

# TEXAS AGRICULTURAL EXPERIMENT STATION

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BULLETIN NO. 173

FEBRUARY, 1915

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DIVISION OF CHEMISTRY

## The Composition of the Soils of the Texas Panhandle



POSTOFFICE:  
COLLEGE STATION, BRAZOS COUNTY, TEXAS



VON BOECKMANN-JONES CO., PRINTERS, AUSTIN, TEXAS

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BY

G. S. FRAPS, Ph. D.,  
CHEMIST IN CHARGE; STATE CHEMIST



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†As of February 1, 1915.

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# THE COMPOSITION OF THE SOILS OF THE TEXAS PANHANDLE

BY G. S. FRAPS, PH. D., CHEMIST IN CHARGE; STATE CHEMIST.

This bulletin is the fourth of a series dealing with the chemical composition of typical Texas soils. The other bulletins are No. 99, No. 125, and No. 161. This bulletin deals with the chemical composition of samples of soils from twenty-six counties in the Texas Panhandle. The samples were sent us by Agents of the Bureau of Soils of the United States Department of Agriculture, co-operating with this division of the Texas Experiment Station.

A description of the soils and maps of this area has been published by the Bureau of Soils under the title of "Reconnaissance Soil Survey of the Panhandle Region of Texas," by William T. Carter and party. The Reconnaissance Survey maps are on a scale of six miles to one inch. The more detailed surveys are made on a scale of one mile to the inch. It is, of course, not possible to show as many types of soils or differences in a Reconnaissance Survey as in a detailed survey.

## SOIL SERIES IN THE AREA.

The following is a brief description of the soil series found in this area:

*Amarillo Series.*—These soils are formed from unconsolidated deposits of Tertiary and Quarternary age. The surface soil consists of chocolate brown to slightly reddish-brown soils with brown to reddish-brown subsoils, which grade into white or purplish white calcareous material within three feet of the surface. This is the most extensive series in the Panhandle area.

*Cottonwood Loam.*—This soil is derived from gypsum and is of low productiveness on account of the gypsum content. Only one or two small areas were found. The surface soil is 8 to 12 inches deep and of a dark brown loam to silty loam, which grades into a gray or white soft impure gypsum at a depth of 12 to 30 inches.

*Kirkland Series.*—This soil is derived from the Permian deposits, but is not as red as the other soils of the Permian derivation.

*Randell Series.*—The soil in this series is a black heavy clay, found in only small areas and not shown on the map of the area.

*Richfield Series.*—The type of this series is a dark grayish black loam with no tinge of red in soil and subsoil, and in this respect is quite different from the Amarillo series.

*Vernon Series.*—These soils are derived from the Permian red beds. They range in color from dark brown to red, while the subsoils are reddish brown to red.

## SOIL TYPES BY COUNTIES.

The following is a list of the types of soils found in the various counties according to maps published by the Bureau of Soils.

*Armstrong County.*

Amarillo silty clay loam.  
 Amarillo loam.  
 Amarillo sands.  
 Rough broken land.

*Briscoe County.*

Vernon loam.  
 Amarillo sands.  
 Amarillo loam.  
 Amarillo silty clay loam.  
 Richfield silty clay loam.  
 Rough broken land.

*Carson County.*

Amarillo silty clay loam.  
 Rough broken land.  
 Amarillo sandy loams and loam (undifferentiated).

*Castro County.*

Amarillo silty clay loam.

*Childress County.*

Amarillo sandy loam.  
 Amarillo sand.  
 Amarillo loam.  
 Vernon loam.  
 Vernon fine sandy loam.

*Collingsworth County.*

Amarillo loam.  
 Amarillo sands.  
 Amarillo sandy loams.  
 Vernon loam.  
 Rough broken land.

*Dallam County.*

Amarillo loam.  
 Amarillo silty clay loam.  
 Amarillo sandy loams.  
 Amarillo sandy loam and loams (undifferentiated).

*Deaf Smith County.*

Amarillo silty clay loam.  
 Rough broken land.  
 Amarillo sandy loams and loam (undifferentiated).



*Donley County.*

Amarillo loam.  
 Amarillo sands.  
 Amarillo sandy loams.  
 Amarillo silty clay loam.  
 Rough broken lands.  
 Vernon loam.

*Gray County.*

Amarillo sands.  
 Amarillo sandy loams.  
 Amarillo silty clay loams.  
 Amarillo loam.  
 Rough broken land.

*Hall County.*

Amarillo sandy loams.  
 Amarillo loam.  
 Amarillo sands.  
 Alluvial soils (undifferentiated).  
 Vernon loam.  
 Vernon fine sandy loams.

*Hansford County.*

Amarillo silty clay loam.  
 Amarillo loam.  
 Richfield silty clay loam.  
 Rough broken land.  
 Alluvial soils (undifferentiated).

*Hartley County.*

Amarillo loam.  
 Amarillo silty clay loam.  
 Amarillo sandy loams.  
 Amarillo sandy loams and loam (undifferentiated).  
 Rough broken land.

*Hemphill County.*

Amarillo sands.  
 Amarillo sandy loams.  
 Amarillo loam.  
 Amarillo sandy loams and loam (undifferentiated).  
 Amarillo silty clay loam.  
 Rough broken land.

*Hutchinson County.*

Amarillo silty clay loam.  
 Amarillo sandy loams and loam (undifferentiated).  
 Richfield silty clay loam.  
 Rough broken land.

*Lipscomb County.*

Amarillo loam.  
 Amarillo silty clay loam.  
 Amarillo sandy loams.  
 Amarillo sands.  
 Alluvial soils (undifferentiated).  
 Rough broken land.

*Moore County.*

Amarillo loam.  
 Amarillo silty clay loam.  
 Amarillo sandy loams and loam (undifferentiated).  
 Rough broken land.  
 Richfield silty clay loam.

*Ochiltree County.*

Amarillo silty clay loam.  
 Amarillo loam.  
 Alluvial soils (undifferentiated).  
 Rough broken land.  
 Richfield silty clay loam.

*Oldham County.*

Amarillo sandy loams and loam (undifferentiated).  
 Amarillo silty and clay loams.  
 Alluvial soils (undifferentiated).  
 Rough broken lands.

*Parmer County.*

Amarillo silty clay loam.  
 Amarillo sandy loams.

*Potter County.*

Amarillo sandy loams and loam (undifferentiated).  
 Amarillo silty clay loam.  
 Rough broken land.

*Randall County.*

Alluvial soils (undifferentiated).  
 Amarillo silty clay loams.  
 Amarillo sandy loams.  
 Richfield silty clay loam.  
 Rough broken land.

*Roberts County.*

Amarillo silty clay loam.  
 Amarillo sandy loams and loam (undifferentiated).  
 Alluvial soils (undifferentiated).  
 Rough broken land.

*Sherman County.*

Amarillo sandy loams.  
 Amarillo loams.  
 Amarillo silty clay loam.  
 Rough broken land.  
 Richfield silty clay loam.

*Swisher County.*

Amarillo sandy loams.  
 Amarillo silty clay loam.  
 Richfield silty clay loams.

*Wheeler County.*

Amarillo sands.  
 Amarillo sandy loams.  
 Amarillo loam.  
 Alluvial soils (undifferentiated).

## DESCRIPTION OF THE SOIL TYPES.

We give below a detailed description of the soil types, analyses of which are given in this bulletin. The descriptions are condensed from the report of the Bureau of Soils already referred to.

*Amarillo Silty Clay Loam.*—The surface soil consists of a light brown or chocolate brown silty loam averaging in depth from 3 to 5 inches. Below this to a depth of 18 to 24 inches the soil is redder and heavier in texture. Calcareous material is found at a depth of from 18 to 24 inches. The surface soil is friable and easily tilled after the first plowing, but when not cultivated it is quite firm and compact.

This type occupies a large proportion of the entire area and is the most extensive as well as the most uniform type of the area, existing in large connected bodies containing thousands of square miles. The largest area is found on the High Plains. It occupies nearly all of this region south of the Canadian river and also a large part of the territory north of this stream.

The surface is gently undulating to gently rolling and in many places has the appearance of a perfectly level plain.

The Amarillo silty clay loam was formed by the weathering of the heavier Tertiary deposits, and it is probable that the wind has played an important part in the formation of the silty layer which covers the surface.

The type is well covered with short prairie grasses and is largely devoted to stock raising. Buffalo grass and mesquite grass are the principal grasses. The turpentine weed, blue weed and Russian thistle are sometimes very troublesome in cultivated fields. This type of soil has not been farmed to any great extent until recently. The soil is very productive when there is sufficient moisture. Sorghum, kafir, and milo are the surest crops, but wheat, oats, millet, and emmer are also grown. Sorghum yields from 5 to 10 tons of cured fodder and

from 15 to 25 bushels of seed per acre, kafir, from 20 to 40 bushels of grain, and milo maize slightly more than kafir, when grown under the same conditions. In favorable seasons, wheat yields 10 to 25 to 40 bushels. Fruit trees do well and small fruits also when the moisture conditions are suitable. For analyses, see soils of Armstrong, Deaf Smith, Parmer and Swisher counties.

*Amarillo Sandy Loams.*—The surface consists of 12 to 14 inches of brown or reddish brown medium to fine sandy loam, loose and friable and low in organic matter. The subsoil consists of a sandy loam to a sandy clay, ranging in color from brown to red. White calcareous material is often found at a depth of 20 to 30 inches.

The most extensive areas of the Amarillo sandy loams are found in the eastern part of the Panhandle, although a large body occurs in the northwestern portion, and a smaller area in the southwestern corner.

The soil was formed from sandy deposits of the Tertiary or Quaternary age. The red loam is due to the weathering of the red beds.

The areas of the Amarillo sandy loams are gently rolling to rolling, and the greater part could be cultivated. Scrub oak attains considerable size on this type. Bear grass and sedge grass are plentiful and make good grazing. Sorghum, kafir, milo, Indian corn, and cotton are grown, but most of this type is used for grazing. Small grains do not do well on this type. Sorghum yields from 5 to 15 tons green forage or 2 to 8 tons cured fodder. Kafir yields, in years of average rainfall, from 20 to 30 bushels per acre. Corn yields from 20 to 30 bushels in good seasons; cotton yields one-third bale per acre. The type is suited to vines, fruit and truck crops. The winds are damaging in the spring, and considerable skill is required to farm the type. The plowing under of legumes, and manure, is recommended. For analyses see Donley, Dallam, Lipscomb and Randall counties.

*Amarillo Loam.*—The surface soil consists of a dark brown, brown, sometimes reddish brown loam to heavy sandy loam, ranging in depth from 8 to 14 inches. The subsoil is usually a brown or reddish brown heavy loam to sandy loam. At a depth of 18 to 30 inches a white calcareous clay is found. The soil is friable in texture when cultivated, but in the uncultivated state packs hard on drying.

The Amarillo loam is gently rolling to rolling, but is sometimes very rolling and sometimes broken. The many streams tributary to the Canadian river have produced the very rough or hilly topography to be found in that locality.

The Amarillo loam is covered with a growth of native prairie grasses, including mesquite, buffalo, and beard grass, the two first mentioned being the most valuable.

This is one of the most productive soils of the area and is very easy to manage. It has been used for grazing a great many years and a great deal of it is still used for that purpose. There are many fine farms in the eastern part of the area, and there are some areas in cultivation on the High Plains.

The crops grown are sorghum, kafir, milo, corn, wheat, oats, millet,

and alfalfa. Truck crops also do well. Sorghum yields from 3 to 8 tons of cured fodder per acre, kafir 20 to 40 bushels, and milo maize a little more than kafir. Wheat yields from 10 to 25 bushels in favorable seasons, and oats from 20 to 50 bushels. Corn does well, yielding from 25 to 40 bushels per acre. Cotton averages one-half bale per acre in favorable seasons.

The Amarillo loam is well suited to dry-farming methods, and some very successful farmers are located on this type. For analyses, see Armstrong and Donley counties.

*Amarillo Sands.*—This term is applied to widely distributed areas of loose and more or less sandy loams scattered over various parts of the Panhandle. Considerable of this sand is fine and medium in texture, and sometimes sufficient coarse material is found to give a typical sand.

The soil of the Amarillo sands consists of about 12 inches of a brown or reddish brown fine or medium fine sand, loose and incoherent and containing very little organic matter. The subsoil to a depth of several feet is composed of a brown or reddish brown loamy sand of a similar texture to the surface soil. In some areas the subsoil is quite red and a whitish calcareous substance is often found at a depth of 18 to 36 inches.

The Amarillo sands are located in the western part of the survey. Some areas also occur in the Great Plains, in the northwest corner. This soil is principally of wind-blow origin, is rolling and is often marked by hills or dunes. The area is well drained throughout.

The greater part of this type is covered with a growth of coarse grasses, consisting principally of bear grass, broom sage, and sage brush. Small oak is also plentiful.

The soil is not a strong or productive soil; it is easily blown by the wind. In Collingsworth county, some areas are cultivated, but here the soil approaches the sandy loam in texture.

Crops grow well and rapidly once they get started, and the land is well adapted to truck and vine crops. The usual forage crops do well in favorable seasons. Corn and cotton do fairly well in the more rolling eastern portion. The soil retains moisture well in Collingsworth county, where it is not in the form of dunes or sand hills. For analyses, see soils of Childress and Lipscomb counties.

*Kirkland Silty Clay Loam.*—The surface of this type consists to an average depth of 10 inches, of a heavy silty loam or silty clay loam, dark brown or reddish brown in color. The subsoil to a depth of 36 inches consists of a brown or yellowish brown heavy silty clay loam or silty clay, sometimes containing small fragments of gypsum. The soil has a rather close structure and heavy texture, but is not difficult to cultivate when worked at the right time.

Only one area of any considerable extent has been mapped, and this was found in the southeast corner of Childress county. The soil in this area is not very uniform, and the boundaries are only approxi-

mate. The soil originated from the weathering of the Permian formation.

The type in its natural condition supports a scattering growth of mesquite trees; and an abundance of buffalo, mesquite, and other grasses are found. Considerable areas are cultivated at present, the leading crops being cotton, Indian corn, kafir, milo, sorghum, and millet. Wheat and oats are grown only to a limited extent, cotton being the principal crop. Cotton yields about one-third bale per acre, Indian corn from 20 to 40 bushels, kafir yields about the same, milo from 25 to 40 bushels per acre, wheat 10 to 25 bushels, and oats 25 to 40 bushels in favorable seasons. The soil is naturally productive, but the climate is such as to make the forage crops the surest crops. The land dries out rapidly if not cultivated, and should be stirred after each rain.

For analyses, see soils of Childress, Ochiltree and Swisher counties.

*Cottonwood Loam.*—The surface soil of this type consists of 8 to 12 inches of dark brown loam to silty loam, containing enough sand to make it friable. At a depth of 12 to 30 inches the soil grades into a gray white soft impure gypsum.

The topography is nearly level and the drainage is good. The soil has been formed from the gypsum rocks on which it rests, and is locally known as "gyp rock" land.

A rather heavy growth of grass and weeds occur where the gypsum has not come too close to the surface, the principal grass being the common poverty grass, and the weed, the golden aster.

This soil is of very low productiveness, owing to the large amount of gypsum in the subsoil. The principal area was found in the eastern part of Childress county, and is used principally for pasture.

For analyses, see soils of Childress county.

*Alluvial Soils.*—The alluvial soils of the Panhandle are of small extent. They occur along the streams as narrow bottom lands and usually so narrow that only the wider strips could be shown on the map. The widest areas are found along the Canadian river and the largest along forks of the Red River, though almost every little stream in the area has some alluvial soil along it.

As indicated by the names, the alluvial soils have been formed through deposition of materials of the streams. This has been washed from the uplands, and the character varies with that of the formation from which it has been derived.

The texture is most often a fine sandy loam, although areas of fine sand, loam, clay loam, and even clay occur. The soils have a reddish tinge which is quite red in places. In some localities the soil is quite dark.

The most important areas of the darker-colored alluvial soils are found along the Terra Blanca, Palo Duro, Coldwater, and Wolf Creeks and Palo Duro, Tule, and Rita Blanca canyons.

The surface is generally level but there are some variations. These alluvial soils are among the most productive of the area. They are

well supplied with moisture and considerable areas are cultivated. Corn yields 30 to 50 bushels per acre in favorable seasons, and alfalfa gives three and sometimes four cuttings. Fruits and all kinds of vegetables do well. Although this type comprises many thousands of acres, it is not found in large enough areas to make good farms, and is usually sold in connection with other land.

For analyses, see soils of Hall, Ochiltree and Randall counties.

*Richfield Silty Clay Loam.*—This soil consists of a dark grayish brown or nearly black silty clay loam, varying in depth from 8 to 16 inches. The soil bakes very hard where not cultivated, often cracking during dry weather. It is compact and difficult to break, but, after being brought in a good state of tilth, it is easily kept in a mellow condition. The subsoil is a light grayish-brown silty clay loam or clay, rather heavy and compact. Spots of white calcareous matter occur at a depth of 24 inches or more.

The Richfield silty clay loam is found on the High Plains north of the Canadian river, principally in Ochiltree, Hansford, Sherman and Moore counties. On the High Plains south of the Canadian river, in Swisher, Briscoe and Randall counties, there are several smaller areas.

The surface of this type is nearly level, and to the eye the land appears as flat as a floor. In spite of this, there is not enough rainfall to classify this type as being poorly drained.

This type was formed by the weathering of the Tertiary material in the same way in which the Amarillo silty clay loam was formed.

The soil supports a heavy growth of short prairie grasses, the predominant and most valuable varieties being buffalo and mesquite grasses. The type has been used for grazing for many years, but now a good number of farms are located upon it. The soil, which is very productive, is adapted to the growing of sorghum, kafir, milo, millet, wheat, oats, alfalfa and emmer.

The type is especially good for wheat and oats, yields of wheat in favorable seasons being from 15 to 30 bushels.

For analysis, see soil of Ochiltree county.

#### DEFINITION OF TERMS.

*Phosphoric Acid.*—Phosphoric acid is an important plant food. Being essential to plants, plants cannot grow without phosphoric acid. If there is a deficiency of phosphoric acid in the soil, the size of the crop will depend upon the extent of the deficiency. Phosphoric acid is particularly needed for the formation of fruit. It often happens that plants which do not fruit well, but make a large stalk, are benefited by applications of phosphates. Sometimes, though the quantity of phosphoric acid in a soil is large, only a small percentage of it can be taken up by the plant. An acre of soil weighs approximately two million pounds to the depth of seven inches. One hundredth of one per cent would be equivalent to two hundred pounds per acre on this basis. Two hundred pounds of phosphoric acid is sufficient for a number of average crops of corn, etc. Texas soils are very often de-

ficient in phosphoric acid. The deficiencies of the soils under discussion will be discussed below. The phosphoric acid given in the table is that soluble in strong hydrochloric acid.

*Nitrogen.*—Nitrogen, like phosphoric acid, is essential to plants and, when deficient, the growth of the plants is conditioned upon the quantity present. Nitrogen is very often deficient in Texas soils. Phosphoric acid and nitrogen are the two forms of plant food commonly deficient. Nitrogen is found in large quantities in the air, but in forms that ordinary plants cannot take up. Legumes, however, such as peas, peanuts, and alfalfa, have the power of taking up the free nitrogen of the air. In this way, nitrogen may be secured from the air for the use of crops, such as corn or cotton. This is done either by turning under the legume crops, or by feeding them and saving the manure. The stems, leaves and roots left from harvesting a crop of hay, of course, leave some nitrogen in the soil, but unless the land has been in legume which was pastured for several years, there is no great actual gain of nitrogen to the soil from the roots and plant residues.

*Potash.*—Potash is essential to plant growth, but it is the least deficient of the elements of plant food in Texas soils. While some Texas soils will contain only sufficient phosphoric acid and nitrogen for 12 to 18 bushels of corn, based on average pot experiments, the same soils will furnish enough potash for 50 to 80 bushels of corn. The deficiency, therefore, lies in the phosphoric acid and nitrogen rather than the potash. Furthermore, soils usually contain large quantities of total potash, which by appropriate methods of cultivation may be rendered to some extent available to plants.

Furthermore, the losses of potash in the parts of the crop harvested are not as large as the losses of phosphoric acid and nitrogen, provided that the by-products of the crops are properly saved and made into manure. There are, of course, some soils deficient in potash, but most of the Texas soils need nitrogen and phosphoric acid rather than potash. The potash given in the table is not the total potash, but is that soluble in strong acids.

*Lime.*—Lime is found in the soil as carbonate of lime and also combined with silicates and other constituents. Only small quantities of lime are needed by plants. It has, however, other beneficial functions. The carbonate of lime prevents clay from becoming too sticky, and it also is needed by crops such as alfalfa; but there are a number of crops grown in the South, such as watermelons and cowpeas, which need only small quantities of lime. Lime may be supplied as limestone, slacked lime, or as quicklime. The cheapest form at present is in the form of ground limestone rock.

*Magnesia.*—Magnesia is related to lime and accompanies it. It is essential to plants, but only small amounts are required.

*Alumina and Oxide of Iron.*—These ingredients of the soil are



present in various combinations. They have very little value to the plant. Iron is indeed essential to plants, but in very small quantity, and all soils contain sufficient iron to supply the needs of plants. The iron and alumina hold the phosphoric acid in combination, to some extent. They also make up the inert portion of the soil, which serves to hold the plant in place.

*Soluble Silica and Insoluble.*—Silica is believed to be useful to plants and is taken up in large quantity by certain plants, such as oats, but practically all soils supply a sufficient quantity. The silica is also in combination, and helps to make up the soil material which holds the plant in place.

*Active Phosphoric Acid.*—This consists largely of phosphates of lime, which appear to be taken up more readily by plants than the more insoluble phosphates. The bulk of the soil phosphates is present in the more insoluble forms, but a portion of this insoluble phosphoric acid may be taken up by plants.

*Active Potash.*—Active potash consists of the potash soluble in dilute acids. It is much more easily taken up than most of the other potash of the soil. Some of the total potash is, however, given slowly up to plants, and suffices for a crop, the size depending on the total potash and its form of combination. The active potash is so loosely held that a part of it may be taken up in excess of the needs of the plant.

*Acidity.*—Acid soils contain free mineral or organic acids, and should receive an application of lime to correct the acidity, which is injurious to some plants. There are no acid soils among those whose analyses are reported in this bulletin.

#### DESCRIPTION OF SAMPLES.

The samples subjected to analysis are described as follows:

##### *Potter County.*

- 2471 Amarillo loam, depth 0-6 inches; reddish brown loam to clay loam; 5 miles northwest of Goodnight.
- 2472 Subsoil to 2471, depth 6-30 inches; reddish brown clay loam to clay.
- 2477 Amarillo silty clay loam, depth 0-6 inches; dark drab to black clay; 5 miles northwest of Claude.
- 2478 Subsoil to 2477, depth 6-30 inches; dark drab to black clay.

##### *Childress County.*

- 2426 Kirkland silty clay, depth 0-12 inches; reddish brown heavy silt loam; 5 miles northwest of Kirkland.
- 2427 Subsoil to 2426, depth 12-36 inches; reddish brown heavy silt loam

- 2428 Amarillo sand, depth 0-20 inches; loamy sand, formed in small dunes by wind action; 10 miles northeast of Childress.
- 2429 Subsoil to 2428, depth 20-36 inches; gray to light brown loam.
- 2430 Cottonwood loam, depth 0-12 inches; dark brown silt loam; 8 miles east of Childress.
- 2432 Subsoil to 2430, depth 12-30 inches; silt, mostly rotted limestone. "Gypsum land."
- 2575 Probably Amarillo sand, depth 0-12 inches; gray, fine sand; 12 miles northeast of Childress.
- 2576 Subsoil to 2575, depth 12-36 inches; gray, loamy fine sand, red at 24-30 inches.

*Dallam County.*

- 3641 Amarillo sandy loam, depth 0-12 inches; reddish brown fine sandy loam; 2 miles northeast of Dalhart.
- 3642 Subsoil to 3641, depth 12-22 inches; reddish brown heavy fine sandy loam.
- 3643 Amarillo sandy loam, depth 0-10 inches; reddish brown loamy fine sand; 13 miles northeast of Dalhart.
- 3644 Subsoil to 3643, depth 10-36 inches; reddish brown, and sticky; depth 30-36 inches.
- 3645 Amarillo sandy loam, depth 0-12 inches; brown compact heavy fine sandy loam; 6 miles southeast of Dalhart.
- 3646 Subsoil to 3645, depth 13-26 inches; contains considerable fine sand.
- 3647 Deep subsoil to 3645, depth 26-36 inches; light and compact loam, brown; contains considerable white material.
- 3648 Deep subsoil to 3641, depth 22-36 inches; brown fine sandy loam; contains considerable chalky material.

*Donley County.*

- 2473 Amarillo sandy loam, depth 0-12 inches; reddish brown sandy loam; 1½ miles east of Clarendon.
- 2474 Subsoil to 2472, depth 12-36 inches; red sandy clay.
- 2475 Amarillo loam, depth 0-12 inches; brown loam; 6 miles west of Clarendon.
- 2476 Subsoil to 2475, depth 12-24 inches; white and chalky.

*Hansford County.*

- 3915 Richfield silty clay loam, depth 16-36 inches; chocolate; silty clay loam, light and loamy after 20 inches; 10 miles northwest of Hansford.

*Hall County.*

- 2469 Alluvial soil, depth 0-15 inches; reddish soil in Permian beds region; 2 miles southwest of Memphis.
- 2470 Subsoil to 2469, depth 14-36 inches; reddish brown heavy silt loam.

*Hemphill County.*

- 3444 Probably Amarillo sandy loam, depth 0-12 inches; chocolate sandy loam; produces 30 bushels corn, 30 bushels kafir and 35 bushels oats per acre; 62 miles southeast of Glazier; J. I. Payton.
- 3445 Subsoil to 3444, depth 12-24 inches, brown sandy soil.

*Lipscomb County.*

- 3911 Amarillo sandy loam, depth 0-10 inches; dark brown field sandy loam; 3 miles west of Higgins.
- 3912 Subsoil to 3911, depth 10-36 inches; reddish brown fine sandy loam.
3913. Amarillo sand, depth 0-10 inches; grayish fine sand; 2 miles west of Higgins.
- 3914 Subsoil to 3913, depth 10-36 inches; grayish brown fine sand.

*Deaf Smith County.*

- 2406 Amarillo silty clay loam, depth 0-7 inches; brown loam; 1 mile southeast of Hereford.
- 2407 Subsoil to 2406, depth 7-20 inches; brown clay loam.
- 2408 Deep subsoil to 2406, depth 20-30 inches; yellowish loam.

*Ochiltree County.*

- 987 Alluvial soil, 0-10 inches; fine sand; produces 40 bushels corn, 16 to 25 bushels wheat; Wolf Creek Valley; J. T. Frye.
- 988 Alluvial soil, 0-10 inches; J. T. Frye, Wolf Creek Valley.
- 989 Probably Amarillo silty clay loam; level plain soil; suffers from drouth; fine clay loam; 10 miles east of Ochiltree.
- 3906 Amarillo silty clay loam, 0-7 inches; light brown silty loam.
- 3907 Subsoil to 3906, depth 7-14 inches; heavy brown silty clay loam.
- 3908 Deep subsoil to 3906, depth 14-36 inches; yellowish brown, mottled with white silty clay loam.
- 3909 Richfield silty clay loam, depth 0-8 inches; dark brown silty clay loam.
- 3910 Subsoil to 3909, depth 8-36 inches; light brown clay loam; white nodules.

*Parmer County.*

- 2416 Amarillo silty clay loam, depth 0-8 inches; brown loam; 15 miles northeast of Farwell.
- 2417 Subsoil to 2416, depth 8-20 inches; reddish brown heavy loam or clay.
- 2418 Deep subsoil to 2416, depth 20-36 inches; reddish brown loam.

*Randall County.*

- 2444 Amarillo sandy loam, depth 0-8 inches; reddish brown fine sandy loam; 5½ miles south of Canyon City.

- 2445 Alluvial soil, depth 0-8 inches; gray brown loam; 1 mile west of Canyon City.
- 2449 Subsoil to 2444, depth 8-36 inches; reddish brown to brown fine sandy loam.
- 2450 Subsoil to 2445, depth 8-36 inches; light brown loam.

*Swisher County.*

- 2441 Amarillo silty clay loam, depth 0-6 inches; brown and reddish brown loams.
- 2442 Amarillo silty clay loam, depth 0-6 inches; reddish brown to brown silt loam.
- 2443 Richfield silty clay loam, depth 0-10 inches; dark brown to black.
- 2446 Subsoil to 2441, depth 6-36 inches; reddish brown heavy loam; friable calcareous material at 20 inches.
- 2447 Subsoil to 2442, depth 6-36 inches; reddish brown clay loam; loose and friable at 26 inches.
- 2448 Subsoil to 2443, depth 10-36 inches; black clay loam, 6-16 inches; friable and reddish brown, 16-36 inches.

TABLE 1.—COMPOSITION OF SOILS.

	Armstrong County.				Childress County.							
	Amarillo Loam.		Amarillo Silty Clay Loam.		Kirkland Silty Clay Loam.		Amarillo Sand.		Cottonwood Loam.		Amarillo Sand.	
	Surface 2471	Subsoil 2472	Surface 2477	Subsoil 2478	Surface 2426	Subsoil 2427	Surface 2428	Subsoil 2429	Surface 2430	Subsoil 2432	Surface 2575	Subsoil 2576
Percent;—												
Phosphoric Acid.....	0.07	0.04	0.11	0.09	0.11	0.09	0.02	0.02	0.11	0.03	0.02	0.01
Nitrogen.....	.15	.07	.14	.08	.09	.07	.03	.04	.20	.04	.03	.02
Potash.....	.70	.80	1.00	.94	1.00	1.21	.09	.35	.69	.88	.20	.16
Lime.....	.47	1.26	4.54	4.15	2.32	2.66	.17	.19	1.73	9.99	.17	.14
Magnesia.....	.49	.24	3.43	1.09	3.04	1.53	.04	.33	1.09	.40	.15	.20
Alumina and Oxide of Iron.....	10.73	12.40	11.75	12.60	9.90	11.91	2.63	3.62	7.39	1.54	1.49	2.17
Insoluble and Soluble Silica.....	78.81	75.33	66.58	63.90	72.24	71.85	94.94	93.04	77.69	56.05	97.66	97.67
Loss on Ignition.....	5.87	5.33	9.40	9.42	5.86	6.33	1.43	2.04	8.24	13.26	.76	.68
Moisture.....	2.35	3.38	4.66	4.00	3.66	2.87	.55	.95	3.28	6.68	.15	.35
Parts Per Million;—												
Active Phosphoric Acid.....	51.7	.....	388.8	.....	434.1	.....	48.8	47.5	43.1	108.8	.....	16.2
Active Potash.....	453.0	.....	641.2	.....	435.3	.....	154.1	198.7	625.0	225.3	.....	67.5
Acidity.....	0	0	0	.....	0	.....	0	0	0	0	0	0
Percent;—												
Sulphur Trioxide.....	.....	.03	.04	.04	.02	.06	.03	.10	.16	7.73	.03	.02

TABLE 1.—COMPOSITION OF SOILS—Continued.

	Dallam County.									Deaf Smith County.		
	Amarillo Sandy Loam.			Amarillo Sandy Loam.		Amarillo Sandy Loam.			Amarillo Silty Clay Loam.			
	Surface 3641	Subsoil 3642	Deep Subsoil 3648	Surface 3643	Subsoil 3644	Surface 3645	Subsoil 3646	Deep Subsoil 3647	Surface 2406	Subsoil 2407	Deep Subsoil 2408	
Percent;—												
Phosphoric Acid.....	0.05	0.07	0.06	0.04	0.04	0.08	0.08	0.08	0.07	0.03	0.04	
Nitrogen.....	.07	.08	.06	.06	.05	.08	.07	.06	.13	.07	.05	
Potash.....	.21	.49	.56	.20	.35	.38	.69	.46	.53	.75	.79	
Lime.....	.27	1.05	6.55	.17	.27	.32	.46	9.53	.80	1.19	1.43	
Magnesia.....	.18	.31	.38	.18	.15	.14	.29	.11	.47	.71	.79	
Alumina and Oxide of Iron.....	4.02	6.87	7.56	2.54	4.95	5.01	8.89	6.71	8.03	6.31	11.42	
Insoluble and Soluble Silica.....	91.50	84.34	74.43	94.61	90.43	89.63	82.93	70.83	81.22	77.33	80.90	
Loss on Ignition.....	2.30	5.41	3.26	1.59	1.97	2.54	3.38	3.88	4.93	4.76	4.48	
Moisture.....	1.14	.16	2.13	.65	1.28	1.30	2.77	1.74	2.25	3.55	3.06	
Parts Per Million;—												
Active Phosphoric Acid.....	35.3	48.1	8.2	16.9	12.5	196.3	238.1	.....	200.5	76.5	.....	
Active Potash.....	304.3	321.2	165.6	172.5	165.0	308.7	470.0	.....	615.3	458.8	.....	
Acidity.....	0	0	0	0	0	0	0	0	0	0	.....	
Percent;—												
Sulphur Trioxide.....	.....	.....	.07	.....	.....	.....	.....	.....	.10	.06	.12	

TABLE 1.—COMPOSITION OF SOILS—Continued.

	Donley County.						Hall County.		Hemphill Co.	
	Amarillo Sandy Loam.		Amarillo Loam.		Probably Amarillo Sandy Loam.		Alluvial Soil.		Probably Amarillo Sandy Loam.	
	Surface 2473	Subsoil 2474	Surface 2475	Subsoil 2476	Surface 7102	Subsoil 7103	Surface 2469	Subsoil 2470	Surface 3444	Subsoil 3445
Percent;—										
Phosphoric Acid.....	0.02	0.02	0.05	0.05	0.06	0.06	0.02	0.04	.002	.002
Nitrogen.....	.06	.05	.12	.06	.87	.06	.07	.11	.09	.06
Potash.....	.23	.33	.24	.16	.32	.42	.51	.52	.38	.35
Lime.....	.23	.28	2.79	14.71	.34	.43	4.44	1.70	.25	.32
Magnesia.....	1.03	.33	.34	.30	.17	.13	2.09	1.67	.25	.31
Alumina and Oxide of Iron.....	3.50	5.34	4.28	8.90	3.90	4.44	7.92	6.90	4.72	5.35
Insoluble and Soluble Silica.....	93.58	90.04	85.26	63.95	90.76	90.55	75.38	81.94	90.18	88.61
Loss on Ignition.....	3.02	2.90	5.14	10.31	1.45	2.30	6.09	5.11	2.97	2.51
Moisture.....	.76	1.01	1.47	.71	3.89	1.43	2.32	1.98	1.26	1.52
Parts Per Million;—										
Active Phosphoric Acid.....	30.0	.....	97.6	14.7	142.2	66.8	292.9	.....	43.5	19.4
Active Potash.....	205.8	.....	224.7	69.4	389.4	272.5	215.3	.....	52.9	175.3
Acidity.....	0	0	0	0	0	0	0	.....	0	0
Sulphur Trioxide.....	.03	.05	.03	.06	.....	.....	.06	.03	.02	.03





TABLE 1.—COMPOSITION OF SOILS—Continued.

	Parmer County.			Randall County.				Swisher County.							
	Amarillo Silty Clay Loam.			Amarillo Sandy Loam.		Alluvial Soil.		Amarillo Silty Clay Loam.		Amarillo Silty Clay Loam.		Richfield Silty Clay Loam.		Alluvial Soil.	
	Surface 2416	Subsoil 2417	Deep Subsoil 2418	Surface 2444	Subsoil 2449	Surface 2445	Subsoil 2450	Surface 2441	Subsoil 2446	Surface 2442	Subsoil 2447	Surface 2443	Subsoil 2448	Surface 6756	Subsoil 6757
Percent;—															
Phosphoric Acid.....	0.05	0.05	0.04	0.02	0.03	0.10	0.10	0.06	0.04	0.04	0.06	0.07	0.06	0.07	0.07
Nitrogen.....	.09	.08	.05	.07	.06	.09	.09	.13	.08	.13	.11	.11	.06	.09	.07
Potash.....	.58	1.18	.05	.27	.58	.65	.55	.54	.81	.69	.74	1.00	.74	.32	1.28
Lime.....	.40	.38	.91	.83	.47	4.01	7.78	.35	.12	.44	1.16	.43	2.75	.77	1.72
Magnesia.....	.32	.42	.72	.32	.66	1.72	.20	.26	.92	.51	1.01	.66	1.27	.42	.33
Alumina and Oxide of Iron.....	9.51	12.03	10.53	3.96	7.41	6.59	6.70	7.54	10.96	8.54	12.73	7.86	9.69	3.88	3.90
Insoluble and Soluble Silica.....	81.21	77.39	80.14	92.04	85.55	72.51	74.99	82.97	77.52	82.02	74.31	82.42	76.59	89.57	88.94
Loss on Ignition.....	4.41	4.66	3.79	2.44	3.12	7.73	9.28	4.63	5.02	5.38	4.42	4.53	3.36	.....	.....
Moisture.....	2.46	3.38	2.61	.52	2.24	3.40	3.20	2.00	2.49	2.25	5.01	2.91	3.95	.....	.....
Parts Per Million;—															
Active Phosphoric Acid.....	54.6	41.7	78.8	40.0	51.8	245.9	143.3	78.2	.....	124.7	218.8	245.2	.....	407.5	310.6
Active Potash.....	458.8	498.8	442.3	347.5	340.0	411.7	253.0	362.4	.....	436.5	617.6	448.2	.....	528.7	621.2
Acidity.....	0	0	0	0	0	0	0	0	0	0	0	0	.....	0	0
Percent;—															
Sulphur Trioxide.....	.06	.05	.....	.05	.07	.07	.07	0.8	.08	.07	.08	.08	.05	.....	.....

## INTERPRETATION OF ANALYSES.

The chemical analysis shows chiefly the relation of the soil to its content of plant food. The interpretation of the analyses is given in Table 2. The standards used in this interpretation have been published in Bulletin No. 161 of this Station, and will not here be repeated.

We must, however, call attention to the fact that the corn possibility in bushels per acre for the active phosphoric acid, the active potash, and the total nitrogen, is based upon the average quantity of plant food which was removed by crops from soils containing corresponding quantities of plant food. The figures do not represent the actual field production which may be expected of the soil, since this depends upon other factors in addition to the plant food, and for the further reason that the active plant food presented to plant roots depends upon the depth occupied by the roots. In this particular locality, moisture conditions are highly important. The figures given show the *relative* deficiencies of the soils, and not their absolute deficiencies. Further, we must point out the fact that soils may vary quite widely from the average on which these figures are based.

*Phosphoric Acid.*—Acid-soluble phosphoric acid is good in most of the soil samples. It is low in 2 samples of Amarillo sand, 1 sample of Amarillo clay, 4 samples of Amarillo sandy loam, 1 sample of alluvial soil and 1 sample of Amarillo silty clay loam. Active phosphoric acid is also present in good quantities in most of these soils. Some of the samples of Amarillo sandy loam are low in active phosphoric acid and may respond to fertilizers containing phosphoric acid.

TABLE 2.—INTERPRETATION OF ANALYSIS.

Type and County.	Phosphoric Acid.	Potash.	Lime.	Corn Possibility in Bu. Per Acre For		
				Active Phosphoric Acid.	Active Potash.	Total Nitrogen.
Armstrong County—						
Amarillo loam.....	good	good	good	30	182	43
Amarillo silty clay loam.....	good	good	high	74	207	43
Childress County—						
Kirkland silty clay loam.....	high	good	high	74	182	13
Amarillo sand.....	low	fair	good	45	80	13
Cotton wood loam.....	good	good	good	74	207	48
Probably Amarillo sand.....	low	good	good	35	37	13
Deaf Smith County—						
Amarillo clay.....	low	good	good	50	207	38
Dallam County—						
Amarillo sandy loam.....	good	good	good	24	157	23
Amarillo sandy loam.....	fair	good	fair	12	80	18
Amarillo sandy loam.....	good	good	good	45	157	23
Donley County—						
Amarillo sandy loam.....	low	good	good	24	120	18
Amarillo loam.....	good	good	high	40	120	33
Probably Amarillo sandy loam.....	.....	good	good	45	157	28

TABLE 2.—INTERPRETATION OF ANALYSIS.

Type and County.	Phosphoric Acid.	Potash.	Lime.	Corn Possibility in Bu. Per Acre For		
				Active Phosphoric Acid.	Active Potash.	Total Nitrogen.
Hall County— Alluvial soil.....	low	good	high	50	120	23
Hemphill County— Probably Amarillo sandy loam...	low	good	good	30	157	18
Lipscomb County— Amarillo sandy loam.....	low	good	good	24	120	23
Amarillo sand.....	low	good	good	50	207	18
Ochiltree County— Alluvial soil.....	good	good	high	.....	.....	8
Probably Amarillo silty clay loam	low	good	good	.....	.....	33
Amarillo silty clay loam.....	good	good	high	30	120	48
Richfield silty clay loam.....	good	good	good	50	207	33
Parmer County— Amarillo silty clay loam.....	good	good	good	30	182	28
Randall County— Amarillo sandy loam.....	low	good	good	24	157	23
Alluvial soil.....	good	good	high	50	182	28
Swisher County— Amarillo silty clay loam.....	good	good	good	35	157	38
Amarillo silty clay loam.....	good	good	good	45	182	38
Richfield silty clay loam.....	good	good	good	50	182	38
Alluvial soil.....	good	good	good	74	182	28

*Lime.*—Lime is good or high in all samples, except one sample of Amarillo sandy loam, in which it is fair.

*Nitrogen.*—Nitrogen appears to be the element most liable to become deficient in these soils. Considering the fact that these soils are deep, and plants root deeply in them, most of them are well supplied with nitrogen, and, with some of them, the nitrogen content is excellent. The table shows, however, that the nitrogen is in many instances much the lowest of the relative deficiencies and is, therefore, the controlling element.

Nitrogen is also more easily lost from the soil than the phosphoric acid or potash. It is also easily secured from the air by growing legumes, such as clover, alfalfa, peanuts, etc. By turning these legumes under, or grazing them off, or feeding them and applying the manure, the nitrogen secured from the air is returned to the soil for the use of other crops, such as milo, kafir, cotton, sorghum, etc.

Nitrogen is most likely to be the deficient element in the Panhandle soils, in case any one is deficient. Phosphoric acid comes next. Except on the Amarillo sand, potash is not likely to be deficient at all, at least for some time.

## ACKNOWLEDGMENT.

Analyses and other work relating to the preparation of the bulletin have been done by Messrs. E. C. Carlyle, T. L. Ogier, J. B. Rather, L. R. Gilmore, and other members of the Staff.