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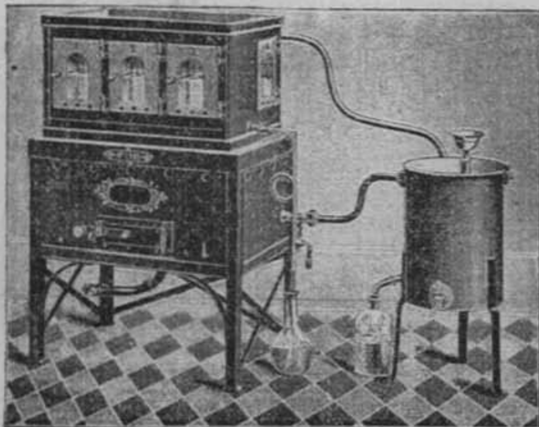
UNIVERSITY OF IDAHO,

AGRICULTURAL EXPERIMENT STATION.

DEPARTMENT OF CHEMISTRY.



I. IDAHO SOILS: THEIR ORIGIN AND COMPOSITION.

II. MISCELLANEOUS ANALYSES.

By CHAS. W. McCURDY, Sc. D.

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IDAHO SOILS:

THEIR ORIGIN AND COMPOSITION.

Introduction.

The purpose of this bulletin is to bring before the farmers of the State some scientific facts relating to their business, and "to diffuse among the people useful and practical information on subjects connected with agriculture."

During the past year considerable time was spent by the Chemical Department in an investigation of the soils of Idaho, and we herewith present the results of such study. The work in no sense is to be regarded as complete, but only preliminary to an exhaustive study of the composition and resources of the arable lands of the State, carried on from year to year.

A knowledge of the soil regarding its meteorological, physical and chemical properties is deemed of the utmost importance to agricultural progress; and since a study of "soil physics" has already been undertaken by the meteorologist of this station, for this reason, also, a thorough study of its chemical composition should no longer be delayed.

Again, as the government has not yet made a complete mineral and agricultural survey of the State, this work is to be regarded as preliminary to a complete *soil survey* to be prosecuted by this department in the interest of agriculture.

The popular mind has long attached undue importance, we think, to a chemical analysis of the soil, except in the case of virgin soil.* From the time of Liebig, whose writings on

*Journal of Am. Chem. Soc., Jan., 1894, p. 34.

Agricultural Chemistry, about 1850, aroused so much discussion, to the present, many chemists and agriculturists have questioned whether the average soil analysis is worth all it costs, in view of the fact of it telling so little, for the large amount of labor involved.

But such indecision should not cause us to falter, since much depends upon even a partial, to say nothing of the ultimate, success of such work. The California station has analyzed upwards of 1,500 samples of soil and has reached results that are invaluable to the agricultural interests of the State. The Louisiana, Maryland, Minnesota and Michigan stations have likewise made several hundred analyses. Such important lines of investigation as the method of cultivation, green manuring, application of fertilizers, rotation of crops, drainage, the treatment of alkaline lands, bear directly upon soil analysis*. And this work will increase in importance and value to the State as system prevails in selecting and sampling soils, area represented, and the grouping of results based upon the comparative study of several hundred analyses.

Chemistry, Geology and Agriculture.

So closely is chemistry connected with geology and agriculture that it is impossible to discuss one broadly and intelligently without overstepping the border lines that separate them Geologists have discovered certain distinguishing marks as common to all igneous and stratified outcroppings; the agriculturist recognizes in these rocks certain elements as essential in all fertile soils; while the chemist ascertains the *kind* and *amount* of the soil principles, determines whether harmful or beneficial, and directs how to maintain the soil's virgin fertility and to increase its productiveness. The term soil, therefore, may be used to designate not only the *medium* in which the plant grows, but also as a *source* of the food principles required by the plant. In this latter sense we use the term.

*A chemical analysis may serve to show the infertility of a soil, as in No. 9, found deficient in potash and phosphoric acid.

Origin of Soils.

Soil is the product of disintegrated rock produced by the prolonged action of heat, cold, moisture, air, vegetation and bacteria. Rock thus exposed crumbles, disintegrates; the process is called *weathering*. All soil was originally laid down as rock, in origin—igneous, aqueous, metamorphic and æolian; but by the action of the forces of nature the surface of the solid rock has been covered gradually with a varying thickness of its own detached or loosened particles. This loosened mass constitutes the *soil*, varying in depth from a few inches to several feet.

Composition of the Soil.

The composition of soil is affected by its origin, its age, kind of exposure, the method of cultivation, the crops grown upon it, and climatic changes. The soil about Moscow, the center of the Palouse country, is dark colored, deep and rich, finely divided, but does not freely drain itself; hence, plowing it when too wet, harrowing it insufficiently to admit of the free circulation of the air—oxygen and nitrogen—a prolonged drouth, or heavy precipitation, as during the fall of 1893, have a tendency to "kill" the soil, to make it unproductive, hence to modify its physical as well as chemical properties. The writer inspected, the past summer, some land south of Moscow which had been thus "killed."

Now, with a knowledge of its chemical and physical properties, and then the exercise of good sense in its cultivation, such soil may be reclaimed and its natural fertility restored.

Every observing and thinking man knows that soil is composed of two classes of compounds (1) the *organic* or volatile portion—that which burns; and (2), the *inorganic* or ash, which will not burn.

The organic portion is largely a black mould or *humus*, so called, the product of decayed animal and vegetable matter. Humus varies greatly in quantity in different soils. Peaty soils may contain 70 per cent.; stiff clayey soils have yielded as high as 12 per cent., while some soils are destitute of humus.

It does not follow, however, that a soil is productive as it is rich in humus, though, as a rule, "a black soil rich in humus is sure to be also rich in nitrogen, an essential plant food; while a soil destitute of humus contains scarcely any nitrogen." * While the humus is a measure of the soil nitrogen, especially in *virgin* soils, it is not, however, immediately available as plant food; it is not easily soluble in water; it is deficient in oxygen which is absorbed from the atmosphere producing carbon dioxid—carbon for the growing plant.

Humus is made serviceable and contributes slowly to plant growth by the action of heat, moisture, alkalies, other chemical agents and tillage. Humus has great absorbent power for ammonia; so also have ferric oxid and alumina.† The *bacteria* present in all soils oxidize the humus and ammonia and their nitrogen is largely converted into nitric acid. Nitrification is most active in soils containing lime carbonate, under good tillage, during the night, at summer temperatures. Good wheat lands should contain from 1.5 to 2.0 per cent. of humus.

Soils Chemically Classified.

The inorganic portion of soil is both soluble and insoluble in water; the soluble parts are the usual saline ingredients found in the ash; the insoluble or earthy portion is the great bulk of most soils. *Silica* in the form of sand; *alumina* combined with sand to form clay; and *lime*, as limestone, chalk and marble, constitute the principal earthy ingredients. Accordingly, we have what is termed *sandy soils*, those which contain about 10 per cent. of clay; *light sandy loam*, containing a maximum of 25 per cent. clay; *sandy loam*, not exceeding 40 per cent. clay; *loam*, not more than 60 per cent. clay; *clay loam*, where the clay constitutes about 75 per cent.; and *strong clay*, fit for making tiles or bricks. *Marl* is soil containing 5 per cent. or more of lime carbonate; if the lime exceeds 20 per cent. the soil is termed *calcareous*; if the quantity of organic matter be above 50 per cent. the soil is called *muck*.‡

*The Chemistry of the Farm, Warington, p. 22.
†The Chemistry of the Farm, Warington, p. 26.
‡Fowne's Agricultural Chemistry, p. 88.

Chemical Elements Present in Soil.

A chemical element is a simple substance composed of but one kind of matter all of whose atoms, if it were broken up, would be alike in every particular. Seventy-two elements are now known to the chemist;* of these fifty-four are called metals; the other eighteen are called non-metals. Some are gases at ordinary temperatures—oxygen; two are liquids—mercury and bromin; others are called solids. Many of these elements were present in the parent rock, but for analytical purposes relating to agriculture only those which contribute to plant growth are enumerated.

METALS.

Aluminum,	Magnesium,
Barium,	Manganese,
Calcium,	Potassium,
Iron,	Sodium.

NON-METALS.

Boron,	Nitrogen,
Carbon,	Oxygen,
Chlorin,	Phosphorus,
Fluorin,	Silicon,
Hydrogen,	Sulfur.

Twelve of the elements above named compose ninety-nine one-hundredths of the earth's crust, and these are usually found in a chemical analysis. Dr. F. W. Clarke, Chief Chemist of the Geological Survey, Washington, D. C., has calculated the relative distribution of the elements as follows:†

Atmosphere.................................. 0.03 per cent.
Water .... 7.08 per cent.
Solid crust of the earth to the depth of ten miles.92.89 per cent.

Chemical Terms Explained.

The chemical and physical properties of some of the elements named were fully explained in Bulletin No. 8, "Water and Water Analyses," pages 13-17, to which the reader is

*Journal Am. Chem. Soc., Mar 1894, p. 192

†Wiley's Agricultural Analysis, Jan , 1894, p. 23.

referred. But any one not possessing a copy of the bulletin and unacquainted with agricultural chemistry may find the tabulated matter that follows uninteresting reading, if not unintelligible, having no key to its interpretation. To such a few words of explanation are necessary. Only the most important elements are noted:

Aluminum forms the basis of the clays and is an abundant element in the constituents of feldspar, mica, kaolin, slate and other rocks and minerals. It gives strength and stability to the soil.

Calcium as lime is known to everybody. It is an essential plant food and greatly increases the fertility of all soils, particularly of alkali soils.

Iron oxids constitute the coloring matter of many rocks and minerals, hence of soils. Iron is an important plant food; it retains the phsophoric acid by converting it into an insoluble basic phosphate, and with alumina has a retentive power for ammonia and potash.

Potassium is abundant in feldspar and granites; it is liberated by weathering and later accumulates in the roots and stems of plants. It is not known just how this substance contributes to plant growth; it is sure, however, plants cannot live without it, and that soil destitute of potash is always barren. This is true of the soils of the Southern States which have been cropped continuously with tobacco. No common crop is as great a robber of the soil of potash as tobacco.

Sodium cannot take the place of potash in soil fertility or plant growth. The carbonates and sulfates of soda constitute the injurious components of our alkali plains. In the "black" alkali, sodium carbonate predominates; while in the "white" alkali the sulfate of soda is in excess.

Oxygen is a supporter of life and combustion, hence oxidizes or burns the organic matter of the soil and unites with the elements to form oxids, varying in degree. It is an acid former;

it composes one-fifth of the bulk of the atmosphere, eight-ninths of water and one-half the weight of the earth's crust.

Silicon combined with oxygen is known as sand. It constitutes one-fourth the earth's crust. In grains and grasses silica tends to stiffen the blades and prevents lodging.

Carbon constitutes the principal part of mineral coal, hence composes the woody tissue of plants, and the principal part of peat and muck.

Phosphorus is an essential element in plant and animal food and is always found in the tissues of the same. Fossiliferous rocks yield phosphoric acid in abundance. "Cereal crops remove about 20 pounds of phosphoric acid per acre from the soil annually, and grass crops about 12 pounds. The total phosphoric acid removed annually by the cereal and grass crops in the United States is nearly 4,000,000,000 pounds.*

Nitrogen constitutes four-fifths of the atmosphere, in a free state; it may also be obtained from sea weeds†, fish, guano, feathers, all animal tissues, insects, and Chile saltpeter‡. Nitrogen in the soil exists largely as combined nitrogen and is found in three classes:

1. Nitrogen combined with oxygen, as nitrates and nitrites.

2. Nitrogen combined with hydrogen, as free and albuminoid ammonia.

3. The humus nitrogen.

The *active* soil nitrogen—that which is more or less immediately available for the crop—comprises the first two classes; the *inert* nitrogen is the third class.

Nitrogen in the free state is not now believed to be directly absorbed by the tissues of the plants but must be oxidized and converted into nitric acid by minute oxidizing germs before the

*Wiley's Agricultural Analysis, Jan., 1894, p. 6.

†Wiley's Agricultural Analysis, Jan., 1894, p. 13.

‡Wiley's Agricultural Analysis, Jan., 1894, p. 16.

plant can assimilate it. Nitrification is most rapid under good tillage, at 98° F. and during the night. At a temperature of 130° F. and during bright sunshine the organism becomes inactive. There must also be plenty of bacterial food in the soil, as phosphoric acid, potash and lime. "The importance of nitrogen as a plant food cannot be overestimated. It is as necessary to plant growth and development as water, phosphoric acid, lime, and potash, and far more costly."*

The acids present in soil are hydrochloric, silicic, phosphoric, sulfuric, nitric, nitrous, and carbonic, some vegetable acids, and water in varying proportions. These acids unite with the metals or bases above mentioned to form salts, which occur as chlorids, and silicates of potassium and sodium, phosphates of iron, magnesium, manganese and aluminum, calcium sulfate or carbonate, with probably some vegetable salts of lime, soda or potash.

Of the above, sulfuric acid, phosphoric acid, iron, lime and humus will be depleted by the crop and must be restored either by the application of green or stable manure, or fertilizers.

It is a question whether a minimum percentage of these food principles for a thrifty, growing crop can be safely calculated; but Dr. E. W. Hilgard† has attempted it, and by way of comparison with Idaho soils we append the substance of his views:

Potash.—A clay loam should contain not less than .50 to .80 of one per cent.; lighter loams at least from .30 to .45; sandy loams from .10 to .30; if virgin soils fall below .06 per cent. they should be regarded as deficient in potash. The average of potash in the arid soils of the Pacific northwest is from .7 to .8 of one per cent.

Phosphoric acid.—In sandy loams .10 per cent. is sufficient when accompanied by lime. European chemists have fixed the minimum percentage of this acid for profitable culture at .05 of one per cent. When less than this quantity is present in any

*Wiley's Agricultural Analysis, Jan., 1894, p. 13.

†U. S. Census, 1880, vol. 5; also Cal. Exp. Sta. Report, 1888.

soil production will cease unless phosphatic fertilizers are used.* Basaltic soils may contain as high as .30 per cent. or more. The writer found 1.74 per cent. of phosphoric acid in soil 33, probably an exceptional case due to crystals of apatite. However, the great eruptive sheet of Oregon, Washington and Idaho has proved to be very rich in phosphates.†

Lime.—Sandy soils fairly productive may carry as low as .1 of one per cent. of this ingredient, says Dr. Hilgard; heavy clay soils range from .3 to 2 per cent.

Iron.—Soils but little tinted carry from .4 to 1.5 per cent. of ferric oxid; loam from 3.5 to 7.0; red mountain soil and red clay should carry from 7 to 12 per cent., which may rise to 20 or more. Soil 16 is of this character.

Humus.—Poor sandy soil, says Dr. Hilgard, should carry .4 to .5 per cent.; black calcareous soils from 1.2 to 2.8. Humus also increases the capillary capacity of the soil to hold water fully 20 per cent.

Physical Properties.

The physical condition of the soil has much to do with the growth and nutrition of plants; *indeed, it may be paramount to its chemical composition.* We will touch upon these factors briefly.

The temperature of a soil is influenced by its color; dark colored soils, as a rule, have the highest absorptive power of the sun's heat, and radiate the fewest rays; hence must attain the highest temperature. Light, sandy soils, on the other hand, are subject to extremes in temperature. The presence of humus is thus favorable to soil warmth.

The porosity of soil is an important factor in fertility. The basaltic soil is characteristically porous and finely divided. As plants assimilate food only from solutions, and the more finely divided the soil so is its dissolving power, the value of this

*Journal Am. Chem. Soc., vol. XVI, No. 1, p. 46.
†Journal Am. Chem. Soc., vol. XVI, No. 1, p. 42.

property becomes apparent. Yet the soil should not be so fine as to become impacted; it should allow of self-drainage.

The capillary capacity of the soil, by which we mean its power to absorb water and hold it, is of the highest importance.

The Minnesota station* has shown that a liberal application of well rotted yard manure will increase the capillary capacity of a soil 3 6 per cent. on an average. Humus also intensifies this property of soil.

Another physical property is weight. The density or specific gravity will be affected by tillage; hence the weight of a soil per cubic foot will vary. This item was not determined in the analyses submitted, but Schubler states the weight in pounds per cubic foot as follows:

Sand	110
Sand and clay	96
Sandy loam	85
Heavy clay	75
Vegetable mould	78
Peat	30 to 50

The average weight of dry soil varies from 62 to 66 pounds per cubic foot; or, an acre of average land, taken to the depth of one foot, will weigh about 4,000,000 pounds.

There are many other physical conditions, as snow, rainfall, clouds, sunshine, winds, altitude, exposure and vegetation, that exercise modifying influences on the fertility of soil and the growth of a crop, but we will omit their discussion.

With this discussion of soils in general we will now turn our thought to the soils of Idaho in particular.

Topographical and Geological.

Idaho is a portion of a vast area acquired by cession and by treaty from France in 1803, and from Spain in 1819. The State lies in longitude 111°-117° west, and in latitude 42°-49° north. Its length is about 410 miles north and south, its width varying from 44 miles in the north to 306 miles in the south. The State has an area of 86,294 square miles, or 55,228,160 acres, an area

*Minnesota Bulletin, No. 30, p. 183.

equal to all of New England and West Virginia, and greater than the combined area of Switzerland, Greece, Portugal and Belgium.

The topographical features of the State are most varied—a vast plateau varying in altitude from the plains of Lewiston (530 ft.), to the more elevated regions of Moscow (2600 ft), Boise (2830 ft.), Pocatello (4446 ft.), Idaho Falls (4712 ft.), and Paris (6000 ft.), to 10,000 feet in the eastern part.

The State is diversified by mountain ranges, broad and fertile hills and valleys, and extensive prairies. The most valuable of gems and the richest of minerals lie underneath its rugged surface, so that Idaho, "Gem of the Mountains," is an apt and literally true appellation of the State.

By the Clearwater river the State is naturally divided into North and South Idaho. The latter is again physically divided east and west into three divisions: 1. That portion included between the Snake river and the southern boundary; 2. The part lying between the Snake and the Salmon rivers; 3. The section between the Salmon and the Clearwater.

South Idaho is largely a great lava plain through which the Snake has cut its way for a distance of 1,000 miles. This great laval overflow probably occurred near the middle of the Mesozoic or at the end of the Jurassic, when the Sierra Nevadas and Blue Mountains were born, subsequent overflows occurring with the formation of the Coast Range during the end of the Middle Tertiary or Miocene.* The violence of this volcanic fire must have been terrific, as the entire northwest was covered with ashes from 25 to 100 feet deep, reaching 3,000 feet where the Columbia breaks through the Cascades, and destroying in its track every vestige of vegetable and animal life.

In the arid regions of Idaho this eruptive material forms the surface soil, which becomes very productive when irrigated. The Silurian formation outcrops in Bear Lake County, overlaid in places by the Carboniferous and well defined areas of the Triassic, Cretaceous and Tertiary strata. The Quarternary areas are largely confined to the river bottoms which constitute

*Elements of Geology, Le Conte, p. 259.

the arable lands, bounded by extensive desert plains, or sage-brush areas.

The central and northern divisions are less arid, rich in mineral resources and timber, and their valleys and prairies (Camas) offer every inducement to the husbandman and stockman.

North Idaho begins at the Clearwater, where at Lewiston there is an abrupt rise of 2,000 feet to a table land as beautiful and extensive and fertile as there is to be found anywhere in the United States. The soil is alluvial, of volcanic origin, and requires no irrigation. The total precipitation at Moscow for the twelve months just passed was 23.89 inches. This is a part of the far-famed Palouse country, remarkable for its productiveness, whose area is about 25,000 square miles, comprising a portion of eastern Washington, and northern Idaho. As before stated, it is a table land, broad and rolling, deeply cut with valleys and hills, which are plowable to the very top. It still bears evidence of its origin, the bed of an immense Paleozoic inland sea which was drained through the Columbia. The soil is deep, finely divided and remarkably fertile still, though cropped continuously for a decade or two, and without the application of fertilizers. Indeed, from the summit of Mount Moscow, or Kamiac Butte, in August, one may look down upon an immense wheat field covering hundreds of square miles, producing from 30 to 60 bushels of wheat per acre. The soil is of basaltic origin, a compound rock, rich in plant food. The rock is very dark, almost black, exceedingly hard and porous and quite heavy. It is composed, mineralogically, of plagioclase, augite and olivine. It crumbles rapidly on exposure, though apparently it would resist in a high degree the agencies of disintegration; but being of a complex nature and containing a considerable amount of ferrous oxid (FeO), which the air further oxidizes quite rapidly forming ferric oxid (Fe_2O_3), the bonds of the minerals are loosened and the rock passes into its integrant parts. Number 33 is an average sample of this basaltic rock.

Agricultural Lands.

There are in Idaho 16,000,000 acres of land classed as agricultural, of which about two-thirds require irrigation. These lands lie principally in Southern Idaho. The grazing lands cover 25,000,000 acres, while the remaining millions may properly be classed as mineral lands.

These arable lands are widely diversified as to altitude and natural fertility, admitting of the growing of every hardy cereal, grasses and all kinds of hardy fruits in great abundance.

"Of the agricultural valley land it is estimated there are 13,000 square miles situated at an elevation of less than 3,000 feet; 10,000 between 3,000 and 4,000 feet; 22,000 between 4,000 and 5,000 feet; and 19,000 square miles between 5,000 and 6,000 feet.* This affords a large field of activity for the practical and experimental agriculturist in testing climatic and soil conditions bearing upon plant growth.

Soils Classified.

No specific classification of Idaho soils is attempted at this time owing to the limited number of analyses made, and to the lack of sufficient data regarding the physical features of the state. It is sufficient to know that the soil is composed of decayed volcanic matter, lava, basaltic, and other rock, disintegrated minerals and vegetable mould. Roughly classified four general divisions may be named:

First.—"Mountain soil," which is rich in iron oxids, and, in the timbered regions, in vegetable mould, deep and black.

Second.—"Soils of the plains and plateaus," which are plentifully supplied with all the essential elements of a rich and abundant vegetation. Three-fourths of the arable lands of the State belong to this class.

Third.—"Valley soils," which possess the highest excellence and may be cropped for years with no material deterioration.

Fourth.—"Alkali soils," which are composed of a superabundance of soluble salts of the sulfate and carbonate of soda. Their composition was discussed briefly in Bulletin No. 3, March, 1893, and will be more thoroughly studied and reported

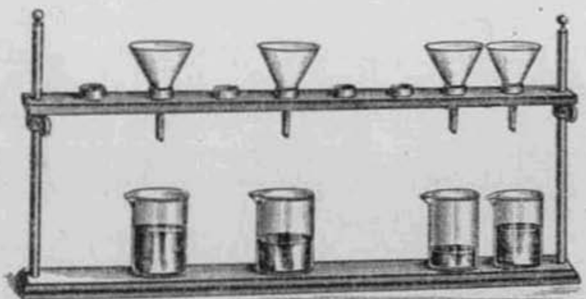
*Idaho's Souvenir at World's Fair.

on in a subsequent number. This department specially desires samples of such soil.

Sampling Soils for Analysis.

As only a limited number of soil analyses can be made each year it will be the purpose of this department to have the work representative as to locality, quality, physical conditions and method of sampling, hence *only those samples taken according to directions sent out from this office will be analyzed.* These directions may be obtained on application. Specimen samples of each soil analyzed are retained in this office for exhibition.

All communications relative to analyses and other matter pertaining to chemical work should be addressed to the chemist of the station.



SOIL ANALYSES.

The soils whose composition is given in the following tables were largely sampled according to specific directions, and all the required data pertaining to each sample is on file in this office. Only the salient parts are selected for publication. The figures represent percentages, that is, pounds of the ingredient per one hundred pounds of soil.

The record of examination of thirty-three soils is found below, and in connection with these analyses it will be desirabie for the reader to again refer to the matter on pages 8 to 11.

TABLE I.

Kootenai County Soils—Cœur d'Alene.

Type of Soil	Worn out Top	Subsoil	Muck	Virgin
Number of Soil	9	10	11	20
Coarse earth	60.00	72.00	32.80	21.30
Fine earth	40.00	28.00	67.20	78.70
Humus	7.31	1.46	7.58	7.90
Capacity to retain water	64.70	47.30	44.90	59.55
Fine Earth.				
Sand and silicates	74.00	79.78	57.82	67.19
Alumina, Al_2O_3	1.60	2.08	2.91	1.39
Iron oxid, Fe_2O_3	8.26	9.64	13.44	2.30
Lime, CaO	1.32	.17	.47	.94
Magnesia, MgO	.03	.04	.03	1.16
Soda, Na_2O / Potash, K_2O Chlorid	.22	.40	.03	2.72
Sulfuric acid, SO_3	.06	.30	.06	.54
Phosphoric acid, P_2O_5	Trace	Trace	.40	.45
Carbonic acid CO_2	Trace	1.14	.00	Trace
Organic matter	11.49	4.74	24.27	17.74
Water	1.85	1.40	.39	5.21
Total	98.83	99.69	99.82	99.64

These soils were selected by Mr. H. S. Back, Cœur d'Alene, from S. W. ¼, Sec. 30, T. 15, R. 3. He says: "Similar tracts of land are extensive at the edge of the foothills and prairies all over this portion of the State; out on the prairies, away from the timber, the soil is better. In a wet, warm season the crop is good; cold and wet, crops fail. In a dry season, on virgin soil, crop is fair; but the soil soon wears out. Fall plowing is of no avail, as the soil gets very hard by spring."

Number 9 is reported as a worn out soil, having been in use 8 years—to potatoes, 3 years; wheat and oats, 2 years, and left idle as worthless, 3 years. Its analysis shows it to be deficient in potash, phosphoric acid and probably available nitrogen.

Number 10 is the subsoil of 9. Note the small amount of humus and organic matter present.

Number 11 is a poor quality of muck, reddens blue litmus and is sour to the taste and smell when moistened. Good muck should have a deep, brown-black color; friable, easily breaking between the fingers; should possess a pleasant earthy smell, but free from any acid odor, or acid reaction.

Sour muck will sour the disposition and drain the pocket of him who attempts to cultivate it. Drainage, and exposure to weathering and to frost, and the application of lime, ashes, even leached ashes, would probably sweeten the soil and make it productive for certain crops. A good bed of muck is the placer mine of the farm, as it contains about 2 per cent. of nitrogen. Harness this factor along with barnyard manure in compost, or mix muck and marl together, and the crop that receives the dressing should bud and bloom even as the rose.

The composition of muck varies with its depth, as illustrated in the following table:*

	Carbon.	Hydrogen.	Nitrogen.	Volatile Matter.
1 foot	57.67 per cent	4.48 per cent	2.34 per cent	90.60 per cent.
2 feet	47.07 per cent	5.15 per cent	1.40 per cent	72.00 per cent.
3 feet	8.52 per cent	0.53 per cent	0.31 per cent	15.00 per cent.

No. 20 is a sample of virgin soil, but, like the others, is deficient in the essentials of plant growth. Fertilizers would benefit the immediate crop on such soil.

TABLE II

Latah and Shoshone County Soils—Moscow and Weippe.

Type of soil Number of soil	Virgin 17	Subsoil 18	Cultivated 19	Cultivated 5
Coarse earth	5.21	11.44	4.00	00.00
Fine earth	94.79	88.56	96.00	100.00
Humus	3.26	1.96	2.24	3.47
Capacity to retain water	59.34	55.44	54.30	65.33
Fine Earth.				
Sand and silicates	77.23	73.77	72.91	78.02
Alumina	4.52	1.68	1.56	.34
Iron oxid	3.21	1.49	2.14	2.29
Lime	2.80	.41	.13	.78
Magnesia	.51	.27	.19	.72
Soda	.01	2.56	.12	.03
Potash	.59	1.83	.61	.04
Sulfuric acid	.48	.34	.18	.18
Phosphoric acid	.49	1.45	1.57	.35
Carbonic acid	.00	.06	.12	.81
Organic matter	6.87	9.55	13.95	13.65
Water	3.32	5.87	6.83	2.85
Total	100.03	99.28	100.31	100.06

The soils comprising this table are representative of the virgin, cultivated and subsoil of the Palouse region for many miles about Moscow.

No. 17 is an average virgin soil taken from the pasture field

*Agricultural Science, 1893, p. 106.

southwest of the University building. Three samples were taken—one from the north side, another from the top, and the third from the south side of the hill. An analysis was made of the mixture.

No. 18 is the subsoil of the preceding. Note that the soda in 17 has apparently been washed into 18 by rainfall.

No. 19 is a representative from the experimental plat of the station at the left of the campus. These samples were taken April 24.

No. 5 is from the centre of sections 23 and 24, township 36 N., range 4 E., Weippe, Shoshone County. It is from the region known as "Long Meadow" or "Long Prairie." Mr. J. M. Sivadie, the owner, says: "It is a fair wheat, oat and barley soil; good grass land; small fruits do finely, large fruits have never been grown."

By reference to the views of Dr. Hilgard, on pages 10 and 11, these soils will be seen to be far above the minimum quantity in the essentials of plant growth.

TABLE III.
Nez Perce County Soils—Lewiston.

Type of soil Number of soil	Virgin 31	Subsoil 32	Rock 33
Coarse earth	.00	16.00	100.00
Fine earth	100.00	84.00	.00
Humus	3.47	2.70	.00
Capacity to retain water	52.10	38.50	29.60
Fine Earth.			
Sand and silicates	83.92	87.98	87.06
Alumnia	.12	.21	.86
Iron oxid	1.35	1.35	2.26
Manganese	.13	.19	.37
Lime	3.75	1.39	2.69
Magnesia	.91	.59	1.94
Soda	.013	.008	.300
Potash	034	.034	.110
Sulfuric acid	.23	.57	.85
Phosphoric acid	.25	1.29	1.74
Carbonic acid	.16	Trace	.00
Organic matter	5.75	3.70	.00
Water	3.20	2.18	.95
Total	99.82	99.49	99.15

This department is indebted to Mr. M. J. Wessels, of Lewiston, for this table of soils. They are from the S. E. ¼ of the S. E. ¼ of section 29, township 36, range 5; selected August 10.

No. 31 is a representative virgin soil of the lower Clearwater valley. It is particularly rich and the climate is most favorable for the growing of all kinds of fruits and vegetables of the choicest varieties in great abundance. Irrigation has to be resorted to.

No. 32 was taken about 100 feet above the Clearwater, and is a virgin subsoil.

No. 33 is a good sample of the basaltic rock in which much of the soil in this and localities elsewhere has had its origin.

These soils are abundantly supplied with lime, iron, phosphoric acid and humus, rather meager in potash, but practically free of soda. With proper care in the rotation of crops and soiling, these lands should constantly increase rather than deteriorate in fertility.

TABLE IV.

Idaho County Soils—Grangeville.

Type of soil	Subsoil	Adobe	Cultivated	Mountain (Virgin)	Tiptop Mountain
Number of soil	12	13	14	15	16
Coarse earth	66.00	2.30	5.00	.00	.00
Fine earth	34.00	97.70	95.00	100.00	100.00
Humus	1.61	.91	9.88	.71	1.24
Capacity to retain water	75.10	61.95	52.40	61.10	50.70
Fine Earth					
Sand and silicates	49.76	70.74	76.61	69.59	70.16
Alumina	2.86	.76	1.34	2.40	.86
Iron oxid	23.60	11.35	1.94	10.20	15.80
Lime	1.35	1.49	1.44	.64	.60
Magnesia	.58	2.52	.34	.22	.20
Soda	1.45	.23	.52	1.72	.72
Potash	.02	.04	.40	1.92	1.16
Sulfuric acid	.07	.02	.30	.63	.23
Phosphoric acid	.09	.62	.01	.01	.07
Carbonic acid	.00	.11	.00	Trace	.00
Organic matter	10.36	7.03	12.46	7.43	7.50
Water	9.00	4.27	5.44	5.10	2.57
Total	99.14	99.18	100.80	99.86	99.87

These soils were taken from the experimental sub-station at Grangeville. I desire to call attention to two samples only.

No. 13 is remarkable for its low contents of potash and extraordinary amount of magnesia, the lime, phosphoric acid and humus being well represented. The "adobe" soil, of which this an excellent sample, when wet "sticketh closer than a brother;" and is unworkable except for marbles or bricks, unless taken just at the right point of moisture. Heavy clay usually forms the subsoil of the adobe. Thoroughly tilled it retains moisture well and produces good crops. It is a fine-grained, porous earth varying in color through many shades of gray and black and difficult to drain because of its natural location, a fact which works against its improvement; otherwise underdrainage and green manuring, I think, would materially enliven the soil and improve its physical condition. Adobe is found throughout the arid region from Mexico to Canada and from the Pacific to the Rockies.

No. 14 is a soil now under cultivation and is a modified adobe. It is probably a good average of the "Camas prairie" soils, plentifully supplied with lime, potash, phosphoric acid, sulfuric acid, and humus at the rate of 57,600 pounds, 16,000 pounds, 400 pounds, 12,000 pounds, and 393,200 pounds per acre respectively, estimating an acre of soil one foot deep to weigh 4,000,000 pounds. The section of the field from which this sample was taken has been laid off into 1-20 acre plats for experimental purposes. Its productiveness, therefore, will be heard from later. The experiment station, consequently, is happily located in a famous county and upon a famous prairie which deserve further mention.

Idaho is by far the largest county in the State and is reported to be one of the largest in the United States; its area is unknown. Its eastern boundary reaches up into the Bitter Root Mountains, even to the Montana line, while its western shore is washed by the milky waters of the Snake—a breadth of nearly 200 miles. The county is destined to become one of the richest and most populous in the State, as its mineral resources are extensive, its grazing facilities unlimited; while the famous Camas prairie, which constitutes the heart of the county, is a paradise for grain growing and fruit raising.

Camas prairie is a big country having but little waste land, watered plentifully from the heavens and from the snow-capped mountains which environ it, and is capable of supporting a quarter of a million people.

Ex-Governor Stevenson, in his report to the Secretary of the Interior in 1888, says of the county and of the prairie n particiular: "Being perfectly familiar with the great northwest, I have no hesitation in saying no other locality offers more or better inducements to the home-seeker than this county. The people are enterprising, intelligent and progressive. Fine farms, buildings, orchards and other improvements on every side tell the traveler that this is the home of a happy, prosperous and thriving people." The prairie is a part of the Clearwater basin and has long been monopolized by the Nez Perce Indians as a reservation but which shortly will be thrown open to settlement. Fortunate is the man who acquires the title to a section of this region; for, as one has said, "Tickle it with a plow and it will laugh you a harvest of flour."

TABLE V.

Canyon County Soils—Nampa.

Type of Soil / Number of Soil	Cultivated 1	Subsoil 2	Lava Rock 3	Rock 4	Cultivated 6	Cultivated 7	Cultivated 8
Coarse earth	.00	5.00	100.00	100.00	.00	.00	.00
Fine earth	100.00	95.00	.00	.00	100.00	100.00	100.00
Humus	1.02	.04	.01	.02	.47	.43	1.77
Capacity to retain water	40.25	54.75	46.00	45.00	43.60	41.50	28.10
Fine Earth.							
Sand and silicates	81.62	77.73	70.96	73.19	69.54	78.28	76.80
Alumina } Iron oxid }	3.50	.51	4.14	2.32	3.36	4.50	2.60
Iron oxid		2.80	11.67	2.30	11.84	6.20	9.00
Lime	2.70	1.34	5.28	6.22	.69	Trace	.65
Magnesia	.58	1.36	.82	.91	1.60	.57	.38
Soda, Potash } Chlorid	1.63	.86	.68	1.31	2.83	.86	1.19
Sulfuric acid	.06	.03	1.09	.26	.41	1.56	2.36
Phosphoric acid	.31	.27	.30	.17	1.20	.09	.19
Carbonic acid	00	6.85	4.63	12.03	Trace	Trace	00
Organic matter	6.45	6.94	.30	.30	7.01	4.50	4.05
Water	2.68	1.30	.18	.20	.15	3.05	2.02
Total	99.53	99.99	100.05	99.21	98.63	99.61	99.24

Soil 1 is a sample from the experiment sub-station at Nampa. Sugar beets were produced on this soil in 1893. A portion of the field has since been platted for experimental purposes.

No. 2 is the subsoil of the preceding. Note the presence of a considerable quantity of lime carbonate.

No. 3 is an analysis of surface lava rock from the station. It is very hard and porous. It contains a good deal of lime and iron which will facilitate oxidation and act as a storehouse for the phosphoric acid.

Soil 4 is a light-colored rock taken at a depth of six feet when excavating in placing the soil thermometers. The sample is fairly rich in lime carbonate. It might be profitable to quarry the rock for fertilizing purposes.

Soil 6 comes from the first bench from the river on land owned by the Ditch Company—located in the N. W. of the S. W. ¼ of Sec. 7, T. 3 N., R. 1 W. One crop, potatoes, had been grown on this soil.

No. 7 comes from the ranch of Mr. Ben. Walling, on Wilson Creek, in the N. E. of the N. E. ¼ Sec. 15, T. 3 N., R. 2 W. The entire absence of lime carbonate and the small quantity of humus and phosphoric acid are noticeable. A root crop was harvested from the soil just before sampling.

Soil 8 is from the N. W. of the N. W. ¼ of Sec. 35, T. 3 N., R. 2 W., comprising the Duff ranch, well up and on the opposite side of the town from the station. One crop, potatoes, had been grown in this soil.

These samples were taken by Mr. T. T. Rutledge in December, 1893. They are fairly representative of Canyon County soils, which are within the arid district and are dependent upon irrigation for agricultural purposes, as the precipitation at Nampa the past year amounted to only 10.82 inches.

TABLE VI.

Bingham County Soils.

Type of soil. Number of soil	Cultivated 21	Cultivated 22	Cultivated 23	Cultivated 24	Virgin 25
Coarse earth	.00	.00	.00	.00	.00
Fine earth	100.00	100.10	100.00	100.00	100.00
Humus	4.09	.52	2.18	.83	3.72
Capillary capacity	53.88	64.90	58.50	63.60	57.50
Fine Earth.					
Sand and silicates	69.19	84.87	82.90	79.85	76.23
Alumina	2.61	.26	.44	.33	2.36
Iron oxid	1.59	.49	1.53	.73	7.24
Lime	.07	2.59	2.15	2.08	.06
Magnesia	.31	.29	.14	1.25	1.09
Soda	2.43	2.47	2.51	2.83	2.03
Potash	1.16	1.22	1.28	.99	1.04
Sulfuric acid	.79	.86	.51	.49	.85
Phosphoric acid	1.39	.47	.41	1.16	.21
Carbonic acid	.00	.00	.44	.00	.00
Organic matter	14.40	3.88	3.84	6.77	5.13
Water	5.92	2.27	3.27	2.57	3.83
Total	99.86	99.67	99.42	99.05	100.07

Mr. W. F. Cash, who gathered the samples comprising Table VI, says: "Number 21 is from the farm of Edward Stauffer, on the south fork of the Snake near where it enters the hills; under cultivation seven years; soil 15 to 30 feet deep; subsoil gravel; soil very productive if summer fallowed, yielding from 40 to 60 bushels of wheat, 60 to 90 bushels of oats and from 300 to 500 bushels of potatoes per acre. If cropped *every* year the third crop will be a failure. This is the typical soil of all the country along the foothills." This sample appears deficient in lime, which would account for its lack of durability.

"Soil 22 is from the place of O. M. Miller, in Louisville townsite; has been under cultivation six years; soil deep with gravel subsoil; equally as productive and 'quicker' than the preceding; makes good brick, and is the typical soil along the South Fork and on Menan Island."

"No. 23 is from section 27, T. 2 N., R. 38, and is known as 'red soil.' The soil is not as deep and is not as productive as Nos. 21 and 22, but quicker than either.

"No. 24 is from the station farm; cultivated two years; soil 1 to 4 feet deep; gravel subsoil; quicker than any of the others but not so productive nor as durable. This is the typical soil of the entire country between the river and the first bench."

No. 25 is virgin soil adjacent to 24. Samples were taken May 9, 1894.

The farmers of the county are enterprising and progressive, grain growing and stock raising being the chief pursuits. The county is under a perfect network of irrigating canals, nearly 300 miles of mains being in operation, representing $1,000,000 investment, with about 500,000 acres under water. As may be seen from the analyses the soil is naturally fertile but not durable, its producing capacity being limited by the system of rotation practiced and irrigating facilities, which at this point appear to be limitless. Root crops, particularly the sugar beet, and alfalfa should here reach almost perfection. The county is also supplied with some timber, coal and an abundance of "red rock," a superior building stone.

TABLE VII.

Bear Lake County Soils.

Type of soil Number of soil	Virgin 26	Top 27	Subsoil 28	Virgin 29	Cultivated 30
Coarse earth	.00	.00	27.00	.00	.00
Fine earth	100.00	100.00	73.00	100.00	100.00
Humus	9.69	3.20	.49	2.80	.47
Capillary capacity	55.70	55.50	45.00	63.25	39.10
Fine Earth.					
Sand and silicates	85.82	62.03	54.56	66.06	60.05
Alumina	.29	5.79	6.23	7.25	6.61
Iron oxid	.52	6.33	2.78	4.25	8.18
Lime	1.43	3.94	8.74	.59	5.92
Magnesia	.37	3.15	.34	3.15	1.24
Soda	2.89	2.08	1.89	2.18	1.16
Potash	1.44	.72	.48	1.12	.72
Sulfuric acid	.53	.38	.96	.96	1.52
Phosphoric acid	.31	.19	.14	.05	.94
Carbonic acid	.14	6.05	15.93	.69	3.24
Organic matter	3.81	8.33	7.28	10.40	8.40
Water	2.33	1.15	1.13	3.30	1.40
Total	99.88	100.14	100.46	100.00	99.38

Bear Lake County is the smallest in the State and lies in the southeastern part, at an altitude of 6,000 feet. Bear Lake Valley, about 50 miles long by 12 in breadth, comprises most of the arable land of the county. The soil is generally productive and adapted to grain and grass growing and potatoes. The people are industrious and thrifty, hence a large part of the county has been brought under cultivation.

Soil 26 is from the ranch of Hon. H. H. Hoff, at Georgetown. Mr. Hoff says: "I send you a sample of virgin top soil from the N. W. ¼ of Sec. 25, T. 11 S., R. 43 E. We grow alfalfa, wheat, oats and barley, which yield respectively 3 tons, 30, 35 and 40 bushels per acre. I believe the land is a little above the average of cther Georgetown lands, as it is on the bench with no gravel, while that in other parts of the town is more or less gravel and lower." The analysis shows a good supply of plant food.

Numbers 27 and 28 came from the farm of Chas. W. Wright, who lives about one mile southeast of Paris. Mr. Wright failing to reply to inquiries from this office pertaining to the samples sent, we are unable to pass judgment upon them.

No. 29 was sent in by Mr. C. H. Brown, of Liberty. He says:

"The land is situated in Secs. 4 and 33, T. 12 and 13, R. 43 E. The soil has never been cropped; is bottom land and taken about six inches below surface. The seasons here are short, but I have grown 52 bushels of wheat per acre, never less than 41. The sample sent is a little above the average, though the upland is nearly as good. Would like to know what elements of plant food are lacking in this sample." This sample appears to be deficient in lime phosphate. Green manuring and summer fallowing will increase its productiveness.

No, 30 comes from Mr. G. E. Gardner, of St. Charles, who says: "In answer to yours of July 11, will say that the sample is an average of the whole, which is situated in the N. E. ¼ of Sec. 35, T. 15, R. 43 E., and said land is adapted to wheat, oats, potatoes and barley; wheat averaging 35 and potatoes 200 bushels per acre." The sample is principally deficient in humus, hence in nitrogen. Green manuring and summer fallowing with frequent harrowing during the hot months will materially improve its fertility.

Summary.

1. Soil is disintegrated rock produced by the prolonged action of heat, frost, water, air, vegetation and bacteria. The process is called weathering.

2. As are the rocks and minerals, so are the soils quite varied in composition, a section of land often illustrating half a dozen varieties of soil.

3. A large part of the soil is insoluble in acids—the inorganic or *passive** elements of the soil; while the remaining substance, the *active* constituents, are relatively small in quantity, but abundant when the relative quantity per acre is estimated—calculated on the basis of 4,000,000 pounds, the weight of an acre of soil one foot in depth.

4. All soil that has a relatively high percentage of phosphoric

*Mich. Board of Agriculture, 1887, p. 321.

acid, potash, lime and combined nitrogen usually manifests a high degree of fertility.

5. The analyses of the soils of Idaho thus far, and of the Pacific Northwest States in general, show them to be rich in phosphoric acid, potash, nitrogen and iron, together with a sufficient supply of lime.

6. Lime has a most beneficial effect on soil; it aids in the oxidation of organic matter and the formation of nitrates; it acts as a preventive of the prongy growth of root crops and accelerates the ripening of grain and fruit.

7. The organic matter of the soil should be increased in every available way possible; the plowing under of stubble and straw and roots instead of burning them, the application of farmyard manure, night soil, and decaying vegetables will materially increase the humic properties of the soil.

8. The physical properties of the soil should be carefully examined into, such as temperature, porosity, water capacity, drainage and other modifying agencies, and the negative causes affecting the growth of the crop reduced to the minimum.

9. Some of the objectionable salts in the soil, as soda carbonate or sulfate, may be removed by irrigating, by the growing of root crops, alfalfa, and other thrifty growing plants, and by the application of gypsum. Even the justly hated Russian thistle is a large consumer of soda, containing when ripe about 13 per cent.*

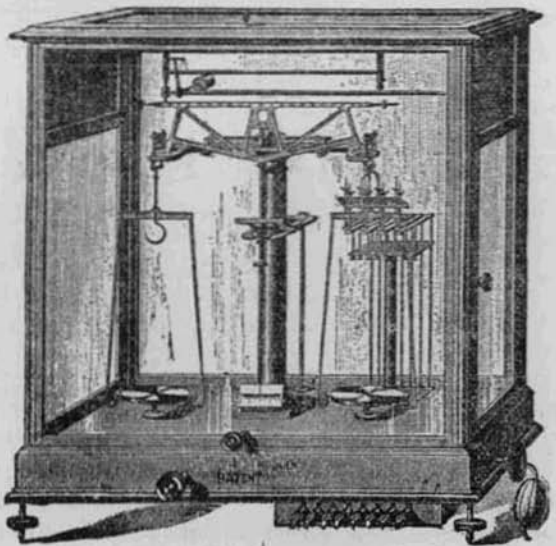
10. Deep, thorough plowing and frequent harrowing or cultivating the soil during July and August will materially hasten the nitrification and otherwise improve the soil's physical condition.

11. Precipitation is a prime factor largely affecting the growth of crops; it materially influences the solvent power of the soil; also shows the soil's durability as affected by leaching.

*Minnesota Bulletin, 34 p. 36.

12. The total precipitation, including the snow fall, in inches, for the preceding twelve months (Oct., 1893–Sept., 1894), at Kootenai was 30.53; at Murray, 43.59; at Fort Sherman, 42.82; at Moscow, 23.89; at Lewiston, 20.54; at Grangeville, 32.56; at Payette, 11.95; at Boise Barracks, 14.65; at Nampa, 10.82; at American Falls, 11.87; at Idaho Falls, 14.17; at Garden Valley, 30.53; at Lake, 20.49; at Martin, 13.85; at Oakley, 8.05; and at Paris, 17.54 inches.*

13. Before sampling a soil for chemical analysis, communicate with the chemist of the station for printed directions; also on any other matter pertaining to chemical work.



*Meteorologists of the respective sta'ions.

NOTE.—The department is under obligations to Richards & Co., Limtd., New York, for cuts used in this bulletin.

MISCELLANEOUS ANALYSES.

During the year quite a large number of analyses of a general character have been made, some by request, others for the purpose of checking fraud. We append only a few of such analyses.

Cider Vinegar.

Two samples of cider vinegar were purchased on the market in Moscow, suspected of containing a mineral acid (sulfuric), and of falling below the standard for acetic acid. The standard in New York is 4.5 per cent. of acetic acid and at least 2 per cent of vinegar solids; Massachusetts requires 5 per cent. and 1.5 per cent. respectively. No specific law relating to the adulteration of foods has as yet been enacted by Idaho; and, consequently, there is no control of the various kinds of adulterated foods that may be placed upon the market.

	No. 1.	No. 2.
Specific gravity	1.015	1.015
Acetic acid	4.20 per cent.	4.25 per cent.
Total solids	6.77 per cent.	8.04 per cent.
Volatile matter	6.40 per cent.	7.59 per cent.
Mineral ash	.37 per cent.	.45 per cent.
Water	89.03 per cent.	87.71 per cent.
Sulfuric acid	None.	Trace.

Kerosene Oil.

The frequency of explosion of kerosene oil lamps in our midst caused us to suspect that possibly the "Pearl Oil" brand offered for consumption was below the standard test, 150° F.

The average of five tests, conducted with great care, placed the "flashing point" at 143.06° F., altitude 2,600 feet, water boiling at 207° F. The oil, therefore, is fully up to requirements. If the burner be kept *clean*, care being exercised to keep the air vent to the oil chamber clear, an explosion from the use of this brand should be of the rarest occurrence.

Milk.

Three samples of milk were taken January 8, 1894, from two dairymen who supply a portion of the city with milk. In No 1 the two milkings were mixed before delivery; No. 2 was drawn in the morning, No. 3 at evening. No. 4 is Chandler's standard for good cow's milk:

	I.	II.	III.	IV.
Specific gravity at 15 degrees C.	1.034	1.034	1.033	1.035
Solids, not fat	11.08 p.c.	10.39 p.c.	11.70 p.c.	8.72 p.c.
Fat	2.46 p.c.	2.45 p.c.	2.65 p.c.	3.83 p.c.
Ash	.41 p.c.	.75 p.c.	.61 p.c.	.70 p.c.
Water	86.05 p.c.	86.41 p.c.	85.04 p.c.	86.75 p.c.
	100.00	100.00	100.60	100.00

Butter.

A sample of high priced genuine (?) butter, quite generally used in some of the best families in the city, failed to hold its color and taste, even for a week, in July, showing striking evidences of adulteration. An analysis of the sample showed a low per cent. of soluble fats and an excess of salts.

	Sample	Genuine* Butter
Water	11.77	11.968
Solids	88.23	88.032
Solids.		
Insoluble fats	79.38	75.256
Soluble fats	1.92	7.432
Caseine	1.02	.182
Salts	5.91	5.162

The proportion of soluble fats contained in genuine butter compared with an oleomargarine variety of same is a characteristic proof of adulteration, the degree of adulteration being indicated by the difference in per cent.

But the accuracy of the analysis being doubted by the retailer, a portion of the sample was sent to Dr. H. W. Wiley, Chief Chemist, Department of Agriculture, Washington, D. C., who reported August 28. He says, in substance: The Reichert-Meissl number for 5 grams of the the dry fat of sample was 22.44, about 7 points below that of ordinary pure butter. A microscopical examination showed crystals that had all the appearance of those given by oleomargarine; while from an ether solution of the fat on evaporation were obtained crystals re-

*Battershall's Food Adulteration and Detection, p. 67.

sembling those given by beef fat. To say the least, the sample was very suspicious and was probably adulterated with about 20 per cent. of oleo-sterine.

The necessity, therefore, of enacting wholesome laws insuring a proper control of and punishment for the sale of adulterated food and food stuffs becomes apparent. Nearly all the States have enacted such laws, and Idaho should not be negligent in the matter of protecting its citizens against fraud.

CHAS. W. MCCURDY,
Professor of Chemistry.

BULLETINS ISSUED BY THE STATION.

MAILED FREE ON APPLICATION.

No. 1 Preliminary Statement.

No. 2 Proposed Plans of Work.

No. 3 The Application of Chemistry to the Agricultural Development of Idaho.

No. 4* I. Methods of Preventing Smut in Wheat and Oats.

II. Carbon Bisulfid as a Squirrel Exterminator.

III. A New Squirrel Exterminator.

No. 5 The Relation of Meteorology to the Agricultural Interests of Idaho.

No. 6 Annual Report for 1893.

No. 7 Insecticides and Spraying.

No. 8 Water and Water Analyses.

No. 9 I. Idaho Soils: Their Origin and Composition.

II. Miscellaneous Analyses.

Five Press Bulletins have been issued by the Station. These are sent only to the newspapers of the State, and to individuals on application.

*The issue is exhausted.