iron and manganese, - - - - -	12.655
Carbonate of lime, - - - - -	5.890
Carbonate of magnesia, - - - - -	.979
Phosphoric acid, - - - - -	.123
Sulphuric acid, - - - - -	.485
Potash, - - - - -	.424
Soda, - - - - -	.148
Sand and insoluble silicates, - - - - -	76.040
Water, organic matter, and loss, - - - - -	3.256
	100.000

Like some of the blue limestone marls previously examined it contains considerable proportion of lime, potash, and sulphuric acid, but less of phosphoric acid than would be desirable in a marl. If not required to be carted to a great distance it might be advantageously used on exhausted land; especially with the addition of some phosphatic manure, as bone-dust, super-phosphate of lime or good guano.

TAYLOR COUNTY.

No. 762—SOIL. Labeled "Virgin soil; the fine mealy soil of the Knobs, derived from the sub-carboniferous ash-colored clays and washings from the fine-grained sandstone of the Knobs, one mile from Allen Garrett's house, in the north-eastern part of Taylor county, Kentucky."

Dried soil of a buff-grey color. Washed with water it left 87.10 per cent. of fine sand, &c., of which all but 5.03 per cent. passed through the fine bolting-cloth. This coarser portion consisted principally of rounded ferruginous particles, with small clear quartz crystals, and rounded grains of chert and reddish quartz.

One thousand grains of the air-dried soil, digested for a month in water charged with carbonic acid, gave up more than five grains of nearly black extract, dried at 212° F., which had the following composition, viz:

	Grains.
Organic and volatile matters, - - - - -	2.130
Alumina, oxides of iron and manganese, and phosphates, - - - - -	1.321
Carbonate of lime, - - - - -	1.047
Magnesia, - - - - -	.209

Sulphuric acid,	.027
Potash,	.125
Soda,	.043
Silica,	.143
	5.145

The air-dried soil lost 2.85 per cent. of moisture at 400° F.; dried at which temperature it has the following composition:

Organic and volatile matters,	7.075
Alumina,	3.765
Oxide of iron,	3.110
Carbonate of lime,	.172
Magnesia,	.435
Brown oxide of manganese,	.095
Phosphoric acid,	.146
Sulphuric acid,	.103
Potash,	.146
Soda,	.046
Sand and insoluble silicates,	85.345
	100.438

No. 763—SOIL. Labeled "Virgin soil from the woods on the sub-carboniferous limestone formation. Primitive forest growth, large oaks, &c.; four miles north of Campbellsville, Taylor county, Kentucky."

Dried soil of a dark buff-grey color. The coarse sieve removed from it some ferruginous and quartzose fragments. Washed with water it left 78.63 per cent. of fine sand, &c., of which all but 9.50 per cent. passed through the fine bolting-cloth. This coarser portion consisted of small fragments of fossils and rounded ferruginous and quartzose particles.

One thousand grains of the air-dried soil, digested for a month in water charged with carbonic acid, gave up more than four and a half grains of dark-brown extract, dried at 212° F., which had the following composition, viz:

	Grains.
Organic and volatile matters,	2.370
Alumina, oxides of iron and manganese, and phosphates,	1.164
Carbonate of lime,	.713
Magnesia,	.157

Sulphuric acid,	.045
Potash,	.125
Soda,	.047
Silica,	.033
	4.654

The air-dried soil lost 2.425 per cent. of moisture at 400° F.; dried at which temperature it has the following composition:

Organic and volatile matters,	5.816
Alumina,	2.530
Oxide of iron,	2.910
Carbonate of lime,	.122
Magnesia,	.423
Brown oxide of manganese,	.120
Phosphoric acid,	.105
Sulphuric acid,	.067
Potash,	.125
Soda,	.052
Sand and insoluble silicates,	87.330
Loss,	.400
	100.000

Of these two soils, the first is slightly more fertile than the other.

TRIMBLE COUNTY.

No. 764—SOIL. Labeled "Virgin soil, Henry Tyris' farm, a quarter of a mile east of Bedford. Primitive forest growth, beech, poplar, white oak, hickory and blue ash. Over the magnesian, earthy and cherty beds of the Upper Silurian formation. Trimble county, Kentucky."

The dried soil is of a light buff-grey color. It is in a state of very fine division. Contains a little charcoal. Washed with water it left 73. per cent. of fine sand, &c., of which all but 1.10 per cent. passed through the finest bolting-cloth. This coarser portion consisted of small rounded quartzose grains, with a very few of hyaline quartz.

One thousand grains of the air-dried soil, digested for a month in water containing carbonic acid, left more than three grains of brown extract, dried at 212° F., which had the following composition, viz:

	Grains.
Organic and volatile matters, - - - - -	1.217
Alumina, oxides of iron and manganese, and phosphates, - - -	.714
Carbonate of lime, - - - - -	.963
Magnesia, - - - - -	.099
Sulphuric acid, - - - - -	.079
Potash, - - - - -	.047
Soda, - - - - -	.003
Silica, - - - - -	.260
	3.382

The air-dried soil lost 2.50 per cent. of moisture at 400° F.; dried at which temperature it has the following composition:

Organic and volatile matters, - - - - -	4.308
Alumina, - - - - -	2.530
Oxide of iron, - - - - -	1.990
Carbonate of lime, - - - - -	.320
Magnesia, - - - - -	.232
Brown oxide of manganese, - - - - -	.170
Phosphoric acid, - - - - -	.089
Sulphuric acid, - - - - -	.033
Potash, - - - - -	.213
Soda, - - - - -	.047
Sand and insoluble silicates, - - - - -	90.195
	100.127

No. 765—SOIL. Labeled "Soil from an old field, Henry Tyris' farm; (same locality as the last;) forty to fifty years in cultivation; now lying waste, and has been for several years. Trimble county, Kentucky."

Dried soil darker colored than the preceding; (grey-ochreous; like a sub-soil.) A few fragments of chert, quartz, and ferruginous mineral were removed from it by the coarse sieve. Washed with water it left 80.07 per cent. of *fine sand*, &c., of which all but 2.87 per cent. passed through the finest bolting-cloth. This coarser portion consisted of dull rounded particles of ferruginous mineral, with very few of clear and yellow quartz.

One thousand grains of the air-dried soil, digested for a month in water charged with carbonic acid, gave up *nearly two and a half grains*

of *buff extract*, dried at 212° F., which had the following composition, viz:

	Grains.
Organic and volatile matters, - - - - -	0.670
Alumina, oxides of iron and manganese, and phosphates, - - -	.331
Carbonate of lime, - - - - -	.873
Magnesia, - - - - -	.143
Sulphuric acid, - - - - -	.119
Potash, - - - - -	.059
Soda, - - - - -	.040
Silica, - - - - -	.200
Loss, - - - - -	.064
	2.490

The air-dried soil lost 2.45 per cent. of moisture at 400° F.; dried at which temperature it has the following composition:

Organic and volatile matters, - - - - -	3.434
Alumina, - - - - -	2.995
Oxide of iron, - - - - -	2.890
Carbonate of lime, - - - - -	.220
Magnesia, - - - - -	.291
Brown oxide of manganese, - - - - -	.170
Phosphoric acid, - - - - -	.096
Sulphuric acid, - - - - -	.020
Potash, - - - - -	.152
Soda, - - - - -	.049
Sand and insoluble silicates, - - - - -	89.920
	100.237

No. 766—SUB-SOIL. Labeled "Sub-soil from the same old field, forty to fifty years in cultivation, &c., &c. Trimble county, Kentucky."

Dried soil lighter colored than the preceding, (slightly lighter than No. 764, and not so yellowish as No. 765, which looks more like a sub-soil than this does.) The coarse sieve removed from it some small angular fragments of ferruginous sandstone. Washed with water it left 75.53 per cent. of *fine sand*, &c., of which all but 2.83 per cent. was fine enough to go through the finest bolting-cloth. This portion consisted mainly of dull, rounded ferruginous particles, with a few of hyaline quartz.

One thousand grains of the air-dried sub-soil, digested for a month in water charged with carbonic acid, gave up *more than three grains of light-buff extract*, dried at 212° F., which had the following composition, viz:

Organic and volatile matters,	0.660
Alumina, oxides of iron and manganese, and phosphates,	.403
Carbonate of lime,	1.530
Magnesia,	.090
Sulphuric acid,	.071
Potash,	.041
Soda,	.027
Silica,	.207

3.029

The air-dried sub-soil gave up 2.425 per cent. of moisture at 400° F., dried at which temperature it has the following composition:

Organic and volatile matters,	3.136
Alumina,	3.470
Oxide of iron,	2.640
Carbonate of lime,	.170
Magnesia,	.294
Brown oxide of manganese,	.245
Phosphoric acid,	.079
Sulphuric acid,	.015
Potash,	.181
Soda,	.028
Sand and insoluble silicates,	90.160

100.418

UNION COUNTY.

No. 767—SOIL. Labeled "Soil from Casey's creek, on the east side of the road; Murray's farm. Coal Measures. Union county, Kentucky."

Dried soil mouse-colored. Washed with water it left 82.97 per cent. of fine sand, &c., of which all but 1.80 per cent. passed through the finest bolting-cloth. This coarser portion is principally small rounded ferruginous particles.

One thousand grains of the air-dried soil, digested for a month in water charged with carbonic acid, gave up *nearly two grains of yellowish-grey extract*, dried at 112° F., which had the following composition:

Grains.

Organic and volatile matters,	0.617
Alumina, oxides of iron and manganese, and phosphates,	.200
Carbonate of lime,	.730
Magnesia,	.123
Sulphuric acid,	.053
Potash,	.033
Soda,	.055
Silica,	.117

1.928

The air-dried soil lost 3.50 per cent. of moisture, at 400° F.; dried at which temperature it has the following composition viz:

Organic and volatile matters,	3.720
Alumina,	3.465
Oxide of iron,	2.920
Carbonate of lime,	.624
Magnesia,	.630
Brown oxide of manganese,	.950
Phosphoric acid,	.196
Sulphuric acid,	.067
Potash,	.133
Soda,	.104
Sand and insoluble silicates,	87.510

100.319

No. 768—SUB-SOIL. Labeled "Sub-soil or clay, near the salt wells, on the Bald Hill fault; Holland Lick. Coal Measures. Union county, Kentucky."

Dried sub-soil of a dark buff-grey color.

Dried at 212° F., it lost 1.30 per cent. of moisture and had the following composition:

Organic and volatile matters,	2.309
Alumina, oxides of iron and manganese, and phosphates,	3.910
Carbonate of lime,	.590
Magnesia,	.466
Sulphuric acid,	.124
Chlorine,	.080

Potash,	-	-	-	-	-	-	-	-	-	.188
Soda,	-	-	-	-	-	-	-	-	-	.213
Sand and insoluble silicates,	-	-	-	-	-	-	-	-	-	92.120
										100.000

No. 769—SOIL. *Labeled "Soil from remarkable flat, post-oak glades. Coal Measures. Union county, Kentucky."*

Soil of a light grey-buff color. In cloddy lumps. Sifted out, with the coarse seive, some rounded ferruginous concretions of the size of a large white mustard seed and a small pebble of milky quartz. Washed with water it left 62.20 per cent. of fine sand, &c., of which all but 11.47 per cent. passed through the fine bolting-cloth. This coarser portion consisted of rounded ferruginous particles, with some of hyaline, milky, and red quartz.

One thousand grains of the air-dried soil, digested for twenty days in water charged with carbonic acid, gave up *less than a grain of yellowish-grey extract*, dried at 212° F., which had the following composition, viz:

	Grains.
Organic and volatile matters,	0.333
Alumina, oxides of iron and manganese, and phosphates,	.190
Carbonate of lime,	.039
Magnesia,	.064
Sulphuric acid,	.016
Potash,	.037
Soda,	.056
Silica,	.131
	0.866

The air-dried soil, lost 3.50 per cent. of moisture at 400° F., dried at which temperature it has the following composition:

Organic and volatile matters,	3.333
Alumina,	4.290
Oxide of iron,	5.365
Carbonate of lime, a trace,	
Magnesia,	.541
Brown oxide of manganese,	.495
Phosphoric acid,	.162
Sulphuric acid,	.076

Potash,	-	-	-	-	-	-	-	-	-	.231
Soda,	-	-	-	-	-	-	-	-	-	.111
Sand and insoluble silicates,	-	-	-	-	-	-	-	-	-	85.330
Loss,	-	-	-	-	-	-	-	-	-	.066
										100.000

The soil, being remarkably deficient in lime, would no doubt be much benefited by its application, or that of calcareous marl.

WASHINGTON COUNTY.

No. 770—SOIL. *Labeled "Virgin soil, from woods, on the Spirifer, Orthis and Leptaena beds of the blue limestone of the Lower Silurian formation. Stephen C. Brown's farm, Pleasant Grove settlement. Primitive forest growth, large yellow poplar and beech. Washington county, Kentucky."*

Dried soil of a yellowish, light-umber color. Washed with water it left 85.83 per cent. of fine sand, &c., of which all but 3.97 per cent. passed through the fine bolting-cloth. This coarser portion consisted of rounded ferruginous particles

One thousand grains of the air-dried soil, digested for a month in water containing carbonic acid, gave up *more than six and a half grains of brown extract*, dried at 212° F., which had the following composition:

Organic and volatile matters,	1.550
Alumina, oxides of iron and manganese, and phosphates,	1.310
Carbonate of lime,	3.347
Magnesia,	.143
Sulphuric acid,	.033
Potash,	.203
Soda,	.033
Silica,	.131
	6.750

The air-dried soil lost 5.05 per cent. of moisture at 400° F.; dried at which temperature it has the following composition:

Organic and volatile matters,	7.753
Alumina,	3.790
Oxide of iron,	3.930
Carbonate of lime,	.636
Magnesia,	.333
Brown oxide of manganese,	.495

Phosphoric acid, - - - - -	.488
Sulphuric acid, - - - - -	.084
Potash, - - - - -	.231
Soda, - - - - -	.030
Sand and insoluble silicates, - - - - -	82.190
Loss, - - - - -	.040
	100.000

No. 771—SOIL. Labeled "Same soil, from a field fifty years or more in cultivation, (a field cleared by Gen. Walton); Stephen C. Brown's farm. Pleasant Grove settlement, Washington county, Kentucky, &c."

Color of the dried soil somewhat lighter, and more buff, than that of the preceding. The coarse sieve removed from it a few fragments of ferruginous sandstone. Washed with water it left 79.23 per cent. of sand &c., of which all but 7.43 per cent. passed through the finest bolting-cloth. This portion consisted of small rounded ferruginous particles.

One thousand grains of the air-dried soil, digested for a month in water charged with carbonic acid, gave up more than three and a half grains of grey-buff extract, dried at 212° F.; which had the following composition, viz:

	Grains.
Organic and volatile matters, - - - - -	0.853
Alumina, oxides of iron and manganese, and phosphates, - - - - -	.253
Carbonate of lime, - - - - -	2.170
Magnesia, - - - - -	.090
Sulphuric acid, - - - - -	.027
Potash, - - - - -	.173
Soda, - - - - -	.023
Silica, - - - - -	.123
	3.712

The air-dried soil lost 3.555 per cent. of moisture, at 400° F.; dried at which temperature it had the following composition:

Organic and volatile matters, - - - - -	5.635
Alumina, - - - - -	4.515
Oxide of iron, - - - - -	4.146
Carbonate of lime, - - - - -	.396
Magnesia, - - - - -	.233
Brown oxide of manganese, - - - - -	.420

Phosphoric acid, - - - - -	.445
Sulphuric acid, - - - - -	.067
Potash, - - - - -	.191
Soda, - - - - -	.011
Sand and insoluble silicates, - - - - -	83.940
Loss, - - - - -	.002
	100.000

No. 772—SUB-SOIL. Labeled "Sub-soil from the same old field, fifty years or more in cultivation. Stephen C. Brown's farm, Pleasant Grove settlement, Washington county, Kentucky, &c."

Color of the dried sub-soil still more buff and lighter than the last. Washed with water it left 73.93 per cent. of fine sand, &c., of which all but 6.37 per cent. passed through the finest bolting-cloth. This coarser portion consisted of small rounded ferruginous particles.

One thousand grains of the air-dried sub-soil, digested for a month in water charged with carbonic acid, gave to it nearly two grains of light greyish-brown extract, dried at 212° F., which had the following composition:

	Grains.
Organic and volatile matters, - - - - -	0.383
Alumina, oxides of iron and manganese, and phosphates, - - - - -	.080
Carbonate of lime, - - - - -	1.130
Magnesia, - - - - -	.037
Sulphuric acid, - - - - -	.022
Potash, - - - - -	.035
Soda, - - - - -	.065
Silica, - - - - -	.113
	1.865

The air-dried sub-soil lost 3.45 per cent. of moisture at 400° F.; dried at which temperature it has the following composition:

Organic and volatile matters, - - - - -	3.340
Alumina, - - - - -	4.565
Oxide of iron, - - - - -	4.385
Carbonate of lime, - - - - -	.222
Magnesia, - - - - -	.308
Brown oxide of manganese, - - - - -	.345
Phosphoric acid, - - - - -	.346

Sulphuric acid, - - - - -	.042
Potash, - - - - -	.160
Soda, - - - - -	.038
Sand and insoluble silicates, - - - - -	86.175
Loss, - - - - -	.074
	100.000

The influence of the fifty years cultivation of the old field, is evidently shown in the above analyses, every ingredient of the soil having been diminished, except the alumina and oxide of iron, sand and insoluble silicates. The sub-soil is not as rich as the surface soil.

No. 773—SOIL. *Labeled "Virgin soil; Wm. Lynton's woods pasture, south-west side of Beech fork of Salt river. Lower Silurian formation. Washington county, Kentucky."*

Dried soil of a greyish-buff color. Washed with water it left 77.47 per cent. of fine sand, &c., of which all but 3.40 per cent. passed through the finest bolting-cloth. This coarser portion consists of small rounded ferruginous concretions, with a few of chert.

One thousand grains of the air-dried soil, digested for a month in water charged with carbonic acid, gave up *nearly four grains of reddish-brown extract*, dried at 212° F., which has the following *composition*, viz:

	Grains.
Organic and volatile matters, - - - - -	1.170
Alumina, oxides of iron and manganese, and phosphates, - - - - -	.650
Carbonate of lime, - - - - -	1.617
Magnesia, - - - - -	.094
Sulphuric acid, - - - - -	.045
Potash, - - - - -	.218
Soda, - - - - -	.040
Silica, - - - - -	.148
	3.982

The air-dried soil lost 3.30 per cent. of *moisture* at 400° F.; dried at which temperature it has the following *composition*:

Organic and volatile matters, - - - - -	4.576
Alumina, - - - - -	3.440
Oxide of iron, - - - - -	2.990
Carbonate of lime, - - - - -	.322
Magnesia, - - - - -	.388
Brown oxide of manganese, - - - - -	.170
Phosphoric acid, - - - - -	.198

Sulphuric acid, - - - - -	.067
Potash, - - - - -	.154
Soda, - - - - -	.021
Sand and insoluble silicates, - - - - -	87.410
Loss, - - - - -	.266
	100.000

No. 774—SOIL. *Labeled "Same soil, from an old field, fifty years in cultivation; Wm. Lynton's farm; south-west side of Beech fork of Salt river. Washington county, Kentucky, &c."*

Dried soil of a greyish-buff color lighter than that of the preceding. Washed out of it 69.07 per cent. of fine sand, &c., of which all but 5.43 per cent. passed through the finest bolting-cloth. This coarse portion consisted of small rounded ferruginous particles, with a few of chert.

One thousand grains of the air-dried soil, digested for a month in water charged with carbonic acid, gave up *less than three and a half grains of brownish extract*, dried at 212° F., which had the following *composition*, viz:

	Grains.
Organic and volatile matters, - - - - -	1.070
Alumina, oxides of iron and manganese, and phosphates, - - - - -	.497
Carbonate of lime, - - - - -	.387
Magnesia, - - - - -	.100
Sulphuric acid, - - - - -	.055
Potash, - - - - -	.034
Soda, - - - - -	.032
Silica, - - - - -	.131
	2.306

The air-dried soil lost 2.15 per cent. of *moisture*, at 400° F., dried at which temperature it has the following *composition*:

Organic and volatile matters, - - - - -	3.055
Alumina, - - - - -	3.015
Oxide of iron, - - - - -	3.390
Carbonate of lime, - - - - -	.222
Magnesia, - - - - -	.344
Brown oxide of manganese, - - - - -	.175
Phosphoric acid, - - - - -	.161
Sulphuric acid, - - - - -	.059

Potash,	.132
Soda,	.035
Sand and insoluble silicates,	89.070
Loss,	.342
	100.000

No. 775—SUB-SOIL. *Labeled "Sub-soil of the same old field, fifty years in cultivation; Wm. Lynton's farm, &c., &c. Washington county, Kentucky."*

Dried sub-soil of a greyish-buff color, lighter than that of the two preceding. Washed out of it 66.70 per cent. of fine sand, &c., of which all but 3.97 per cent. passed through the finest bolting-cloth. This coarser portion consisted principally of rounded ferruginous particles, with a few of chert.

One thousand grains of the air-dried sub-soil, digested for a month in water charged with carbonic acid, gave up *a little more than a grain and a half of grey-buff extract*, dried at 212° F., which had the following composition, viz:

	Grains.
Organic and volatile matters,	0.630
Alumina, oxides of iron and manganese, and phosphates,	.450
Carbonate of lime,	.187
Magnesia,	.066
Sulphuric acid,	.045
Potash,	.037
Soda,	.038
Silica,	.187
	1.640

The air-dried sub-soil lost 2.89 per cent. of *moisture* at 400° F.; dried at which temperature it has the following *composition*:

Organic and volatile matters,	2.894
Alumina,	3.565
Oxide of iron,	3.440
Carbonate of lime,	.145
Magnesia,	.443
Brown oxide of manganese,	.170
Phosphoric acid,	.129

Sulphuric acid,	.077
Potash,	.128
Soda,	.052
Sand and insoluble silicates,	89.020
	100.000

The remarks appended to the preceding set of soils apply pretty fully to these also.

WOODFORD COUNTY.

No. 776—LIMESTONE. *Labeled "Lowest rock in the bluff at Shryock's ferry; Kentucky river; Versailles road; Woodford county, Kentucky. Lower Silurian formation."*

A greyish drab-colored, fine granular limestone; homogeneous in structure; with no appearance of fossils in the specimen analyzed. Under the lens appearing to be made up of pretty pure, fine, crystalline grains. Powder yellowish-white.

Specific gravity, 2.655

Dried at 212° F., the powdered rock lost 0.40 per cent. of *moisture*.

Composition, dried at 212° F.—

Carbonate of lime,	59.86 = 33.59 per cent. of <i>Lime</i> .
Carbonate of magnesia,	36.64 = 17.44 per cent. of <i>Magnesia</i> .
Alumina, oxides of iron and manganese, and phosphates,	.98
Sulphuric acid,	.16
Potash,	.40
Soda,	.08
Silex and insoluble silicates,	2.48

100.60

A pretty pure magnesian limestone, which promises to be a durable building material; resembles, in composition, the building stone from Grimes' and the neighboring quarries in Fayette county, on the Kentucky river.

TABLE 1.

Soils, Sub-soils, and Marls.

Number in the report.	County.	Dissolved from 1000 grains by water contain- ing carb. acid.	Moisture.	Organic and vol- atile matters.	Alumina.	Oxide of iron.	Carbonate of lime.	Magnesia and carbonate.	Oxide of man- ganeue.	Phosphoric acid.	Sulphuric acid.	Potash.	Soda.	Sand and sili- cates.	Formation, &c.
557	Anderson,	2.201	4.125	5.453	1.615	6.305	0.345	0.335	0.315	0.181	0.056	0.156	0.023	84.845	Lower Silurian.
558	Anderson,	2.105	3.075	4.332	2.165	2.890	0.215	0.465	0.220	0.103	0.032	0.101	0.047	89.140	Lower Silurian, sub-soil.
559	Anderson,	0.789	3.250	4.313	2.465	3.555	0.070	0.601	0.220	0.142	0.056	0.130	0.026	80.970	Lower Silurian.
565	Boone,	4.600	4.635	7.827	2.495	2.790	0.395	0.495	0.195	0.187	0.187	0.152	0.040	84.630	Lower Silurian.
566	Boone,	3.100	3.750	5.506	3.520	3.124	0.495	0.469	0.245	0.136	0.067	0.213	0.030	87.645	Lower Silurian, sub-soil.
567	Boone,	1.936	3.190	3.455	3.945	3.490	0.265	0.536	0.395	0.476	0.119	0.227	0.133	79.045	Lower Silurian.
568	Boone,	6.078	5.120	8.406	5.745	5.185	0.945	0.170	0.370	0.335	0.065	0.209	0.114	83.310	Lower Silurian, sub soil.
569	Bourbon,	3.149	3.840	5.574	4.925	4.185	0.355	0.521	0.395	0.330	0.085	0.195	0.100	84.070	Lower Silurian, shell
570	Bourbon,	2.263	3.840	4.196	5.360	4.313	0.355	0.521	0.420	0.440	0.050	0.840	0.116	63.770	Lower Silurian, shell
571	Bourbon,	1.834	6.450	4.783	12.785	9.450	6.235	1.946	0.495	0.425	0.145	0.224	0.077	78.680	Lower Silurian.
574	Bourbon,	6.760	5.865	7.702	4.620	6.585	0.622	0.508	0.720	0.321	0.145	0.248	0.103	81.080	Lower Silurian.
575	Bourbon,	2.834	4.600	5.897	5.195	5.910	0.446	0.416	0.593	0.282	0.101	0.217	0.130	82.930	Lower Silurian, sub-soil.
576	Bourbon,	2.671	7.085	4.785	5.275	5.660	0.421	0.517	0.345	0.243	0.170	0.347	0.159	74.145	Lower Silurian un'r clay.
577	Bourbon,	1.849	3.500	5.958	8.720	10.015	0.446	0.753	0.470	0.221	0.093	0.183	0.071	83.470	Lower Silurian.
580	Boyle,	5.853	3.500	5.958	3.515	3.895	0.247	0.571	0.320	0.486	0.119	0.183	0.017	91.145	Sub-carboniferous.
581	Breckinridge,	1.897	2.625	3.532	2.080	2.215	0.022	0.323	0.095	0.108	0.059	0.194	0.020	90.420	Sub-carboniferous.
582	Bullitt,	1.900	2.600	5.030	1.640	1.490	0.147	0.285	0.095	0.139	0.043	0.258	0.058	85.555	Devonian.
583	Bullitt,	2.022	4.680	5.665	2.476	4.790	0.196	0.526	0.176	0.253	0.054	0.258	0.037	90.555	Upper Silurian.
584	Bullitt,	1.390	2.920	3.130	2.390	2.740	0.182	0.348	0.165	0.097	0.067	0.145	0.058	91.635	Upper Silurian.
585	Bullitt,	0.834	2.725	3.696	1.890	2.215	0.072	0.320	0.145	0.070	0.055	0.104	0.042	86.720	Upper Silurian, sub soil.
586	Bullitt,	1.321	3.250	3.229	4.345	4.495	0.197	0.289	0.012	0.109	0.050	0.235	0.042	86.720	Upper Silurian, sub soil.
587	Bullitt,	-	2.550	1.904	5.480	6.585	0.622	0.508	-	0.157	0.066	0.573	0.152	48.084	Upper Silurian, marl.
588	Bullitt,	2.874	3.150	5.614	11.190	2.147	0.274	0.474	0.110	0.215	0.066	0.308	0.055	74.079	Upper Silurian.
590	Campbell,	1.866	1.925	3.441	3.084	2.685	0.274	0.474	0.110	0.215	0.066	0.308	0.055	86.730	Lower Silurian.
591	Campbell,	0.864	2.700	2.826	2.990	2.110	0.146	0.592	0.055	0.177	0.119	0.111	0.052	91.095	Lower Silurian.
592	Campbell,	0.864	2.700	2.826	3.740	3.270	0.072	0.430	0.055	0.146	0.076	0.159	0.048	88.845	Lower Silurian, sub soil.

593	Carroll,	4.890	3.800	5.744	3.910	3.455	2.455	2.22	3.96	0.54	0.312	0.022	85.483	Lower Silurian.
594	Carroll,	4.342	2.375	3.618	2.820	2.845	1.70	3.40	1.55	0.203	0.38	0.264	89.921	Lower Silurian.
595	Carroll,	1.919	2.300	2.814	5.070	2.630	0.280	0.300	0.180	0.227	0.059	0.256	90.515	Lower Silurian.
596	Crittenden,	1.057	3.415	4.695	2.470	5.285	0.050	0.606	trace.	0.106	0.167	0.188	83.548	Millstone grit.
597	Davies,	4.433	4.200	6.972	1.360	1.660	0.536	0.536	0.358	0.177	0.103	0.193	88.394	Coal Measures.
598	Davies,	3.720	2.880	6.301	1.776	2.360	0.416	0.341	0.038	0.181	0.095	0.158	89.236	Coal Measures.
599	Davies,	5.070	3.440	4.722	2.156	5.120	0.038	0.156	0.174	0.177	0.068	0.097	92.276	Coal Measures, sub-soil.
603	Franklin,	5.860	3.920	5.911	2.840	4.360	1.490	0.826	0.338	0.304	0.055	0.212	84.974	Lower Silurian.
604	Franklin,	3.787	2.400	4.722	2.156	5.120	0.038	0.156	0.174	0.177	0.068	0.097	92.276	Lower Silurian.
606	Franklin,	1.525	4.125	5.935	2.820	2.370	0.295	0.296	0.220	0.182	0.084	0.196	87.950	Lower Silurian.
607	Franklin,	1.436	4.815	3.405	4.095	4.825	0.246	0.450	0.335	0.359	0.081	0.202	85.810	Lower Silurian.
608	Franklin,	1.000	4.400	4.205	6.390	7.240	0.097	0.781	0.320	0.320	0.033	0.444	80.680	Lower Silurian, un. clay.
611	Franklin,	3.083	4.250	6.292	3.890	4.755	0.495	0.607	0.272	0.404	0.153	0.215	82.270	Lower Silurian.
612	Franklin,	3.037	4.625	6.292	3.975	4.045	0.430	0.519	0.365	0.305	0.093	0.206	84.130	Lower Silurian.
613	Franklin,	3.037	4.625	6.292	3.975	4.045	0.430	0.519	0.365	0.305	0.093	0.206	84.130	Lower Silurian.
614	Franklin,	3.037	4.625	6.292	3.975	4.045	0.430	0.519	0.365	0.305	0.093	0.206	84.130	Lower Silurian.
619	Gallatin,	2.908	5.575	7.005	5.715	6.170	0.970	0.818	0.520	0.589	0.128	0.393	77.380	Lower Silurian.
620	Gallatin,	3.441	6.000	6.543	6.190	3.920	1.910	0.763	0.320	0.310	0.079	0.354	77.855	Lower Silurian.
621	Garrard,	4.586	4.550	5.238	7.805	5.165	0.320	0.358	0.649	0.484	0.059	0.366	75.570	Lower Silurian.
622	Garrard,	4.586	4.550	5.238	7.805	5.165	0.320	0.358	0.649	0.484	0.059	0.366	75.570	Lower Silurian.
623	Garrard,	3.186	4.950	4.294	8.577	5.745	3.880	1.476	0.590	0.513	0.059	0.354	74.780	Lower Silurian.
624	Garrard,	4.932	3.350	4.640	3.140	2.875	4.20	0.692	0.270	0.379	0.102	0.045	88.920	Lower Silurian.
625	Garrard,	4.932	3.350	4.640	3.140	2.875	4.20	0.692	0.270	0.379	0.102	0.045	88.920	Lower Silurian.
626	Garrard,	3.343	3.365	4.957	3.040	3.844	3.85	0.207	0.110	0.335	0.067	0.106	87.170	Lower Silurian.
627	Garrard,	1.409	2.915	2.945	5.815	3.290	1.70	0.412	0.210	0.251	0.043	0.020	89.095	Lower Silurian.
628	Garrard,	3.170	3.150	5.212	2.530	2.595	0.247	0.472	0.322	0.283	0.033	0.186	87.445	Lower Silurian.
629	Garrard,	2.590	3.135	4.572	3.520	3.115	0.247	0.433	0.292	0.135	0.050	0.232	87.595	Lower Silurian.
630	Garrard,	1.493	2.415	3.111	3.745	3.425	1.47	0.379	0.212	0.204	0.045	0.232	88.650	Lower Silurian.
631	Garrard,	2.493	3.925	6.162	2.815	2.734	1.96	0.309	0.170	0.203	0.072	0.133	87.045	Lower Silurian.
636	Hancock,	4.890	3.325	6.022	2.995	2.930	0.310	0.334	0.145	0.196	0.067	0.250	87.910	Coal Measures.
637	Hancock,	1.820	3.415	3.883	2.120	2.430	0.240	0.278	0.260	0.063	0.067	0.174	91.070	Coal Measures.
638	Hancock,	1.198	3.175	3.020	4.190	4.865	0.130	0.605	0.070	0.107	0.101	0.219	86.645	Coal Measures, sub soil.
641	Hardin,	2.078	3.760	5.069	1.936	2.860	0.270	0.388	0.236	0.396	0.054	0.208	88.096	Sub carboniferous.
642	Hardin,	1.466	1.600	2.443	1.715	1.440	0.920	0.209	0.095	0.079	0.016	0.032	93.020	Sub carboniferous.
643	Hardin,	2.742	1.965	3.417	2.245	2.075	1.97	0.203	0.095	0.177	0.067	0.104	91.445	Sub carboniferous.
644	Hardin,	1.992	1.600	2.309	1.745	1.420	0.947	0.191	0.040	0.078	0.021	0.075	93.495	Sub carboniferous.
645	Harrison,	2.093	1.965	2.407	2.670	2.415	1.47	0.325	0.070	0.096	0.028	0.032	91.395	Sub carboniferous.
646	Harrison,	4.847	3.325	7.721	3.540	3.865	0.466	0.483	0.420	0.394	0.114	0.170	82.595	Lower Silurian.
647	Harrison,	3.093	2.750	6.051	3.655	3.835	0.296	0.463	0.480	0.385	0.107	0.150	84.630	Lower Silurian.
648	Harrison,	3.093	2.825	5.119	3.565	3.660	0.313	0.491	0.345	0.316	0.101	0.151	85.710	Lower Silurian.
649	Henry,	4.617	4.075	5.180	2.515	3.940	0.372	0.503	0.476	0.615	0.101	0.284	86.900	Lower Silurian.
650	Henry,	2.439	3.935	5.159	3.915	4.115	0.492	0.558	0.220	0.407	0.101	0.298	85.760	Lower Silurian.
651	Henry,	3.382	4.110	4.918	4.125	4.545	0.396	0.512	0.160	0.448	0.085	0.227	84.943	Lower Silurian, sub soil.

TABLE I—Continued. SOILS, SUB-SOILS, AND MARLS.

Number in the report.	County.	Dissolved from carbonated water.	Moisture.	Organic and volatile matters.	Alumina.	Oxide of iron.	Carbonate of lime.	Magnesia and carbonate.	Oxide of manganese.	Phosphoric acid.	Sulphuric acid.	Potash.	Soda.	Sand and silt.	Formation, &c.
659	Jefferson,	1.822	3.100	4.231	3.580	4.421	0.220	0.359	0.445	0.262	0.084	0.167	0.045	86.066	Sub carboniferous.
660	Jefferson,	5.194	3.175	4.983	3.245	4.130	1.195	3.355	3.370	2.295	0.085	0.213	0.051	85.895	Sub carbonif'rs, sub-soil.
662	Jessamine,	4.210	2.900	4.737	2.695	3.800	3.345	1.199	2.980	1.333	0.067	0.121	0.047	87.995	Lower Silurian.
663	Jessamine,	3.212	2.950	4.250	3.695	3.240	2.295	3.666	2.385	2.339	0.050	0.185	0.044	87.245	Lower Silurian.
664	Jessamine,	3.985	4.200	5.349	5.065	4.900	5.955	7.500	2.220	2.665	0.106	0.344	0.212	81.720	Lower Silurian.
665	Jessamine,	8.083	6.775	9.745	9.190	5.840	3.570	1.290	4.700	5.532	0.119	0.569	trace.	69.070	Lower Silurian.
667	Kenton,	2.460	3.935	5.429	3.255	2.520	1.197	4.461	1.599	2.226	0.076	0.272	0.035	87.445	Lower Silurian.
668	Kenton,	1.705	3.210	3.621	3.570	3.245	1.147	4.460	3.345	2.016	0.074	0.212	0.035	87.495	Lower Silurian, sub-soil.
669	Kenton,	1.630	3.165	3.901	3.660	3.290	1.478	4.783	3.320	1.150	0.050	0.205	0.060	88.745	Lower Silurian.
670	Larue,	1.586	2.625	6.498	3.175	2.715	0.072	2.990	2.330	1.114	0.050	0.135	0.025	88.680	Sub carboniferous.
671	Larue,	1.970	2.425	5.380	3.175	2.815	1.106	3.342	2.245	1.113	0.055	0.123	0.021	89.340	Sub carbonif'rs, sub-soil.
672	Larue,	1.134	2.725	2.981	3.955	3.265	0.015	4.677	2.235	0.096	0.050	0.130	0.033	88.625	Sub carbonif'rs, sub-soil.
673	Marion,	3.409	3.375	4.786	6.495	3.565	2.922	3.339	2.711	2.632	0.042	0.157	0.011	85.040	Devonian?
674	Marion,	1.360	3.400	4.748	3.940	4.970	2.222	3.302	3.12	2.979	0.062	0.181	0.033	84.720	Devonian? sub-soil.
675	Marion,	4.478	3.679	3.911	1.896	2.040	1.136	2.205	0.036	1.151	0.041	0.269	0.042	91.436	Sub carboniferous.
676	Meade,	1.627	2.840	2.620	3.136	2.580	2.236	2.998	1.116	1.25	0.130	0.154	0.084	91.036	Sub carboniferous.
677	Meade,	1.205	2.320	6.361	3.955	4.050	4.495	3.341	3.445	3.309	0.076	0.144	0.024	83.712	Lower Silurian.
678	Meade,	5.200	4.500	5.208	3.590	3.790	3.885	3.365	2.235	3.397	0.098	0.130	0.036	86.250	Lower Silurian.
679	Mercer,	5.310	4.000	4.369	3.750	3.415	3.995	3.390	3.320	3.362	0.050	0.114	0.040	86.720	Lower Silurian.
680	Mercer,	4.000	3.700	4.365	5.395	7.110	1.995	1.234	6.300	3.333	0.090	0.762	0.106	72.035	Lower Silurian.
681	Mercer,	11.095	4.500	10.365	7.315	7.110	2.080	1.184	7.69	4.559	0.058	0.650	0.050	71.395	Lower Silurian, sub-soil.
682	Mercer,	6.157	4.375	7.252	8.315	7.335	2.850	1.477	7.69	4.559	0.058	0.650	0.050	71.395	Lower Silurian, un. clay
683	Mercer,	5.818	4.450	5.494	6.195	5.184	14.170	6.04	4.90	4.556	0.041	0.817	0.123	66.245	Lower Silurian.
684	Mercer,	5.855	4.985	6.659	4.655	4.065	7.770	4.52	3.95	5.35	0.093	0.932	0.026	86.195	Lower Silurian.
714	Nelson,	2.859	2.700	3.423	3.140	2.835	3.330	2.82	2.980	3.116	0.078	0.130	0.036	88.595	Lower Silurian.
715	Nelson,	1.579	2.850	2.804	3.490	3.370	3.300	2.54	2.930	2.77	0.059	0.101	0.034	88.970	Lower Silurian, sub-soil.
716	Nelson,	1.579	2.850	2.804	3.490	3.370	3.300	2.54	2.930	2.77	0.059	0.101	0.034	88.970	Lower Silurian.
717	Nelson,	1.620	5.575	4.090	8.240	7.065	1.725	7.31	3.80	4.38	0.033	0.283	0.058	79.730	Lower Silur. shell earth.
718	Nelson,	1.746	5.050	4.449	7.290	6.015	5.520	9.67	2.25	3.68	0.033	0.283	0.058	79.730	Lower Silurian.
719	Nelson,	4.816	3.750	5.298	3.890	3.875	2.970	4.16	4.20	1.114	0.051	0.098	0.036	85.895	Upper Silurian.
720	Nelson,	5.032	3.425	5.384	4.280	3.905	4.405	4.92	4.70	2.28	0.117	0.193	0.049	84.395	Lower Silurian.

721	Nelson,	3.842	3.250	4.858	4.070	3.995	2.22	5.53	2.295	3.31	0.067	0.298	0.015	85.585	Lower Silurian.
722	Nelson,	2.000	4.000	4.088	5.910	5.160	3.66	4.57	3.20	3.45	0.085	0.275	0.055	83.210	Lower Silurian, sub soil.
723	Nelson,	1.956	5.275	6.280	9.325	7.885	3.34	1.100	2.95	7.73	0.062	0.449	0.272	73.095	Under shell earth.
724	Nelson,	5.892	2.575	7.195	3.995	3.110	4.45	5.22	1.95	3.42	0.096	0.154	0.021	84.595	Lower Silurian.
725	Nelson,	4.835	2.640	7.164	3.495	3.535	5.20	6.56	2.20	3.43	0.067	0.125	0.027	83.770	Lower Silurian.
726	Nelson,	-	-	-	11.850	9.430	3.93	9.66	-	1.21	0.463	0.749	0.482	84.990	Marl, sub carboniferous.
728	Nelson,	-	-	1.127	5.190	4.650	8.43	1.533	-	0.144	0.227	0.657	0.229	85.840	Marl, sub carboniferous.
729	Nelson,	-	-	4.200	2.214	2.240	3.96	6.13	2.30	0.172	0.085	0.282	0.095	84.495	Lower Silur. shell earth.
734	Oldham,	2.100	3.000	4.778	2.270	2.690	3.40	3.38	1.72	0.251	0.076	0.111	0.027	89.420	Upper Silurian.
735	Oldham,	1.547	2.200	2.613	3.355	2.540	1.25	3.65	1.45	1.12	0.050	0.130	0.039	91.295	Upper Silurian.
736	Oldham,	1.237	2.575	2.537	1.120	2.625	2.39	2.33	0.72	1.07	0.079	0.075	trace.	89.820	Upper Silurian, sub-soil.
737	Oldham,	3.100	1.475	2.537	3.970	3.290	1.80	4.44	0.35	1.79	0.054	0.256	0.024	92.747	Upper Silurian.
738	Owen,	1.850	3.225	3.978	3.995	3.290	1.45	3.88	1.80	1.63	0.050	0.179	0.017	87.195	Lower Silurian.
739	Owen,	0.980	3.250	3.956	3.995	3.515	1.95	4.41	2.65	1.63	0.044	0.262	0.006	87.380	Lower Silurian, sub soil.
740	Owen,	1.801	3.050	3.146	2.290	2.655	2.96	1.57	1.45	2.27	0.107	0.207	0.078	88.010	Lower Silurian.
743	Pendleton,	3.354	2.450	4.766	2.565	2.510	2.75	3.41	1.45	1.78	0.055	0.140	0.037	88.570	Lower Silurian.
744	Pendleton,	2.649	2.675	4.906	2.500	3.200	1.62	6.85	1.46	1.95	0.089	0.188	0.068	88.010	Lower Silurian, sub soil.
745	Pendleton,	2.183	2.450	3.459	3.500	3.200	1.020	2.93	5.65	4.38	0.141	0.214	0.106	78.145	Lower Silurian.
748	Scott,	6.114	5.450	9.042	5.025	5.310	1.920	2.93	5.65	4.38	0.141	0.214	0.106	81.260	Lower Silurian.
749	Scott,	6.578	3.400	5.197	5.425	5.110	1.195	5.04	3.97	3.19	0.179	0.197	0.125	81.260	Lower Silurian, sub-soil.
750	Scott,	3.599	3.415	6.669	2.685	3.175	2.220	4.54	1.64	1.06	0.062	0.154	0.030	81.580	Lower Silurian, sub-soil.
751	Shelby,	-	3.700	3.193	12.130	12.655	1.290	9.14	-	2.84	0.066	0.395	0.038	80.690	Lower Silurian, a marl.
752	Shelby,	2.010	3.565	4.648	2.895	3.280	3.320	4.06	1.70	2.49	0.064	0.159	0.026	87.222	Lower Silurian.
753	Shelby,	1.851	3.400	4.593	3.070	3.190	2.95	3.66	trace.	1.52	0.050	0.128	0.051	88.050	Lower Silurian.
754	Shelby,	1.117	3.350	4.336	3.174	4.080	2.95	3.54	0.45	1.96	0.059	0.214	0.014	88.445	Lower Silurian, sub-soil.
755	Shelby,	3.128	3.575	4.734	4.590	3.585	4.45	5.33	2.70	4.79	0.138	0.190	0.097	85.670	Lower Silurian.
756	Shelby,	4.279	3.225	4.970	4.115	3.660	4.47	4.97	5.15	5.59	0.067	0.173	0.093	84.970	Lower Silurian.
757	Shelby,	1.614	2.925	3.245	4.690	3.865	2.46	5.58	3.95	3.93	0.050	0.208	0.051	86.320	Lower Silurian, sub soil.
758	Shelby,	2.798	3.350	4.317	3.096	2.590	3.45	4.93	5.15	1.47	0.059	0.236	0.014	87.370	Lower Silurian.
759	Spencer,	2.111	2.425	2.973	2.496	2.640	2.45	2.41	1.70	1.44	0.041	0.183	0.047	90.095	Lower Silurian.
760	Spencer,	1.050	3.075	2.347	2.685	3.175	2.220	4.54	1.64	1.06	0.062	0.154	0.030	90.320	Lower Silurian, sub soil.
761	Spencer,	-	3.256	3.256	12.655	12.655	5.890	9.79	-	1.23	0.485	0.424	0.148	76.040	Lower Silurian, marl.
762	Taylor,	5.145	2.850	7.075	3.765	3.110	1.73	4.35	-	1.46	0.103	0.146	0.046	85.345	Sub carboniferous.
763	Taylor,	4.654	2.425	5.816	2.530	2.910	1.22	4.23	1.20	1.05	0.067	0.125	0.052	87.330	Sub carboniferous.
764	Trimble,	3.382	2.500	4.308	2.530	1.990	3.30	2.32	1.70	0.69	0.033	0.213	0.047	90.195	Upper Silurian.
765	Trimble,	2.499	2.450	3.434	2.995	2.890	2.20	2.91	1.70	0.96	0.020	0.152	0.049	89.920	Upper Silurian.
766	Trimble,	3.029	2.425	3.136	3.470	2.640	1.70	2.94	2.45	0.79	0.015	0.181	0.028	90.160	Upper Silurian, sub soil.
767	Union,	1.928	3.500	3.720	3.465	2.920	6.24	6.30	9.50	1.96	0.067	0.133	0.104	87.510	Coal Measures.

TABLE 1—Continued. SOILS, SUB-SOILS, AND MARLS.

Number in the report	County.	Dissolved from carbonated wa- ter.	Moisture.	Organic and vol- atile matters.	Alumina.	Oxide of iron.	Carbonate of lime.	Magnesia and carbonate.	Oxide of man- ganese.	Phosphoric acid.	Sulphuric acid.	Potash.	Soda.	Sand and sili- cates.	Formation, &c.
768	Union,	0.866	—	2.309	3.910	5.365	.590	.466	—	.162	.124	.188	.213	92.120	Coal Meas., .080 chlorine.
769	Union,	6.750	3.500	3.333	4.290	5.365	trace.	.541	.495	.076	.076	.231	.111	85.330	Coal Measures.
770	Washington,	3.712	5.050	7.753	3.790	3.930	.636	.333	.495	.084	.084	.231	.030	82.190	Lower Silurian.
771	Washington,	3.712	3.555	5.635	4.515	4.145	.396	.333	.420	.067	.067	.191	.011	83.940	Lower Silurian.
772	Washington,	1.865	3.450	3.340	4.565	4.355	.220	.308	.345	.042	.042	.160	.038	86.175	Lower Silurian, sub-soil.
773	Washington,	3.982	3.300	4.576	3.440	2.930	.322	.368	.170	.096	.067	.154	.021	87.410	Lower Silurian.
774	Washington,	2.306	2.150	3.055	3.015	3.390	.222	.344	.175	.161	.059	.132	.035	89.070	Lower Silurian.
775	Washington,	1.619	2.890	2.894	3.565	3.440	.145	.443	.170	.129	.077	.128	.052	89.030	Lower Silurian, sub-soil.

TABLE 2.

Limestones, &c.

Number in the report.	County.	Specific gravity.	Carbonate of lime.	Carbonate of Magnesia.	Carbonic acid.	Alumina, oxide of iron & man- ganese.	Phosphoric acid.	Sulphuric acid.	Carbonate or oxide of iron.	Potash.	Soda.	Bituminous matters.	Silica, &c.	Remarks.
572	Bourbon,	—	81.34	0.979	45.645	0.640	0.221	0.324	—	0.104	0.177	—	16.646	Lower Silurian.
573	Bourbon,	—	94.680	.980	53.130	1.120	.196	.592	—	.166	.233	—	1.086	Lower Silurian.
578	Bourbon,	—	97.540	.699	53.735	.237	.093	.180	—	.065	.206	—	1.446	Lower Silurian.
579	Bourbon,	—	95.480	1.398	53.580	.797	.183	.180	—	.085	.135	—	2.369	Lower Silurian.
605	Franklin,	—	95.150	2.550	53.390	.870	.080	.850	—	.230	.230	—	0.550	Lower Silurian.
615	Franklin,	—	95.380	1.510	53.522	.769	.311	.579	—	.108	.003	—	2.080	Lower Silurian.
616	Fayette, A.	2.728	59.880	37.650	—	1.380	—	—	—	not es	not es	—	2.000	Do. (Magnesian.)
617	Fayette, B.	2.767	64.400	33.900	—	.950	—	—	—	not es	not es	—	.527	Fossil Chertetes.
658	Fayette,	—	97.820	.839	—	.480	.118	.235	—	.166	.020	—	2.170	Coal Measures.
659	Hopkins,	2.776	23.790	4.413	—	Alumi.	.247	.006	11.717	.270	.091	2.170	.555	Lower Silurian.
666	Jessamine,	—	92.980	8.390	52.176	1.590	.567	.133	—	.166	.055	—	3.146	Lower Silurian.
685	Mercer,	—	88.900	1.468	49.855	2.040	.631	.235	—	.168	.053	—	7.186	Lower Silurian.
705	Muhlenburg,	2.777	82.880	4.196	46.509	2.340	.247	4.717	—	.135	.150	—	4.280	Coal Measures.
709	Nelson,	2.758	82.880	33.900	34.900	4.330	—	—	—	.460	.350	—	3.180	Upper Silurian.
711	Nelson,	—	51.660	32.000	29.000	.680	—	.090	—	.770	.460	—	9.780	Denovian.
732	Nicholas,	—	78.680	1.566	44.150	5.550	.947	.270	—	.173	.172	—	16.640	Lower Silurian.
742	Owen,	—	92.920	.559	52.139	2.480	.349	.338	—	.162	.160	—	1.720	Lower Silurian.
776	Woodford,	2.655	59.860	36.640	33.590	3.580	—	.160	—	.400	.080	—	2.480	Do. (Magnesian.)

TABLE 3.

Iron Ores. (A.) Limonites.

Number in report.	County.	Specific gravity.	Peroxide of iron.	Carbonate of iron.	Brown oxide of manganese.	Carbonate of lime.	Magnesia.	Alumina.	Phosphoric acid.	Sulphuric acid.	Sulphur.	Potash.	Soda.	Combined water.	Silica, &c.	Per centage of iron.	Ballitt's Lick. Raccoon Furnace.
589	Bullitt,		33.990		0.480	trace.	0.680	1.580 not est.			.350	0.440	0.230	6.750	56.130	23.800	
609	Franklin,		26.690		3.690	trace	1.150	0.630			.050	.630	trace.	7.500	52.680	18.690	
634	Greenup,		20.870		.180	trace	3.240	.690	.310		.950	.360	.100	3.150	60.028	14.610	
635	Hancock,		34.600			trace.	.500	1.380			.060	.670	.170	6.500	55.580	24.230	
633	Hopkins,	2.785	54.080		.720	trace.	.244	1.380	1.400		.210	.251	.055	7.180	34.480	37.870	
654	Hopkins,		62.250		.860	trace.	6.432	5.830	1.170		.356	.571	trace.	8.800	12.180	43.593	
655	Hopkins,	4.563	91.780		.486	trace.	.921	1.035	.055		.310	.154	.029	1.140	5.286	64.266	
698	Morgan,		22.040	15.340	1.020	1.640	2.920	.810	.370		.270	.170	.310	.630	54.480	22.100	
727	Nelson,		39.340		1.180	.886	4.827	2.560	.315	.201		.668	.342	4.961	44.720	27.550	
746	Rowan,	2.868	26.680		.260		.330	.980			.050	.570		2.800	68.910		
747	Rowan,	3.261	56.140		.380		.180	.960				.210	.110	1.600	31.780	39.310	

TABLE 3.

Iron Ores. (B.) Carbonate of Iron.

Number in report.	County.	Specific gravity.	Carbonate of iron.	Oxide of iron.	Carbonate of lime.	Carbonate of magnesia.	Carbonate of manganese.	Alumina.	Phosphoric acid.	Sulphur.	Potash.	Soda.	Bituminous matter.	Silica, &c.	Water.	Per centage of iron.
640	Estill,		52.600	13.640	1.000	3.960	1.180	1.010	0.370	0.130	0.250	trace.		20.780	5.700	42.730
651	Greenup,		42.260	46.650	.480	.380	1.480	.380	.760	.090				2.980	4.080	52.950
653	Greenup,		51.240	9.420	.680	2.760	1.310	1.090	.640	.090	.150			32.480		31.020
656	Hopkins,	3.227	61.730		4.890	1.848	.887	.480	.183	.122	.201	.058		27.140		26.845
757	Hopkins,	3.146	45.119	16.457	4.780	5.616	2.093	.270	1.720	.212	.262	.097		19.930	3.454	33.860
708	Nelson,	5.201	33.500	5.500	4.580	9.820	.710	3.150	.630	.080	.480	.230		21.480		29.690
710	Nelson,	3.348	62.960	2.640	3.940	9.430	1.330	1.550		.090	.340	.340		10.480		35.640

TABLE 4.

Coals.

Number in the report	County.	Specific gravity.	Moisture.	Volatile combustible matters.	Carbon in coke.	Ashes.	Total volatile matters.	Coke.	Sulphur.	Bituminous oil for 1000 grains.	Designation.
686	Morgan,	1.365	0.80	45.00	32.70	21.50	45.80	54.20	0.90	234 grains.	Crow's Cannel.
687	Morgan,	1.280	3.00	36.60	53.10	2.30	32.60	60.40	1.15		Crow's Bituminous.
688	Morgan,	1.360	1.90	45.30	31.80	21.00	47.20	52.80	0.87		Crow's Cannel.
689	Morgan,	1.328	3.00	40.00	44.00	13.00	43.00	57.00	0.82		Cannel, (Barber's.)
690	Morgan,	1.307	2.50	40.50	48.70	8.30	43.00	57.00	1.25		Cannel, (Crow's.)
691	Morgan,	1.336	3.30	36.40	53.60	4.70	39.70	60.30	0.74		Bituminous, (Crow's.)
692	Morgan,	1.327	5.00	37.80	46.60	10.60	42.80	57.20	0.63		Cannel, (Barber's.)
693	Morgan,	1.299	2.60	37.00	45.40	5.00	39.60	60.40	0.54		Bituminous, (Smedley's.)
694	Morgan,	1.542	1.00	37.60	31.40	30.00	38.60	61.40	1.23		Cannel, (Crow's.)
695	Morgan,	1.288	1.40	44.40	4.00	6.20	45.80	54.20	0.68	176 grains.	Cannel, (Schoolfield's.)
696	Morgan,	1.345	3.00	39.60	48.20	9.20	42.60	57.40	4.84		Bituminous.
697	Morgan,	1.296	2.70	42.90	50.40	4.00	45.60	54.40	2.42		Bituminous.

TABLE 5.

Sandstones and Shale.

Number in the report	County.	Sand and silt-cases.	Carbonate of lime.	Carbonate of magnesia.	Alumina and oxide of iron.	Oxide of manganese.	Phosphoric acid.	Sulphuric acid.	Potash.	Soda.	Water.	Designation.
610	Franklin,	80.680	0.990	2.440	9.470		0.180	2.600	2.370	0.130	1.140	Sandstone.
631	Grant,	89.620	1.563	2.766	6.202		.378	.107	.363	.200	1.950	Sandstone.
699	Morgan,	84.380	1.760	1.080	12.780							Ferruginous sandstone.
730	Nicholas,	93.390	1.113	.199	4.140		.092	.076	.020	.131	1.667	Lower Silurian.
731	Nicholas,	88.440	.743	.322	8.560	.290	.572	.100	.473	.233		Lower Silurian.
741	Owen,	88.090	1.193	1.600	6.320	.240	.860	.184	.602	.212	.699	Lower Silurian.

TABLE 6.
Iron Furnace Slags.

Number in the report.	County.	Silica.	Alumina.	Lime.	Magnesia.	Protoxide of iron.	Protoxide of manganese.	Potash.	Soda.	Oxygen in the silica.	Oxygen in the bases.	Proportion of oxygen in the bases to O in the silica.	Furnace.
706	Muhlenburg,	42.080	23.080	24.230	6.103	1.044	1.023	2.066	0.809	21.849	21.076	1 : 1.036	Airdrie.
712	Nelson,	53.524	19.957	14.000	5.706	2.673	.059	3.344	1.401	27.793	17.105	1 : 1.624	Nelson.

TABLE 7.
Pig Iron.

Number in the report.	County.	Specific gravity.	Iron.	Graphite.	Combined carbon.	Total carbon.	Manganese.	Silicon.	Slag.	Aluminium.	Calcium.	Magnesium.	Potassium.	Sodium.	Phosphorus.	Sulphur.	Furnace.
707	Muhlenburg,	7.067	88.428	1.360	0.106	1.556	0.980	6.216	3.090	0.099	trace.	0.309	0.059	0.091	0.209	0.219	Airdrie.
713	Nelson,	7.1493	95.173	2.880		2.880	.274	.697	.190	.101	0.025	.114	.096	.026	.339	.096	Nelson.