

ART. XXIV.—*An Analysis of a Soil from Washington Territory, and some remarks on the utility of Soil-analysis;*
by EDWARD A. SCHNEIDER.

THE soil and rock, the analyses of which are given on the following pages, were kindly furnished to me by Professor E. W. Hilgard from his extensive collection of soil specimens, for which favor I offer him on this occasion once more my thanks.

The place of occurrence of these specimens is the Rockland Ridge, near "The Dalles," on the Columbia River, Washington Territory. The geological indications, as I have been told, were that the soil was formed "in situ" by disintegration of the rock. Comparative analyses have confirmed this supposition; still it is probable that the soil contains a small amount of constituents which do not form a part of the mother-rock; particularly noticeable among this class is mica. I am indebted to the kindness of Professor A. W. Jackson, of the University of California, for the petrographic analysis of the thin sections which I had prepared. According to the statement of Professor Jackson, the constituents of the Rockland Ridge rock are: "plagioclase, augite, apatite, magnetite, undifferentiated glass;" the rock is consequently, according to the same authority, an augite andesite.

The analyses of the mother-rock and of the soil disclosed the following results:

Analyses of the mother-rock and of the soil.

	By fusion.		By extraction with HCl.		
	Rock.	Soil.	Rock, finely triturated.	Soil, untrituated.	Soil, untrituated.
Matters insoluble in HCl.	----	----	75.41	71.42	71.87
SiO ₂ soluble in Na ₂ CO ₃ ..	----	----	1.57	7.73	11.00*
Matters insol. in Na ₂ CO ₃ ..	----	----	63.84	63.69	60.87
Total SiO ₂	50.85	58.16	-----	-----	-----
P ₂ O ₅ †	0.76	0.43	0.76	0.43	0.36
SO ₃	0.05	0.07	0.05	0.07	0.08
H ₂ O	0.34	1.77	0.34	1.77	1.77
K ₂ O	1.13	1.68	not‡	0.78	0.78
Na ₂ O	2.37	2.56	determined	1.02	0.67
CaO	9.33	4.57	6.29	3.02	2.48
MgO	5.57	1.99	3.42	not	.97
FeO	7.11	-----	-----	determined	-----
Fe ₂ O ₃	10.03	10.59	13.85	9.22	9.22
Al ₂ O ₃	12.54	15.03	8.25	9.35	8.95
Org. matter	----	3.52	----	3.52	3.52
	100.08	100.37	----	----	100.67

Since a soil is a very complex mixture. I proceeded first of all to separate it as far as possible into its mechanical elements. For this purpose I passed the reddish brown soil consecutively through three different sieves. I obtained thus rock fragments $> 2^{\text{mm}}$ □, fragments $< 2^{\text{mm}}$ □ $> 6^{\text{mm}}$ □, and a quantity of fine earth $< 6^{\text{mm}}$ □, which formed the bulk of the soil-specimen.

19.6987^{grm} of the fine earth dried at 100° were treated according to the directions of Professor Hilgard for the mechanical analysis of soils.§ I thus obtained

2.8500 ^{grm} clay	14.46	per cent.
3.4232 sediment $< 25^{\text{mm}}$ h. v. || .....	17.38	"
.7125 " .25 "	3.62	"
.7987 " .5 "	4.05	"
1.9012 " 1 "	9.65	"
2.2637 " 2 "	11.49	"
2.7200 " 4 "	13.81	"
1.6350 " 8 "	8.55	"
1.5242 " 16 "	7.74	"
1.1617 " 32 "	5.88	"
.6382 " 64 "	3.24	"
19.6784	99.87	"

* It is possible that soda-solution dissolves more silica from the untrituated than from the triturated soil, because, during the process of boiling, it gets better access to each particle of the soil.

† By extraction with HNO₃.

‡ Alkaline chlorides—4.54 per cent (alkaline chlorides obtained by fusion = 6.25 per cent.

§ This Journal, vol. vi. Oct., 1873.

|| h. v. = hydraulic value.

or

I.	2·8500 ^{grm}	clay	-----	14·46	per cent.
II.	3·4232	sediment	<·25 ^{mm} h. v.-----	17·38	“
III.	10·0811	“	·25 ^{mm} h. v.—8 ^{mm} h. v.-----	51·17	“
IV.	3·3241	“	8 ^{mm} h. v.—64 ^{mm} h. v.-----	16·86	“
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19·6784				99·87	“

These four fractions, obtained by mechanical analysis, represent the natural and characteristic subdivisions of this soil, as the general aspect, the microscopic examination and the chemical analysis have shown. They are described as follows:

I. *Clay*; has a brownish yellow color, and appears amorphous under the microscope.

II. *Silt*, or *sediments* <·25^{mm} *h. v.*; has a bright brick-red color. Under the microscope most of the soil-constituents which can be detected in the fractions composed of sediments of higher hydraulic values are visible also in this fraction with the exception of magnetic iron. All the iron in this fraction appears to be in the form of peroxide.

III. *Sediments* ·25^{mm} *h. v.*—8^{mm} *h. v.*; have a light chocolate color; the “streak” of the finely triturated powder is gray and approaches that of the mother-rock, being only slightly darker with a tinge of brown. The subdivisions of this fraction appear under the microscope very much alike; particles of magnetic iron are discernible in all of them and are larger with the increase of the hydraulic values.

IV. *Sediments* 8^{mm} *h. v.*—64^{mm} *h. v.*; appear grayish black, somewhat like the mother-rock, when coarsely pulverized. All constituents of the mother-rock can be discerned under the microscope in this fraction in an unchanged state.

Since it thus appears that the natural subdivisions of this soil correspond with those obtained by mechanical analysis I undertook the chemical analysis of these four fractions.

Plan of chemical analysis.—My plan was to execute a complete analysis by fusion of each of the four fractions, in order to ascertain their ultimate composition; further, to analyze the same fractions by extraction with hydrochloric acid both in their natural state and after previous trituration, in order to be able to compare them more directly, for estimating their agricultural value. The analysis of the soil itself, triturated and untriturated, by fusion and extraction, entered also into my plan of work. Lack of time, however, prevented me from executing all of these analyses; but the data which I have obtained enabled me to draw some conclusions.

Analytical methods.—The analytical methods which I have used in this comparative investigation are somewhat different

from those which it would be advisable to use if the object were to determine with the greatest possible accuracy the constituents of a rock or of a mineral. Still they are accurate enough to guarantee fair results, particularly as great pains have been taken to maintain the utmost possible uniformity of conditions.

The hydrochloric acid which was used for the extraction had the spec. grav. = 1.112. The digestions with this acid were effected in all instances on a constant water-bath for five days; 25^{cc} of acid to about 2.5^{gram} of mineral powder were used. For the determination of the total phosphoric acid the finely triturated powders were digested for two and a half days on the constant water-bath with nitric acid (spec. grav. = 1.25) and the phosphoric acid in the extract after precipitation with ammonic molybdate was weighed as magnesium-pyrophosphate. For the determination of the total alkalies the method of J. Lawrence Smith was used. Sulphuric acid was only determined in the hydrochloric extracts. On account of the insignificant quantities found, the determinations of this soil-ingredient were not repeated in the analyses by fusion. Only traces of manganese were found. The determination of the halogens (F, Cl) was omitted, as it had no particular value for this comparative investigation.

Extraction of the soil with cold hydrochloric acid.—It was interesting to see how the soil would be acted upon by cold hydrochloric acid. For this purpose 25 grams of the soil were digested with 250^{cc} hydrochloric acid (sp. gr 1.112) at the ordinary temperature. It was found that the extract contained :

SiO ₂	0.22	per cent.
P ₂ O ₅	0.28	"
SO ₃	0.01	"
K ₂ O	0.17	"
Na ₂ O	0.05	"
CaO	0.69	"
MgO	0.58	"
MnO	—	"
FeO	—	"
Fe ₂ O ₃	5.61	"
Al ₂ O ₃	2.42	"
	<hr/>	
	10.03	"

In "How Crops Feed,"* Professor Johnson mentions the results of a similar experiment by Grouven on a soil of Salz-münde. Grouven found that hot diluted acid dissolved five

* Page 370.

times as much oxide of iron and alumina, as cold dilute acid, four times as much potash, three times as much soda, twice the amount of magnesia, sulphuric acid and phosphoric acid, and the same quantity of lime.

The following table shows plainly how very different the action of acids of different strength on soils can be. Hot dilute acid takes up

From the soil of Salzmünde.		From the Rockland Ridge soil.	
Al_2O_3	} 5 times as much		3.7 times as much.
Fe_2O_3			
K_2O	4 " "	4.5	" "
Na_2O	3 " "	13	" "
MgO	} 2 " "	1.6	" "
SO_3		8	" "
P_2O_5	} the same amount	1.3	" "
CaO		3.5	" "

as cold dilute acid.

I believe these two examples prove the wide range of errors, which the agricultural chemist would commit in judging as to the fertility of a soil from the composition of the extract by hot hydrochloric acid; for it is evident that if the action of hot and cold hydrochloric acid on a soil shows such wide discrepancies, the action of carbonic and other weak organic acids, which occur in the soil can hardly be compared with that of hot hydrochloric acid.

Humus determination (according to Grandeau). 10.6395^{grm} of the soil after extraction* with weak hydrochloric acid yielded to weak ammonia water .1269^{grm}=1.19 per cent of humus, which contained .0451^{grm} inorganic matter=.42 per cent. The phosphoric acid in this inorganic residue amounted to 16.17 per cent of the same and to .07 per cent calculated on the total soil.

*The soil was extracted on a filter by pouring repeatedly small quantities of the weak acid over it. 825^{cc} of a mixture containing 800^{cc} distilled water and 25^{cc} hydrochloric acid (sp. gr. = 1.112) were used. The extraction was completed in a time of about five hours. As I had already compared the action of moderately strong hot and cold acids on the soil, I thought it was worth while to ascertain the dissolving properties of a 32-times weaker cold acid on the soil. I found that the solution contained .18 per cent P_2O_5 (extraction with HCl sp. gr. = 1.112 for five days on water-bath yielded .28 per cent P_2O_5). Owing to an accident the determination of the bases was not completed. I can, however, state that the extract contained a considerable quantity of gelatinous silica, (zeolites).

Analyses by fusion of rock, soil and sediments.

	Mother-rock.	Fragments $\geq 2\text{mm}$ (sieve) decomposed mother-rock.	Soil.	Sediments 8mm h. v. — 64mm h. v.	Sediments 25mm h. v. — 8mm h. v.	Sediments $< 25\text{mm}$ h. v.	Clay.
SiO ₂	50.85	48.42	58.16	57.07		55.94	41.52
P ₂ O ₅ *	.76	.78	.43	.33	.24	.42	.11
SO ₂	.05	.03	.07	.04		not determ.	.08
H ₂ O	.34	1.20	1.77	.21		---	---
K ₂ O	1.13	1.16	1.08	1.53		1.76	---
Na ₂ O	2.37	2.29	2.56	2.90		1.67	---
CaO	9.33	8.98	4.57	6.55		3.07	.41
MgO	5.57	4.58	1.99	2.59		1.72	1.57
FeO	7.11	4.77	---	2.80		---	---
Fe ₂ O ₃	10.03	10.80	10.59	8.24		11.98	17.93
Al ₂ O ₃	12.54	16.00	15.03	17.57		16.32	17.18
Org. matter	---	---	3.52	---		7.40†	18.86†
	100.08	99.01	100.37	99.83	----	100.28	----

Discussion of the analyses by fusion of the sediments obtained by mechanical analysis.

I. *Clay*: M. Th. Schloesing, the celebrated French agricultural chemist, in speaking about "clay," says:‡ "Clay derives its origin from the decomposition of siliceous rocks. Under atmospheric influences, such as humidity, oxygen, carbonic acid, these rocks are slowly decomposed. Their alkalies and alkaline earths are transformed into carbonates. These are leached out by water; the calcium carbonate with the help of free carbonic acid; at the same time a part of the silica is set free and becomes soluble. The silicate of alumina remains intact; by taking up water it becomes clay. The iron which becomes insoluble, changing into peroxide, remains with the clay. The clay retains besides small quantities of other substances, such as alkalies and alkaline earths, in a sense as the witnesses of its origin."

It is interesting to hear another agricultural chemist upon the same subject. In the chapter on soil investigation,§ which forms a part of the "General Discussion of the Cotton production of the United States" Prof. E. W. Hilgard says: "The concentration of the available portion of the plant-food of soils in their finest portions is almost a maxim already, scarcely need-

* By extraction with HNO₃.

† Organic matter and water.

‡ P. 62, *Chimie Agricole*. (Frémy. *Encyclopédie Chimique*.)

§ Tenth U. S. Census.

ing the corroboration afforded by the investigation of Dr. Loughridge.”*

My own results seemed to confirm M. Schloesing's opinion, as reference to the tables containing the analyses by fusion will show; since, however, it is possible that the large quantities of water employed in mechanical analysis had leached out a considerable portion of the alkalies and alkaline earths, I prepared another portion of clay, by treating 100^{gms} of the soil with 5300^{cc} of distilled water and evaporating the resulting “clay water” to dryness.

The clay procured in this way gave the results under *a*, while the clay, which was prepared in the ordinary manner afforded these under *b*. Even if the higher figures of *a* were not partly due to the presence of the soil extract they are still lower than those obtained by analysis of the sediments 8^{mm} h. v. — 64^{mm} h. v. which are given under *c*.

	<i>a.</i>	<i>b.</i>	<i>c.</i>
CaO	2.60 per cent.	.41 per cent.	6.55 per cent.
MgO	2.30 “	1.57 “	2.59 “
P ₂ O ₅ .....	.65 “	.11 “	.33 “

I give here also the analyses of *b* and *c* by extraction with hot hydrochloric acid.

	<i>b.</i>	<i>c.</i>
CaO .....	.17 per cent.	3.01 per cent.
MgO	1.16 “	1.06 “
P ₂ O ₅ .....	.11 “	.14 “

We see that the results obtained by extraction with hydrochloric acid are nearly proportional to those obtained by fusion.

Why is it now that Dr. Loughridge found the clay of his soil to be of all the sediments the richest in bases, while I have found the opposite? The coarser sediments of Loughridge's soil contained “nothing but quartz-sand,” as that author expresses himself, while in the Rockland Ridge soil the coarser sediments are the least decomposed fragments of a rock, which is extremely rich in bases and phosphoric acid.

I have not succeeded, unfortunately, in determining the amount of alkalies in the clay, owing to the difficulty of preparing the latter in a sufficient pure state for an alkali-determination; I believe, however, that the alkalies would show a decrease, probably in the same proportion as the alkaline earths. The high percentages of alkalies which Loughridge found in the clay that he analyzed may be partly due to the solution of common salt with which the clay was precipitated. These contradicting results seem to me to indicate that the truth about

* On the distribution of soil ingredients among the sediments obtained in silt analysis by R. H. Loughridge, of Oxford, Miss. Proceed. of the Am. Assoc. for the Advanc. of Science, 1874.

the matter may be found between Schloesing's and Hilgard's views; the Mississippi soil of Loughridge and the Rockland Ridge soil which I have analyzed represent extreme types; between them numberless gradations are possible. All of the iron contained in the clay exists probably in the form of oxide. It was not possible to make a determination of iron protoxide as the amount of organic matter present was large.

II. *Silt* (*sediments* $< .25^{\text{mm}}$ *h. v.*); contains a still larger percentage of bases than the clay. It was impossible to determine the iron protoxide, owing to organic matters. A prominent feature is the high percentage of phosphoric acid. Of the coarser matters only the fraction embracing the sediments of 8^{mm} *h. v.*– 64^{mm} *h. v.* has been analyzed.

III. *Sediments* 8^{mm} *h. v.*– 64^{mm} *h. v.*; These sediments are the richest in bases. The amount of alkalies and alkaline earths in them approaches very nearly that of the mother-rock; the quantity of phosphoric acid, however, is only half as large as that contained in the rock. The increased percentage of silicic acid (57.07 per cent against 50.95 per cent in the rock) and the decrease of iron protoxide (2.80 per cent against 7.11 per cent) shows that a considerable chemical change has already taken place.

Analyses by extraction with hydrochloric acid of rock, soil and sediments.

	Mother-rock.	Fragments $> 2^{\text{mm}}$ \square (sieve) decomposed mother-rock.	Soil.	Sediments 8^{mm} <i>h. v.</i> – 64^{mm} <i>h. v.</i>	Sediments $.25^{\text{mm}}$ <i>h. v.</i> – 8^{mm} <i>h. v.</i>	Sediments $< .25^{\text{mm}}$ <i>h. v.</i>	Clay.
Matters insol. in HCl.....	65.41	66.28	71.87	80.21	83.98	66.89	42.90
SiO ₂ sol. in Na ₂ CO ₃ ..	1.57	3.74	11.00	1.46	7.64	8.95	33.49
Matters insol. in Na ₂ CO ₃ .	63.84	62.54	60.87	78.75	76.34	57.94	9.41
P ₂ O ₅ *	0.76	0.78	0.36	0.14	0.18	0.42	0.11
SO ₃	0.05	0.03	0.08	0.04	0.05	not det.	0.08
H ₂ O	0.34	1.20	1.77	0.21	0.34	.....	.....
K ₂ O	not†	not	.78	0.32	0.38	0.61	.....
Na ₂ O	deter.	deter.	.67	0.91	0.63	0.52	.....
CaO	6.29	6.54	2.48	3.01	2.58	2.07	0.17
MgO	3.42	3.05	.97	1.06	0.82	1.44	1.16
Fe ₂ O ₃	13.85	14.50	9.22	3.53	4.56	10.83	17.90
Al ₂ O ₃	8.25	10.25	8.95	10.63	5.90	9.15	15.48
Org. matter..	.....	---	3.52	----	----	7.40†	18.86†
-----	-----	-----	100.67	100.06	99.42	99.33	-----

* By extraction with HNO₃. † KCl + NaCl=4.54 per cent. ‡ Org. matter and water.

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Discussion of the analyses of the sediments by extraction with hot hydrochloric acid.

These analyses have first of all revealed the fact that the amounts of alkalies and alkaline earths, which were obtained by extraction with hydrochloric acid from the sediments 8^{mm} h. v.—64^{mm} h. v., .25^{mm} h. v.—8^{mm} h. v., <.25^{mm} h. v., and from the clay decrease almost proportionately to the decrease of total percentages obtained in the analyses by fusion.

The total amount of alkali-chlorides for instance in sediments 8^{mm} h. v.—64^{mm} h. v. yielded by the method of J. Lawrence Smith, is equal to 7.88 per cent. By extraction with hydrochloric acid 2.50 per cent were found. The total amount of alkali-chlorides in the silt obtained by the J. Lawrence Smith method is equal to 5.94 per cent. If we write now the proportion :

$$7.88 : 2.50 = 5.94 : x$$

we find $x = 1.88$ per cent, while 1.95 per cent of alkali-chloride were found in the silt by extraction with hydrochloric acid. The following tables exhibit these facts.

Sodium and potassium chlorides found.

h. v.	By J. Lawrence Smith		By extraction with HCl.	
	Method.		Per cent.	
8 ^{mm} —64 ^{mm}	7.88%	$\begin{cases} \text{K}_2\text{O} = 1.53\% \\ \text{Na}_2\text{O} = 2.90 \end{cases}$	2.22%	$\begin{cases} \text{K}_2\text{O} = .32\% \\ \text{Na}_2\text{O} = .91 \end{cases}$
.25 ^{mm} —8 ^{mm}			1.79	$\begin{cases} \text{K}_2\text{O} = .38 \\ \text{Na}_2\text{O} = .63 \end{cases}$
<.25 ^{mm}	5.94	$\begin{cases} \text{K}_2\text{O} = 1.76 \\ \text{Na}_2\text{O} = 1.67 \end{cases}$	1.95	$\begin{cases} \text{K}_2\text{O} = .61 \\ \text{Na}_2\text{O} = .52 \end{cases}$
Soil	7.48	$\begin{cases} \text{K}_2\text{O} = 1.08 \\ \text{Na}_2\text{O} = 2.56 \end{cases}$	2.50	$\begin{cases} \text{K}_2\text{O} = .78 \\ \text{Na}_2\text{O} = .67 \end{cases}$

Calcium oxide and magnesium oxide found.

h. v.	By fusion.		By extraction with HCl.	
	Per cent.		Per cent.	
	CaO.	MgO.	CaO.	MgO.
8 ^{mm} —64 ^{mm}	6.55	2.59	3.01	---
.25 ^{mm} —8 ^{mm}	---	---	2.58	.82
<.25 ^{mm}	3.07	1.72	2.07	1.44
Soil	4.57	1.99	2.48	.97

Phosphoric acid found.

h. v.	Total	By extraction with HNO ₃ .
	Per cent.	Per cent.
8 ^{mm} —64 ^{mm} .....	.33	.14
.25 ^{mm} —8 ^{mm} .....	.24	.18
<.25 ^{mm} .....	.42	.42
Soil .....	.43	.36

It is worth while to inspect these data a little more closely.

We have found, for instance, that the soil yields to hydrochloric acid 2.50 per cent sodium and potassium chlorides ($=.78$ per cent K_2O + $.67$ per cent Na_2O). We have further found by mechanical analysis that the silt and the clay, those fractions from which, owing to their fineness, the plant-roots most probably derive their food, form only about one-third part of the soil (31.84 per cent). We have also seen that the other two-thirds, which consists of coarse sediments, yielded absolutely and relatively much larger quantities of alkalies to hydrochloric acid than the finer sediments. The 2.50 per cent of alkali-chlorides found in the entire soil have therefore to be divided at least by four or five in order to give us an idea of the available plant-food, which even then is very uncertain. Exactly the same reasoning can be applied to the alkaline earths.

Speaking about soils, Professor Storer says in his text-book, "Agriculture in some of its relations with chemistry," vol. i, p. 199. "With the exception perhaps of midwinter, when everything is frozen stiff, it is certain that chemical changes are constantly occurring in every soil. From the chemical point of view nothing like rest can be conceived of in a mixture so complex as the loam of an ordinary field."

Considering again the results above discussed, I should like to add that to produce a "mixture so complex" nature has to work many thousand years; it seems to me, therefore, to be a vain attempt to force an answer from a soil by a single analysis as to its fertility, which is the result of the coincidence of numerous factors, of which some, and probably many, are so occult as to escape our direct observation. Among the favorable conditions which determine the fertility of a soil must be classed,

The distribution of the phosphoric acid.

My analyses show that the sediments $<.25^{mm}$ h. v. contain the largest amount of phosphoric acid ($.42$ per cent). With what bases is the phosphoric acid in the silt and in the other sediments combined?

In order to answer this question approximately I made use of the different behavior of the phosphates of iron, aluminum, and calcium toward dilute acetic acid, in which both the first-mentioned phosphates are almost insoluble and the latter soluble. The analytical results obtained by this method did not decide the question.* However, it is probable that in the

* 100 grm. silt and the same quantity of sediments $.25^{mm}$ h. v. - $.8^{mm}$ h. v. were treated each with 300 c.c. dilute acetic acid (25 parts glacial acetic acid to 75 parts water) for five days at ordinary temperature.

I. The silt yielded0074 grm. P_2O_5 .
 II. The sediments $.25^{mm}$ h. v. - $.8^{mm}$ h. v. yielded... .0043 grm. P_2O_5 .

coarser portions of this soil the alkaline earth phosphates predominate, owing to undecomposed apatite, while in the finer portions which contain more of the oxides of iron and alumina they change into phosphates of iron and alumina. This supposition is confirmed by the researches of E. Peters* and Warrington, Jr.†

Should we now attempt to decide about the degree of fertility of the soil, it would not be sufficient to know how much‡ phosphoric acid is contained in the soil, and with what bases it is combined; we ought also to know if the conditions in the soil are favorable to the decomposition or solution of the phosphates, particularly those of iron and alumina, so that the phosphoric acid could become available as plant-food.

Being aware of the omnipresence of the phosphates of iron and aluminum in the soil, Thenard§ has attempted to solve this question. By a laboratory experiment he showed that the available form of phosphoric acid—phosphate of calcium—is formed by a double decomposition of the phosphates of iron and aluminum and a soluble modification of calcium silicate. We must confess that even if that should be the true explanation of the phenomenon we are unable to trace those conditions in nature.

I have not made determinations of nitrogen and ammonia in the soil owing to lack of material, and other determinations have been omitted for the same reason.

The results of this investigation may be summarized as follows:

1. The action of hydrochloric acid on soils is far from uniform. This is seen when we compare the results obtained by extracting the Rockland Ridge soil with hot and cold hydrochloric acid, and the results which Grouven has published.

2. It is probable that plant-roots derive their nutrition from the finest sediments of the soil, from the clay. But this does not make necessary that the clay should be the richest of all sediments in plant-food. Such may be only the case if the coarser sediments consist of quartz-sand.

3. Hydrochloric acid corrodes powerfully not only the finest sediments of the soil, but also the coarsest. We have good

I. 100 grm. silt contain	·42 grm. P_2O_5 .
II. 100 grm. sed. ·25 ^{mm} h. v.—8 ^{mm} h. v. contain	·24 grm. P_2O_5 .

The acetic acid has therefore dissolved 1·76 per cent of the total P_2O_5 contained in the silt and 1·41 per cent of the total P_2O_5 contained in sediments ·25^{mm} h. v.—8^{mm} h. v. This experiment would have been probably more decisive if the sediments ·25^{mm} h. v.—8^{mm} h. v. had been converted by trituration to the same degree of fineness as the silt possesses.

* *Annalen der Landwirtschaft*, vol. xlix, p. 31.

† *Journ. of the Chem. Soc.*, new series, vol. vi, 1868, p. 5.

‡ "A soil may contain many thousand pounds of phosphoric acid or of nitrogen and yet be in a poor condition."—R. Warrington, *The Chemistry of the Farm*, p. 17.

§ *Comptes rendus*, 1858, vol. xlii, p. 212.

reason to suppose that plant-roots derive their food only from the finest sediments with the help of carbonic and weak organic acids. Therefore, extraction with hydrochloric acid does not reproduce or represent the processes which are going on in nature.

4. The fertility of a soil greatly depends not only upon the quantity of phosphoric acid which is present, but also upon the mode of its occurrence. We are unable to ascertain with accuracy with what bases the phosphoric acid is combined in the soil; we are further utterly unable to find out if the conditions for transformation of the insoluble phosphates into soluble ones are favorable in any given soil.

5. Therefore, it is not possible to decide about the fertility of a soil on the strength of a chemical analysis. As an exception, however, I must mention certain desert-soils. If chemical analysis should reveal that such a soil consists almost entirely of silica, we can with good conscience predict to the farmer very poor harvests.

I do not profess to have brought forward any new facts. I believe to have only confirmed by my work opinions which were expressed already long ago by authorities in the domain of agricultural chemistry. As chemical soil-analysis is still carried on in America and in Europe, often, it must be acknowledged, with industry and laudable perseverance, I thought it to be my duty to communicate my results, however modest and fragmentary they may be, to my fellow workers, with the hope to prove myself useful to them.

1887. Berkeley, Cal.