U. S. DEPARTMENT OF AGRICULTURE

BUREAU OF SOILS

IN COOPERATION WITH THE UNIVERSITY OF ARIZONA DEPARTMENT OF IRRIGATION

SOIL SURVEY OF THE SAN SIMON AREA ARIZONA

BY

E. J. CARPENTER, OF THE U. S. DEPARTMENT OF AGRICULTURE, IN CHARGE, AND W. S. BRANSFORD, OF THE UNIVERSITY OF ARIZONA DEPARTMENT OF IRRIGATION

[Advance Sheets—Field Operations of the Bureau of Soils, 1921]

WASHINGTON
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[PUBLIC RESOLUTION—No. 9.]

JOINT RESOLUTION Amending public resolution numbered eight, Fifty-sixth Congress, second session, approved February twenty-third, nineteen hundred and one, "providing for the printing annually of the report on field operations of the Division of Soils, Department of Agriculture."

Resolved by the Senate and House of Representatives of the United States of America in Congress assembled, That public resolution numbered eight, Fifty-sixth Congress, second session, approved February twenty-third, nineteen hundred and one, be amended by striking out all after the resolving clause and inserting in lieu thereof the following:

That there shall be printed ten thousand five hundred copies of the report on field operations of the Division of Soils, Department of Agriculture, of which one thousand five hundred copies shall be for the use of the Senate, three thousand copies for the use of the House of Representatives, and six thousand copies for the use of the Department of Agriculture: *Provided*, That in addition to the number of copies above provided for there shall be printed, as soon as the manuscript can be prepared, with the necessary maps and illustrations to accompany it, a report on each area surveyed, in the form of advance sheets, bound in paper covers, of which five hundred copies shall be for the use of each Senator from the State, two thousand copies for the use of each Representative for the congressional district or districts in which the survey is made, and one thousand copies for the use of the Department of Agriculture.

Approved March 14, 1904.

[On July 1, 1901, the Division of Soils was reorganized as the Bureau of Soils.]

CONTENTS.

ILLUSTRATIONS.

PLATES.

FIGURE.

MAP.

Soil map, San Simon sheet, Arizona.

SOIL SURVEY OF THE SAN SIMON AREA, ARIZONA.

By E. J. CARPENTER, of the U. S. Department of Agriculture, in Charge, and W. S. BRANSFORD, of the University of Arizona Department of Irrigation.

DESCRIPTION OF THE AREA.

The San Simon area lies in the northeastern part of Cochise County, which is situated in the extreme southeastern part of Arizona. The area surveyed, which covers but a small part of the county, embraces about 448 square miles, or 286,720 acres.

The boundary of the area has been established to include, in so far as present information would indicate, all the agricultural lands in the San Simon Valley in Arizona that may be irrigated either from underground sources or by a proposed project which purposes to utilize the seasonal run-off from the eastern slopes of the Chiricahua and Dos Cabezas Mountains. In places along the margin of the survey are included small areas of nonagricultural land, consisting of the lower slopes of the adjacent mountains. A small part of the San Simon Valley lying in New Mexico was not included.

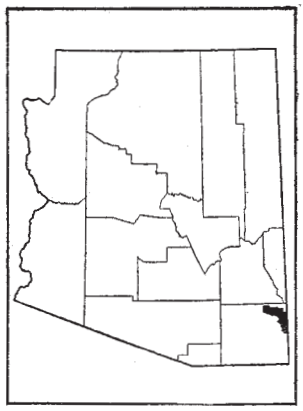


FIG. 23.—Sketch map showing location of the San Simon area, Arizona.

In shape the area roughly resembles the figure 7. The eastern side extends along the Arizona-New Mexico line from near Cavot on the north to a point 6 miles below Cave Creek on the south. The Chiricahua Mountains, with elevations of over 8,000 feet, border the area for a short distance on the southwest, giving way to the Dos Cabezas Mountains which trend in a northwesterly direction to the low pass through which the Southern Pacific Railroad crosses the mountains on the northwest. At this point the San Simon Valley has a width of 35 miles, and here the area surveyed broadens out to a maximum width of about 25 miles, forming the upper arm of the figure 7. On the northwest the northern boundary of the area approaches to within 2 miles of the Cochise-Graham County line, but owing to a series of offsets of from 1 to 6 miles, the northern boundary at its eastern end is about 10 miles farther south.

The general topography can best be described by comparing the area to a shallow trough occurring between two nearly parallel mountain chains. The sloping sides of the trough have been formed through the accumulation of sediment washed down from the bordering mountains, the coarser material being deposited on the steeper

slopes adjacent to the mountains and the finer sediments being carried down the alluvial fans to the points where the water spreads out over the surface of the land. Where the valley is narrow the bases of the alluvial-fan slopes almost meet at its axis, but where it broadens out it has the appearance of a nearly level plain with upward curving edges.

The surface of the area in general is fairly smooth, except where the drainage ways leaving the mountains have cut deep, narrow channels through the steeper slopes of alluvial fans. Nearly everywhere the slope of the land is sufficient to insure good to moderately good drainage, and only in a few places is the slope steep enough to interfere with irrigation. The bottom lands along San Simon Creek are small in extent and are in places badly dissected by the stream, which is slowly cutting its channel deeper. The mountains that rise abruptly from San Simon Valley are steep and precipitous. They consist principally of quartz-bearing crystalline rocks, with some sedimentary and metamorphic rocks, such as sandstone, limestone, shale, and quartzite. (Pl. XVI, fig. 1.)

Elevations of the agricultural land of the survey range from 3,500 to 4,800 feet above sea level. San Simon, which is located near the axis of the valley, in the north-central part of the area, has an elevation of 3,612 feet; Bowie, to the west, has an elevation of 3,760 feet; and Vanar, to the east, 3,909 feet. Some of the included mountain areas attain an elevation of nearly 6,000 feet.

San Simon Creek, the principal drainage way of the area, empties into the Gila River about 35 miles northwest of the area surveyed. San Simon Creek has its source in the San Simon Cienega, a low, marshy area, in which the ground-water level is at the surface. For most of its course it flows in a narrow channel between high vertical banks. This channel has been formed almost entirely since the region was first settled by white men in the early seventies. The creek is normally intermittent, but in places a small perennial flow is maintained either by seepage or overflow from the marsh or by waste water from flowing wells. Following severe storms the run-off from the mountain slopes is very rapid and the creek may rise in a few minutes to a point where it overflows its present channel and spreads over the bottom lands for a quarter of a mile or more on each side. Its chief tributaries are Cave, Turkey, and Whitetail Creeks, which, even in the mountains, carry little or no water during most of the year. Except for several square miles in the vicinity of San Simon, the surface drainage of the area is excellent.

When the first white settlers entered the region now known as the San Simon Valley they found the country covered with a luxuriant growth of grasses, affording excellent pasturage for all kinds of stock. The occupation of the range, however, was fraught with considerable danger, because of a warlike tribe of Indians (the Apache), which has been subdued only in comparatively recent years.

The open ranges were controlled largely by big cattle companies and the country was consequently sparsely settled. However, upon the discovery of artesian water late in 1910, there came a rapid influx

of settlers, mostly from the Southern and Eastern States, who homesteaded nearly all the open land in the valley.

After gaining title to their land, the majority of the homesteaders left the country; only those located in the more favorable sections, as regards water supply, remained to farm their land. The most thickly settled section is in the artesian belt in the vicinity of San Simon. In the vicinity of Bowie, where the seasonal rainfall is more favorable for dry farming, there is another small group of settlements. As census figures are not available dealing directly with the area surveyed no estimate can be given of the total population. Except for the Mexicans employed on the railroads there are scarcely any foreign-born persons in the area. Bowie is the largest town in the area and San Simon is the only other town. According to the census, the precincts in which these towns are situated had 885 and 526 inhabitants, respectively, in 1920. Cavot, Vanar, Bawtry, Karro, Olga, and Holt are rural railroad sidings and stations.

The main line of the Southern Pacific Railroad, operating between Los Angeles and New Orleans, traverses the entire width of the northern part of the area. The Arizona Eastern Railroad operates a branch line from Globe and Miami traversing the northwestern part of the area and connecting with the Southern Pacific Railroad at Bowie.

One of the trunk highways from east to west passes through the area, following the Southern Pacific Railroad right of way. A little work has been done on this road, but during stormy weather it is often in bad condition, Other roads in the valley have had little or no attention and large areas are entirely without roads. Telephones are found only in parts of the better settled communities around San Simon and Bowie, and electricity is available only from private plants.

The principal shipments from the valley consist of cattle and hogs, which go to market in Omaha and Kansas City. A few small shipments of potatoes, sweet potatoes, and hay have been made. Some fruit is shipped from the southern part of the area. Rodeo, N. Mex., on the El Paso & Southwestern Railroad, which is only a few miles south of the area surveyed, serves as the shipping point for that part of the area. The mining towns of Douglas and Bisbee, in the southern part of Cochise County, afford a good market for fresh fruit and vegetables.

CLIMATE.

The climate of the San Simon Valley is arid and warm, but with temperatures more moderate than in many desert regions. These facts are brought out in the appended tables compiled from the records of the Weather Bureau stations at San Simon and Paradise, giving the mean and absolute maximum and minimum temperature and precipitation by months and seasons. San Simon is situated in the valley at an elevation of 3,609 feet above sea level, and Paradise lies at the foot of the Chiricahua Mountains, a short distance west of the southern part of the area at an elevation of 5,436 feet.

Normal monthly, seasonal, and annual temperature and precipitation at San Simon, Cochise County.

[Elevation, 3,609 feet.]

Month.	Temperature.			Precipitation.			
	Mean.	Absolute maximum.	Absolute minimum.	Mean.	Total amount for the driest year (1887).	Total amount for the wettest year (1905).	Snow, average depth.
	°F.	°F.	°F.	Inches.	Inches.	Inches.	Inches.
December	44.0	80	14	0.47	0.00	1.43	0.8
January	43.8	82	−5	.44	.01	1.63	.5
February	48.6	88	10	.46	.78	2.34	1.3
Winter	45.5	88	−5	1.37	.79	5.40	2.6
March	55.6	92	9	70	.00	6.63	.0
April	60.7	95	28	.11	.10	.21	.0
May	67.8	99	30	.15	.00	.00	.0
Spring	61.4	99	9	.96	.10	6.84	.0
June	75.7	106	40	.11	.00	.53	.0
July	82.1	108	48	.82	.00	.50	.0
August	80.7	111	47	1.58	.00	2.25	.0
Summer	79.5	111	40	2.51	.00	3.28	.0
September	73.0	101	38	.62	.10	.80	.0
October	59.7	98	20	.37	.00	.04	.0
November	49.6	85	19	.35	.00	2.51	.3
Fall	60.8	101	19	1.34	.10	3.35	.3
Year	61.8	111	−5	6.18	.99	18.87	2.9

Normal monthly seasonal, and annual temperature and precipitation at Paradise, Cochise County.

[Elevation, 5,436 feet.]

Month.	Temperature.			Precipitation.		
	Mean.	Absolute maximum.	Absolute minimum.	Mean.	Total amount for the driest year (1910).	Total amount for the wettest year (1914).
	°F.	°F.	°F.	Inches.	Inches.	Inches.
December	39.1	75	5	1.74	0.00	6.09
January	40.1	75	1	1.55	.15	.86
February	42.6	76	7	1.21	57	.51
Winter	40.6	76	1	4.50	.72	7.46
March	48.2	83	8	1.05	T.	.71
April	53.2	88	16	.53	T.	.00
May	60.6	95	25	.32	.00	.30
Spring	54.0	95	8	1.90	T.	1.01
June	69.2	97	37	.81	2.35	2.38
July	71.5	104	42	4.63	2.27	6.19
August	69.5	95	44	3.35	1.25	3.13
Summer	70.1	104	37	8.79	5.87	11.70
September	65.0	91	27	1.87	.80	2.94
October	56.4	87	21	1.09	T.	2.28
November	46.4	81	7	1.43	.90	1.24
Fall	55.9	91	7	4.39	1.70	6.46
Year	55.2	104	1	19.58	8.29	26.63

It will be noted that the mean annual precipitation at these two stations differs greatly, and that the annual rainfall is very irregular, ranging from 0.99 inch to 18.87 inches at San Simon and from 8.29 to 26.63 at Paradise. The points of higher elevation are the most favorably situated as regards rainfall, though a sufficient quantity for dry farming is never assured. In the valley the months of April, May, and June are generally very dry, the mean rainfall averaging about 0.12 inch per month, making irrigation essential for the successful growing of nearly all crops. Snow falls almost without exception during the winter months on the highest peaks bordering the valley and often remains for a month or more at a time. In the interior of the valley light snowfalls are sometimes experienced, but remain for only short periods. Hail is not uncommon, but seldom does any damage to crops.

The precipitation occurs principally during two parts of the year—a maximum rainfall in the late summer and early fall and a secondary wet season during the winter and early spring months. During the summer the rains arise quickly and occur as local thunderstorms on or near the slopes of the mountains, but decrease in intensity toward the interior of the valley. Though the rains are of short duration, large quantities of water fall, and crops and buildings must be protected against damage by flooding and washing. Run-off is very rapid, and little benefit is derived from such rains as the soils are seldom wet to any considerable depth. The winter rains, however, are gentle and are accompanied by little run-off.

The mean annual temperature at Paradise, located a short distance from the area, near the foot of the Chiricahua Mountains, is 55.2° F., with a mean for the summer months of 70.1° F. At San Simon, in the interior of the valley, the mean annual temperature is 61.8° F., the highest temperature on record is 111° F., and the mean temperature for the three hottest months of the year (June, July, and August) is 79.5° F. The absolute minimum at this station is −5° F.

Owing to a low humidity and comparatively high elevation, the heat of summer is never oppressive, and the nights are always cool enough for pleasant rest. The winter temperatures are fairly constant, the days being warm and pleasant and the nights generally rather cool. The abundance of sunshine and the fresh, invigorating air make this climate especially healthful for people suffering from pulmonary troubles.

The earliest recorded frost in the fall at San Simon occurred on October 15, and at Paradise on September 27. The latest in spring occurred on March 14 at San Simon and on May 21 at Paradise. The average date of the last killing frost in spring at San Simon is February 22, and the average date of the first in fall November 26, giving an average growing season of 277 days. At Paradise the average length of growing season is 172 days. Cattle and sheep are pastured on the range throughout the year, and winter grains can be planted without danger of winterkilling in any part of the valley.

Wind movement is principally from the west and southwest. During the late winter and early spring, winds of high velocity are common and usually carry a great deal of dust, making this season of the year rather unpleasant at times.

AGRICULTURE.

Before the discovery of artesian water in 1910, the San Simon Valley was devoted largely to stock raising. The central part of the valley afforded an abundant supply of grasses for summer grazing, and the neighborhood mountains provided good pasture for the fall and winter seasons. During seasons of drought the stock subsisted largely on sagebrush and the leaves and beans of the mesquite tree.

The discovery of artesian water was followed by a rapid influx of settlers, who homesteaded land in all parts of the valley. Most of these settlers were people of limited means, so that only in the more favorable artesian areas were wells sunk and utilized for irrigation. Outside of the artesian district dry farming was attempted rather extensively, and in a few cases water was pumped for irrigation.

However, owing to the uncertainty of sufficient rainfall for dry farming, most of the early settlers outside of the artesian district remained only long enough to obtain title to the land, then moved away leaving their homesteads unoccupied. A few still remain, supplementing dry-farming methods with water obtained by diversion from some of the small drainage ways during storms, or by pumping. Largely because of a higher annual precipitation, dry farming is most successfully practiced in the vicinity of Bowie.

At the present time the principal agricultural area of the valley is confined to a narrow belt lying on both sides of San Simon Creek, east and southeast of the town of San Simon. In this district artesian water is reached at depths of 400 to 600 feet. With rare exceptions, the wells are cased only at the surface, and as a consequence they have silted or sanded up until the flow in most cases is 20 to 80 per cent less than formerly. That the supply is not failing is suggested by the fact that new wells recently developed show a larger flow than many of the old ones.[1]

The present agriculture consists largely of the production of cereals and alfalfa and other forage crops. During 1920 short-staple cotton was grown on a small area and showed considerable promise. Potatoes and sweet potatoes do well in this area and are being grown more extensively each year on soils adapted to their culture.

Agriculture in the San Simon Valley, however, is still in a more or less experimental stage. No statistics directly applicable to the area are available. At the present time (1921) cattle and hogs are produced in excess of home needs, and a few shipments of potatoes and hay have been made to outside markets. Apples and peaches of excellent quality are produced in places favorably situated as regards freedom from frost, and in recent years several shipments of fruit have been made from the southern part of the area. Grains, vegetables, poultry, and dairy products are being produced more extensively each year and with further development should prove valuable sources of income.

Stock raising is the most important source of income to farmers in the area. Some cattle are still run on the open range, but owing to several causes, chiefly the fencing off of the open range and a scarcity of grass caused by several seasons of drought, some of the

[1] Water-Supply paper 425-A, U. S. Geological Survey, Ground Water in San Simon Valley, Arizona and New Mexico.

cattle companies are going out of business, and in all cases the number of cattle kept is being materially reduced. Cattle, however, outnumber any other kind of livestock, with horses and hogs next in importance in the order named. Under the stimulus of the high prices paid for mohair in recent years (1917–18), the goat industry was found quite profitable, and a few large herds are still kept in the mountains adjacent to the survey. Dairying has not been extensively developed, though a few cows are kept on every ranch to supply home needs. The local demand for fresh dairy products is small, and no attempt has been made to produce for outside markets.

In conjunction with other farm operations, the production of hogs and poultry has proved quite profitable, the sale of these products constituting the chief source of income on many farms. Hogs are pastured on alfalfa throughout the year, and are usually given some supplemental feed, such as milo, before being marketed.

Beef cattle produced on the range are rounded up some time in the fall or early winter and shipped as feeder cattle, at a lower freight rate than is given on fat cattle, to the Central or Southern States near the Omaha and Kansas City markets, where they are fattened and then marketed.

As water is the limiting factor in crop production in this region, the areas where agriculture is best developed are defined more largely by facilities for irrigation than by recognized differences in soils. Where water for irrigation is available, the sandy soils are utilized largely in the production of such crops as potatoes, alfalfa, and cotton, and the heavier textured soils are devoted to the production of grains.

The land for grain is plowed, or more commonly disked, in the late summer or early fall, after the previous crop is harvested. The grain is sown after the first fall rains have provided sufficient moisture to germinate the seed. During the late fall and winter the fields are often pastured by young beef or dairy stock. Milo is produced more extensively by dry-farming methods than any other grain, irrigation being used to supplement the seasonal rainfall in the production of grains that are less drought resistant.

Farm buildings are generally more or less temporary structures, though some of the more successful farms are rather well improved. Adobe furnishes a cheap building material and is used extensively in the construction of all buildings.

The Hereford and Shorthorn breeds are the most popular range cattle in this area, though mongrel animals still occupy more than half the ranges. Several farms are stocked with good grades of hogs and in a few instances purebred herds are kept exclusively.

Little or no fertilizer, except barnyard manure, is used. Alfalfa is being grown more extensively each year, and when the fields are plowed up they are generally planted to some of the grain crops or to potatoes, though in no case is any systematic rotation of crops practiced.

The farms are usually small, the area under irrigation rarely exceeding 40 acres, while on most farms it includes 20 acres or less. Where dry farming is practiced larger areas are cultivated, the fields ranging in size from 40 to 100 acres or more.

The farms are nearly all operated by the owners. Little outside labor is hired, the ranch owners exchanging labor wherever possible. The Mexicans furnish most of the day labor and are paid $1.50 to $1.75 a day and board. Men hired on cattle ranches by the month receive $35 to $45 a month and board.

Land values range from $50 to $100 an acre for the better improved areas along San Simon Creek. Unimproved lands sell for $10 to $25 an acre, depending largely on location and type of soil.

SOILS.

The San Simon area lies in the mountain region of southeastern Arizona. It is situated between two nearly parallel chains and includes the greater part of the San Simon Valley lying in Cochise County. The soils of the area are classified as of the arid southwest soil region. They are unleached, are predominantly of high lime content, the rainfall being generally too low to have removed even this very soluble salt into the country drainage.

The mountains bordering the survey are geologically complex, the rock formations including rocks sedimentary, metamorphosed sedimentary, igneous, and volcanic in origin. They include sandstone, shale, and quartz formations, and lavas composed largely of basalt. Materials from all these have no doubt entered into the composition of the soil to greater or less extent. These rocks have been weathered and the materials eroded, and the mountain slopes have been entrenched at irregular intervals by deep, narrow canyons, at the mouths of which are large alluvial fans extending far out into the valley. (Pl. XVI, fig. 2.) Some of these are symmetrical in form and retain their individuality; more commonly, however, they coalesce and form continuous slopes extending from each side of the valley and meeting at its axis. The soils of the area, exclusive of Rough stony land, which represents about 1 per cent of the area surveyed, are derived from these materials, which differ in the time of deposition, in the degree of fineness and assortment, in the extent of modification by weathering since they have been accumulated, and in the vertical arrangement of the material. The sediments in the interior part of the valley are finer and more perfectly stratified than near the mountain slopes and the mouths of the canyons, where the coarser textured débris has been dumped with but little assortment.

The soils of the area may be classed in three main groups: (1) Old valley-filling soils, (2) recent-alluvial soils, and (3) miscellaneous materials. These main groups of soils are distinguished mainly by differences in mode of formation, or agency of accumulation and in age of the material, or, in other words, in the stage reached in soil development.

In each of the first two groups the soils are further arranged into soil series and the series into types. Soils that are similar in color, origin, mode of formation, character of subsoil, and other structural features are considered of the same series, and within any series there may be a number of types determined by the texture of the surface soil. The soil type is the unit of classification and of mapping. Each soil series thus consists of related soil types which may range in texture from coarse sand or gravel to clay loam or clay. Variations within

soil types that are of sufficient importance are designated as phases. These ordinarily are indicated on the map by ruling over the color assigned to the typical soil.

The soils of the old valley-filling group occupy about 85 per cent of the area surveyed. They are derived from old stream-laid or alluvial-fan deposits, transported from the adjacent mountain slopes, and have been more or less modified through weathering since their deposition, usually with development of distinct zonation in the profile. An abundance of lime is present; in places this has been leached from the surface soil and accumulated in the subsoil, giving rise to a compact layer or in some instances to a cemented hardpan. The soils are low in organic matter, the arid conditions favoring neither the growth of vegetation nor accumulation of plant remains. The surface is generally smooth and gently sloping, erosion having taken place only on the steeper slopes adjacent to the mountains. With the exception of a few square miles of lands in the vicinity of San Simon, the drainage of this group of soils is excellent. Differences in origin, color, lime content, and character of subsoil have given rise to seven soil series, the Mohave, Cavot, Cave, Cochise, Dos Cabezas, Imperial, and Karro.

The surface soils of the Mohave series are red to dull red or reddish brown in color, and generally without lime accumulations within 8 inches of the surface. The subsoil consists of a red, moderately compact layer of heavier material of high lime content, underlain at depths of 18 to 36 inches by very compact, pale-red, light brownish-red, or pinkish-colored material of similar or lighter texture. Below depths of 40 to 60 inches the material becomes more friable and contains gray mottles of limy material, the number increasing with depth. This series is derived mainly from the weathering of old valley-filling deposits composed largely of materials from granite and other igneous rocks, though in this survey sedimentary rocks have also entered into its formation. A moderate slope insures good drainage and freedom from injurious accumulations of alkali salts. The Mohave sand and the gravelly sandy loam, with two phases, are mapped in this survey.

The surface soils of the Cavot series are brown to reddish brown or purplish brown in color, free of lime or at most only mildly calcareous. The subsoil has about the same or a more reddish color than the surface soils, is calcareous, and moderately compact, and contains large quantities of gravel cobble, either more or less uniformly mixed with the material or appearing in strata or lenses. The series occupies the upper or steeper slopes of the alluvial fans, where the coarser material carried from the mountains in times of heavy rainfall has been deposited. The streams emerging from the mountains have cut deep, narrow channels through the upper slopes, but with increasing distance from the mountains and more gentle slope the channels become more shallow, until finally the water spreads out fan-shape over the surface. Drainage is good to excessive. The soils of the series are derived from old alluvial-fan deposits of mixed origin. The Cavot gravelly sandy loam and the alluvial phase of the Cavot loam are mapped.

The Cave series is characterized by brown to reddish-brown or somewhat purplish-brown calcareous surface soils overlying an upper subsoil of highly calcareous gray or grayish-brown material. In typ-

ical developments this is underlain at depths ranging from 10 to 36 inches by a gray, gravelly, lime-cemented hardpan or "caliche," extending in places to a depth of 6 feet or more. In areas which grade into soils of the Cavot series, however, this hardpan material is only slightly cemented and is mixed with gravel and cobblestones. The series is derived from old valley-filling deposits, which have their source in a variety of rocks. Limestone and volcanic rocks appear to predominate in the included stone and gravel. The series occurs on the upper slopes of fans. The surface is smooth, except for occasional drainage ways. A moderately steep slope gives good to excessive surface drainage, but the internal drainage is restricted. The Cave gravelly fine sandy loam, with a heavy phase, occurs in the present area.

The surface soils of the Cochise series are light grayish brown to dull brown in color and free of lime or only feebly calcareous to depths varying from 6 to 14 inches. They are underlain by a moderately compact, dull-brown or grayish-brown, heavier textured, calcareous subsoil, in which the lime appears as grayish mottlings rather uniformly distributed. This series is derived from the weathering of old valley-filling deposits of mixed origin. Weathering is not as far advanced in this series as in the other old valley-filling soils of this survey; consequently the subsoil is less compact and the lime accumulation less pronounced. The series is confined principally to the lower slopes of alluvial fans and positions adjacent to the present stream courses. The topography is moderately sloping, both surface and internal drainage being well developed. Three types are mapped, the Cochise gravelly sandy loam, fine sandy loam, and silt loam.

The surface soils of the Dos Cabezas series are light brown to light yellowish brown or light grayish brown,[2] with a faint tinge of pink, and are moderately to highly calcareous. The subsoil consists of light-brown or light grayish-brown, compact, calcareous material, in most places of heavier texture than the soil, slightly mottled with gray limy material and containing here and there soft lime-carbonate nodules. The Dos Cabezas series in general occupies the more gentle slopes of alluvial fans. The surface is smooth and gently sloping, affording good drainage. This series is derived from old valley-filling materials having their source in a variety of rocks. The Dos Cabezas sandy loam and loam, the latter including several phases, are mapped.

The Imperial series, as recognized in previous surveys, is characterized by chocolate-brown or brown color, of reddish or purplish hue, in both surface soils and subsoil. The subsoil consists of well-stratified, heavy-textured sediments so compact that they materially restrict percolation, capillarity, and subdrainage. Both surface soils and subsoil are decidedly calcareous, with the lime in most places rather uniformly distributed through the material.

The material included with this series in this survey, however, represents a variation which departs quite widely from the typical Imperial material as previously recognized. Here the upper subsoil may be slightly lighter in color than the surface soil, and in places is

[2] In this survey there has been included some material in which the surface soil is reddish brown and which in more detailed mapping would be recognized as representing a separate series.

underlain by lighter reddish-brown or purplish-brown to yellowish-brown material mottled with soft gray lime accumulations. The surface soils are also either devoid of lime accumulations or else contain only a little lime, though the upper subsoil is highly calcareous. Moreover, the typical Imperial soils are derived from only slightly weathered and leached, well-stratified river or lake-laid deposits having their source in a wide variety of rocks, while in this survey they are derived from more completely weathered and modified old alluvial-fan deposits having their source mainly in volcanic rocks.

In the San Simon area the series occupies a terrace 20 feet or more above overflow of the San Simon Creek, and adjacent to the lower slopes of alluvial fans from the mountains. The surface is smooth and gently sloping, though erosion has taken place to some extent in the depressions that carry the run-off from the rather infrequent but at times torrential rains. Surface and subsoil drainage are generally good, but are locally restricted. Two types, the Imperial loam and the Imperial clay, are mapped.

The surface soils of the Karro series when dry are light grayish brown to light brownish gray or light yellowish gray in color. Under moist field conditions a more pronounced brown or light-brown color is developed. They are low in organic matter, highly calcareous, and somewhat compact. In places in virgin areas the surface soil has a thin crust, underlain by a thin layer of loose, flocculated mulch, consisting of pellets or granules of soil material. The upper subsoil is similar to or grayer in color, and usually heavier in texture than the surface soil. It is compact and high in lime, containing many small nodules or fragments of lime carbonate or "caliche." The deeper subsoil consists of a light-gray or white, heavy-textured, compact clay-like material, more or less cemented by lime into a mass (clay caliche), which normally has a jointed or nodular structure, but contains occasional layers of relatively impervious hardpan. Fragments of this material, which become hard upon exposure, are also embedded in the surface soil and upper subsoil and scattered over the surface.

The Karro series is derived from old valley-filling deposits, which have been greatly modified by weathering and accumulation of lime. This series is confined principally to comparatively flat parts of the valley trough bordering San Simon Creek. The surface is smooth and gently sloping to flat. Surface drainage is poor to fair, and internal drainage is arrested by the compact subsoil. Two types—the Karro fine sandy loam and the clay loam—each with phases, are mapped.

The recent-alluvial soils are not extensive, but, including the alluvial phases of the old valley-filling group, they are relatively of much importance. The chief distinguishing characteristic of this group of soils is the loose, permeable nature of the subsoils as compared with the compact, poorly aerated subsoils of the old valley-filling group. The soil profile has not been modified through weathering and is highly stratified, because the streams deposited their suspended material under different degrees of velocity. The materials are normally calcareous, but the lime is rather uniformly distributed through the soil profile. The surface is generally smooth and comparatively flat, resulting in some places in the accumulation of injurious

quantities of alkali salts. The recent-alluvial soils are still in the process of accumulation and are subject to occasional overflow. Three series of this province are represented in the area, the Gila, Pima, and San Pedro.

The surface soils of the Gila series are brown to light grayish brown in color, and overlie a stratified subsoil, in which the various strata may vary in color from light brown to light brownish gray. Both surface and subsoil materials are highly calcareous. This series occurs principally in the flood plains of San Simon Creek and of a few of the larger drainage ways which enter it. Within recent years San Simon Creek has cut its channel 10 feet or more into the alluvial deposits, thus affording good surface and internal drainage. Formerly, however, drainage was not so well developed and alkali salts were widely deposited. The material consists of recent alluvial deposits, derived from a variety of rocks. Two soil types, the Gila fine sandy loam, including a phase, and the Gila loam, are mapped.

The Pima series includes types with dull-brown to dull grayish brown calcareous surface soils, underlain by a calcareous subsoil of the same general color and texture as the surface soils or of stratified materials of varying texture. As occurring in this survey, gravel, cobble, and bowlders are scattered through both surface soil and subsoil near the mouths of the canyons, but with distance from the mountains the quantity of such coarse material decreases. In places the material giving the Pima series is laid down upon old valley-filling deposits of brown or reddish-brown color, which appear at depths varying from 40 to 72 inches or more. These areas are not extensive and have not been shown separately on the soil map. The surface is somewhat dissected by small drainage ways and is moderately to gently sloping. Drainage is good to excessive. The Pima fine sandy loam with a gravelly phase is mapped.

The San Pedro series includes types with dull grayish brown to light-brown calcareous surface soils, and a dark-gray to black heavy-textured subsoil, containing soft lime-carbonate nodules and accumulations of gray lime material. The material below 6 feet in this area generally consists of brownish-gray material of lighter texture than the subsoil and mottled with rusty brown. These soils occupy the San Simon Cienega, a low, somewhat marshy area at the head of San Simon Creek. Drainage in general is poorly developed, though, owing to the lowering of the channel of San Simon Creek, the lower part of the area is now comparatively well drained. The San Pedro soils are classed in the present survey as recent alluvial soils, though some modifications in profile appear to have taken place, and although in previous surveys the series has been grouped with the old valley-filling soils. Alkali salts are found in varying degrees of concentration in these soils. The San Pedro clay loam, with a light-textured phase, is mapped.

The miscellaneous materials in the San Simon area include Rough stony land and Riverwash, both of which are entirely nonagricultural.

The following table gives the name and actual and relative extent of each of the types mapped in the San Simon area:

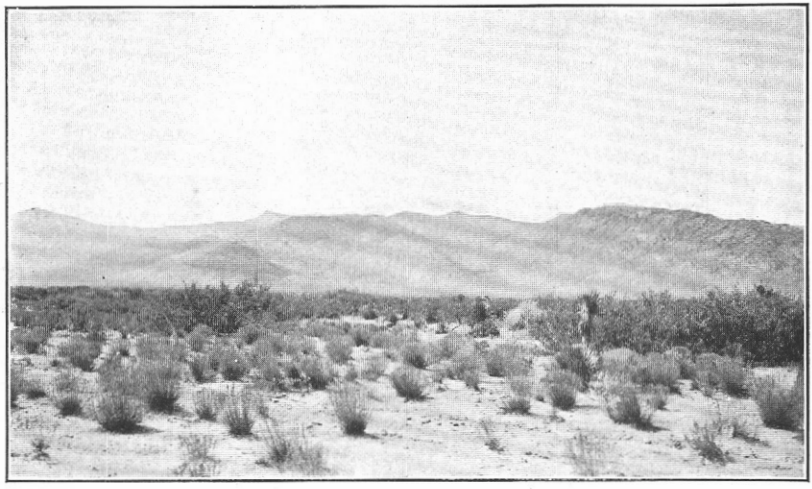


FIG. 1.—ABRUPT MOUNTAIN SLOPES BORDERING THE ALLUVIAL FANS. SOILS OF THE COCHISE SERIES IN THE FOREGROUND

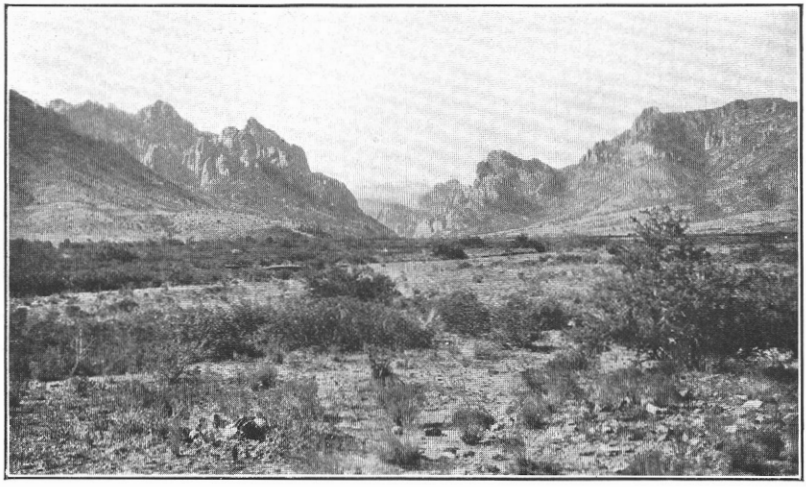


FIG. 2.—ALLUVIAL FAN AT MOUTH OF CAVE CREEK CANYON. SOILS OF THE PIMA SERIES IN THE FOREGROUND

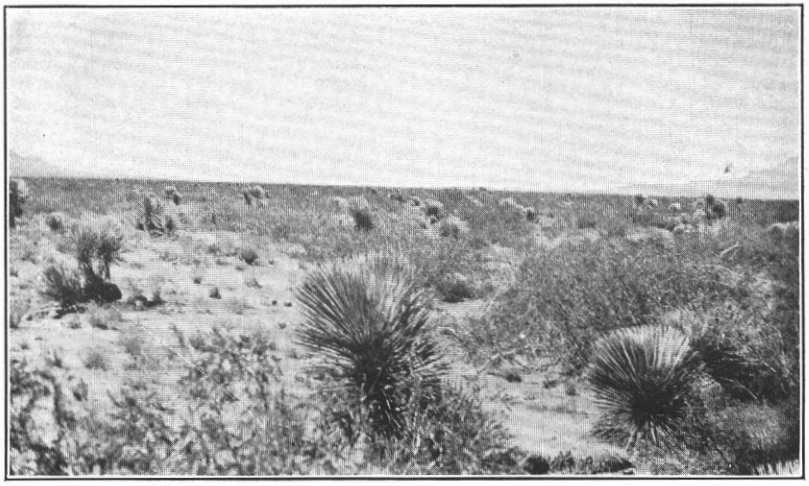


FIG. 1.—TOPOGRAPHY AND NATIVE VEGETATION ON SOILS OF THE MOHAVE SERIES

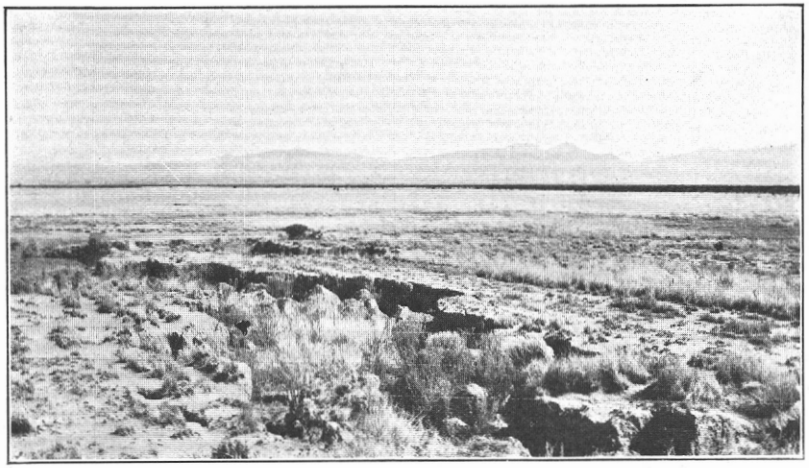


FIG. 2.—GRASS-COVERED AREA, OR "HAY FLAT," IN THE DOS CABEZAS LOAM. NOTE EFFECTS OF RECENT EROSION

Areas of different soils.

Soil.	Acres.	Per cent.	Soil.	Acres.	Per cent.
Cavot gravelly sandy loam	113,216	39.5	Karro clay loam	2,112	1.3
Mohave gravelly sandy loam	37,888		Alluvial phase	1,664	
Heavy alluvial phase	4,608	16.1	Gila loam	2,944	1.0
Alluvial phase	3,584		Imperial loam	2,880	1.0
Karro fine sandy loam	8,960		Imperial clay	2,880	1.0
Heavy phase	15,616	9.1	Rough stony land	2,688	.9
Alluvial phase	1,533		Pima fine sandy loam	576	.7
Dos Cabezas loam	14,528		Gravelly phase	1,344	
Silty alluvial phase	3,712	6.9	Cochise silt loam	1,792	.6
Heavy phase	320		Gila fine sandy loam	704	.5
Eroded phase	1,216		Fine-textured phase	448	
Cochise gravelly sandy loam	15,808	5.5	Riverwash	832	.3
Cochise fine sandy loam	14,080	4.9	San Pedro clay loam	256	.2
Cavot loam, alluvial phase	10,624	3.7	Light-textured phase	384	
Dos Cabezas sandy loam	9,792	3.4	Mohave sand	384	.1
Cave gravelly fine sandy loam	8,832	3.3			
Heavy phase	512		Total	286,720	

MOHAVE GRAVELLY SANDY LOAM.

The surface soil of the Mohave gravelly sandy loam is a red to dull-red or reddish-brown, noncalcareous gravelly sandy loam 8 or 10 inches deep. It has a relatively large content of fine and very fine sand. The gravels are confined principally to the surface 3 or 4 inches of soil. The fragments range in size from the size of a pea to an inch or more in diameter. They are of irregular or subangular shape and appear to be derived mainly from quartz-bearing crystalline rocks. Some small areas are almost or entirely free of gravel. The subsoil is composed of three sections. The upper one, extending to a depth of 24 to 30 inches, consists of a moderately compact, highly calcareous, pale-red to red heavy sandy loam, or loam with faint gray mottles resulting from accumulations of soft limy material. The second section, extending to a depth of 24 to 60 inches, is very compact, grayish red in color, and highly calcareous. The lower subsoil is of more pronounced or darker red color than the overlying material of about the same texture, only moderately compact, and strongly mottled with gray.

This type occurs principally in the vicinity of Bowie and south of Karro, where it occupies the higher desert slopes. Other areas occupy the lower slopes of the Cave Creek fan. Most of the areas are somewhat irregular in outline.

The Mohave gravelly sandy loam is formed by weathering of unconsolidated water-laid materials, derived largely from igneous rocks, but containing some materials from sedimentary and volcanic rocks. The topography is smooth and moderately sloping, affording excellent surface drainage and lending itself especially well to irrigation. A great deal of the rain that falls on uncultivated land of this type is lost as run-off. The type is entirely free from injurious accumulations of alkali salts.

The Mohave gravelly sandy loam is used more than any other type for dry farming, which is supplemented by some irrigation. The native vegetation consists mostly of mesquite, cat's-claw, yucca, and sotol. (Pl. XVII, fig. 1.) The principal crops cultivated are milo, wheat, oats, and barley.

There are a few small plantings of peaches, apricots, and grapes. The soil seems well adapted to their growth, but the yields are made somewhat uncertain, because of likelihood of frosts at critical stages. Watermelons and muskmelons yield well on this type. Where water is available to supplement dry-farming methods, wheat yields 10 to 20 bushels per acre, and barley 15 to 25 bushels.

Improved land of the Mohave gravelly sandy loam type is held at $50 to $80 an acre; unimproved land under fence sells at $10 to $25 an acre.

This soil is low in content of organic matter and could be materially improved by incorporating barnyard manure or by plowing under green-manure crops. Where dry farming is practiced, more thorough cultivation of the land would be advisable. Maintaining a mulch of loose earth over the surface when not in crop would help to absorb and retain rainfall for subsequent use.

Mohave gravelly sandy loam, alluvial phase.—The surface soil of the Mohave gravelly sandy loam, alluvial phase, consists of 6 to 15 inches of brown to light-brown noncalcareous sandy loam overlying the typical red calcareous Mohave subsoil. Locally the surface soil is light reddish brown, and in places it is slightly calcareous. Gravel, a distinctive feature of the surface soil of the typical Mohave gravelly sandy loam is almost or entirely wanting in the soil of this phase.

Areas of the alluvial phase occur in the northwestern and southern parts of the area, associated with areas of the typical Mohave gravelly sandy loam. It is of small extent and little agricultural importance. It occupies the beds of shallow drainage ways or slight depressions in which material carried in suspension by the run-off waters of desert storms is deposited as an alluvial overwash over the materials of the Mohave series. The phase has good drainage, and is well adapted to irrigation. It is free from accumulations of alkali salts and yields about as well as the adjoining soils. The native vegetation is practically the same as on the typical Mohave gravelly sandy loam, though usually slightly more vigorous.

This phase is subject to overflow at irregular periods, making necessary some protection against washing out of crops. The addition of organic matter and thorough cultivation would be advisable. It is sold only in connection with other soils.

Mohave gravelly sandy loam, heavy alluvial phase.—The heavy alluvial phase of the Mohave gravelly sandy loam is characterized by a brown to light-brown friable surface soil of loam texture, consisting of recent-alluvial material occurring as an overwash on the typical Mohave materials. The depth of the alluvial surface material varies from 6 to 14 inches. The surface soil is usually free from gravel or only slightly gravelly, and is generally noncalcareous or only very slightly calcareous, while lime accumulations are abundant in the subsoil.

The phase is associated with the typical Mohave gravelly sandy loam and occupies slight depressions or shallow desert drainage ways which carry the run-off following heavy showers and severe storms.

The areas are usually long and narrow, with smooth and gently sloping surfaces. The phase is free of alkali salts, is well adapted to irrigation in connection with the associated soils, and produces about the same yields. The native vegetation consists of mesquite and cat's-claw of somewhat more vigorous growth than that found on the typical Mohave gravelly sandy loam. Since the phase is subject to occasional overflow, protection should be provided to prevent the washing out of crops.

The table below gives the results of mechanical analyses of samples of the surface soil and the three sections of the subsoil of the typical Mohave gravelly sandy loam:

Mechanical analyses of Mohave gravelly sandy loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
510507	Surface soil, 0 to 8 inches..	4.1	9.9	5.8	30.7	24.0	21.8	3.9
510508	Upper subsoil, 8 to 24 inches	3.4	15.9	7.1	23.8	14.1	15.2	20.4
510509	Middle subsoil, 24 to 42 inches	6.6	19.4	8.7	30.0	15.8	11.4	8.0
510510	Lower subsoil, 42 to 72 inches	3.4	14.2	6.2	22.4	16.4	18.5	18.7

MOHAVE SAND.

The surface soil of the Mohave sand consists of 10 to 18 inches of reddish-brown to red sand, devoid of lime carbonate, and low in organic matter. The subsoil is a reddish-brown or red slightly compact loamy sand, which is slightly calcareous. The type contains coarse and medium sand, but is composed largely of the finer grades. The particles are generally rounded and well worn and consist largely of granitic material, though some sandstone or basaltic material is also present.

The type is derived from old valley-filling deposits which have been blown about and modified by winds. The material is relatively stable at present, supports a desert vegetation, and appears to have been sufficiently modified by weathering in places to develop a noticeable compaction or accumulation of clay particles in the subsoil. The subsoil, however, is much more pervious and much lower in lime than the typical Mohave material. It represents a wind-modified inclusion, which, if of greater extent, might have been classified in a distinct series of wind-laid soils.

The Mohave sand occupies numerous small areas in the vicinity of Bowie, the largest area being about 3 miles north of that point. One area lies on the west side of San Simon Creek, about 3 miles north of the San Simon Cienega. The topography is rolling or ridgelike, the smaller areas consisting generally of single mounds with smooth, sloping sides.

The type is very droughty and supports a desert vegetation including yucca or sotol and some rabbit brush. None of the type is under cultivation, and it is sold only in connection with other soils.

CAVOT GRAVELLY SANDY LOAM.

As typically developed the surface soil of the Cavot gravelly sandy loam consists of 8 to 14 inches of light-brown to reddish or somewhat purplish-brown friable gravelly sandy loam, which is low in organic matter and rather compact. When wet the soil is distinctly reddish brown. The upper subsoil is reddish brown or purplish brown to red, compact, and contains varying quantities of gravel and cobblestones mixed with the finer materials. It is somewhat heavier in texture than the surface soil. Below 36 to 48 inches the subsoil is very gravelly and contains numerous cobblestones, with only small quantities of red or grayish-red material of heavy sandy loam or finer texture. Typically the surface soil is noncalcareous or only slightly calcareous, but the subsoil contains large quantities of lime carbonate and in places the lower section is slightly cemented with this salt, though not hard enough to interfere with the penetration of roots.

As mapped in this survey the type includes rather extensive developments which differ somewhat from the typical in color, lime content, and profile. In the most important of these variations the surface soil is calcareous and both surface and subsoil materials while brown are grayer in color than the normal soil. In some places in this variation the subsoil is nearly free of gravel. As mapped this type also includes small areas of red or reddish-brown soil similar in the surface soil to the Mohave types, but with the open porous subsoil of the Cavot series. In more detailed mapping these should probably be recognized as representing a distinct series. A few small areas in which the surface soil is heavier in texture than is typical are also included. Cobblestones are scattered over the surface of the type; and areas in which these are present in sufficient quantities to interfere with cultivation have been indicated on the map by stone symbols.

The Cavot gravelly sandy loam is the most extensive type in the San Simon area. It occupies alluvial-fan slopes in all parts of the area. The largest developments are east, northeast, southeast, and south of San Simon. Small areas lie north of San Simon and in the vicinity of Bowie. A large body of the type occurs at the mouth of Cave Creek, in the southern part of the area. The included land of heavy texture is represented by two small areas about 1½ miles south and slightly west of the Cochran ranch and about 6 miles southeast of Bowie.

The topography varies from smooth and gently sloping on the lower slopes of the fans to slightly rolling and dissected on the slopes adjacent to the mountains. The greater part of the type, however, could be put under irrigation without much difficulty, and with the addition of organic matter should be fairly well adapted to irrigation. Some of the more friable, porous-structured areas would be droughty and would require a great deal of water to mature a crop successfully. Surface and internal drainage are well developed throughout the type, and upon some of the more gravelly areas the slope is moderately steep and drainage is excessive.

The material composing the Cavot gravelly sandy loam is comparatively old, as is shown by the presence of the compact and slightly cemented subsoil, which has been formed through the leaching of lime

from the upper soil layers and its concentration in the lower part of the soil profile.

Less than 1 per cent of the type is under cultivation. The native vegetation consists largely of creosote bush, but includes several varieties of cacti, rabbit brush, and grasses, and, bordering the drainage ways, some mesquite and cat's-claw. Where cultivated, good yields of potatoes, corn, and alfalfa are obtained. Sweet potatoes yield 200 to 300 bushels, potatoes yield 100 to 200 bushels, and milo 60 to 70 bushels of grain per acre. Alfalfa is cut on an average of five times a year and yields about 1 ton per cutting. Some Sudan grass also has been grown on the type with good yields. Some of the more droughty areas, however, are of little agricultural importance.

Improved land is valued at $40 to $85 an acre, and unimproved land under fence is held at $10 to $20 an acre, depending on location.

Where air drainage is good, thus eliminating as far as possible the likelihood of frost, the Cavot gravelly sandy loam should prove well adapted to the production of such fruits as apples, peaches, cherries, and apricots. Small fruits, vegetables, watermelons, and muskmelons should also do well on this type. Under irrigation, however, one of the first steps taken in the cultivation of this soil should be the addition of organic matter, by applying barnyard manure or by turning under rye or oats as green manure. On the steeper slopes some care should be taken in laying out an irrigated tract to prevent washing of the soil. In all cases protection should be provided against damage to crops from run-off following storms.

The following table gives the results of mechanical analyses of samples of soil and upper and lower subsoil of the Cavot gravelly sandy loam:

Mechanical analyses of Cavot gravelly sandy loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
510525	Soil, 0 to 8 inches	4.6	12.1	6.7	31.9	16.8	16.4	11.6
510526	Upper subsoil, 8 to 36 inches	3.0	9.4	5.2	22.8	20.2	25.3	14.0
510527	Lower subsoil, 36 to 72 inches	5.0	10.6	4.4	17.2	14.8	25.1	22.9

CAVOT LOAM, ALLUVIAL PHASE.

The typical Cavot loam is represented in this survey only by an alluvial phase. This consists of a surface soil, 8 to 24 inches deep, of a recent-alluvial overwash of light grayish brown or light-brown calcareous very fine sandy loam, lying upon a subsoil of calcareous, light grayish brown, compact silt loam or clay loam. In color and texture the soil is quite uniform throughout its occurrence, though somewhat variable in depth.

The phase occupies comparatively level areas on the lower slopes of the Cave Creek fan and long, narrow areas of imperfect surface drainage which traverse the fan. Small areas also occur adjacent to San Simon Creek. The surface is generally smooth, except for occasional gullies, and drainage is sufficient to prevent the accumulation of alkali. The entire area of the phase should prove well adapted to irrigation.

Though none of the phase is under cultivation, it is relatively important. The vegetation consists almost entirely of a luxuriant growth of native grasses, and the areas are known locally as "hay flats." They are largely under fence and are used for grazing, stock being driven there when the pasturage on the outside range suffers from drought. Over part of the phase grass is cut for hay, stacked in the field, and fed when needed. Yields vary from one-half to 1 ton per acre. On account of its present agricultural value, the phase is held at a slightly higher price than other unimproved land. Under good management this soil can be maintained in its present state of productiveness indefinitely.

CAVE GRAVELLY FINE SANDY LOAM.

The surface soil of the Cave gravelly fine sandy loam consists of 10 to 14 inches of brown to reddish-brown, or purplish-brown, calcareous gravelly fine sandy loam. The subsoil is a grayish-brown or gray, calcareous gravelly sandy loam, which at depths of 18 to 40 inches is underlain by a dense, lime-cemented, gravelly hardpan or "caliche." The hardpan in places extends to a depth of 6 feet or more, but may be underlain by a compact or partly cemented gray, stony, gravelly sand or sandy loam within the 6-foot profile. Some included areas, in which the hardpan formation directly underlies the soil at depths of 10 to 14 inches, have a slightly grayish brown or light reddish brown surface soil.

The largest area of the Cave gravelly fine sandy loam borders the hills of limestone formation in the vicinity of Cave Creek. Another large area lies on the east side of the valley just north of the San Simon Cienega. Less important areas occur at the base of the foothills northeast of San Simon and about 10 miles south of San Simon. The surface is generally smooth and undulating, except for occasional drainage ways, which are several feet in depth near the mountains. A moderately steep slope insures good surface drainage and a complete freedom from accumulations of alkali salts.

The native vegetation includes only the more hardy desert plants, because the dense "caliche" restricts root penetration, and moisture can be drawn solely from the surface soil. The nearness of the hardpan formation to the surface and the presence of large quantities of gravel and stone throughout the soil profile make the type difficult to handle and of little or no economic value. The area in the northeastern part of the survey contains excessive quantities of stone in the surface soil.

Cave gravelly fine sandy loam, heavy phase.—The heavy phase of the Cave gravelly fine sandy loam consists of 10 to 14 inches of brown to reddish-brown, calcareous very fine sandy loam, overlying a subsoil of grayish-brown, calcareous gravelly sandy loam. A gray, cemented, gravelly hardpan is encountered at 20 to 45 inches. This continues to variable depths and is underlain by gray or grayish-brown, compact sandy loam or gravelly sandy loam. The hardpan, which is not so well developed in this phase as in the typical Cave gravelly fine sandy loam, varies in thickness from 10 to 36 inches, and consists of firmly cemented layers of gravel and sand.

This phase occupies one area about 6 miles northeast of Portal School. It has a smooth and gently sloping surface which affords good surface drainage and is favorable for irrigation, but owing to the shallow nature of the soil and the imperviousness of the subsoil, the type has little present or prospective value. The native vegetation consists almost entirely of creosote bush and scattering clumps of grass. This land has a rather low value for grazing, for which it is chiefly adapted.

The results of mechanical analyses of samples of the soil and subsoil of the typical Cave gravelly fine sandy loam are given in the following table:

Mechanical analyses of Cave gravelly fine sandy loam.

Number	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
510515	Soil, 0 to 10 inches.....	2.4	5.8	4.2	30.4	33.3	18.9	5.6
510516	Subsoil, 10 to 72 inches....	10.7	22.9	8.0	20.5	13.2	16.7	8.0

COCHISE GRAVELLY SANDY LOAM.

The surface soil of the Cochise gravelly sandy loam consists of 12 to 18 inches of brown to light-brown, friable, gravelly sandy loam, which appears reddish brown when wet. It is low in organic matter, and without lime accumulations or only slightly calcareous to a depth of 14 inches or more. The subsoil is variable in texture, ranging from gravelly sandy loam to dull-brown silt loam; it is slightly compact and mildly calcareous. The type generally shows some stratification, and in places it has a recent overwash of material similar in color to the underlying older material. The surface soil is of rather light texture and as mapped the type may include some areas of sand. The gravelly material in the type is mostly of basic igneous rock, with some of quartz-bearing granite and sedimentary and metamorphic rocks. The gravel fragments range from the size of a pea to an inch or two in diameter. Angular, subangular, and rounded cobblestones are scattered over the type in the vicinity of drainage ways.

The type is rather extensive. Some of the largest areas lie south and southwest of Bowie and west and southwest of San Simon. One large area east of San Simon Creek parallels the creek for a distance of over 8 miles. Several areas lie about 8 miles north of Portal School.

Drainage is good to excessive, some of the higher lying areas having comparatively steep slopes. The surface is gullied somewhat by shallow drainage ways, but most of it could be easily leveled for irrigation. The type is capable of absorbing large quantities of water, but it is not retentive and plants growing on it quickly show the effects of drought. Some of the areas with more porous textured subsoil would require large quantities of water under irrigation, and probably would not make as economical use of it as the heavier textured types, from which evaporation and percolation would not be so great.

The type is used largely for pasture. The vegetation consists of mesquite, cat's-claw, rabbit brush, and a scant growth of grasses. A few farms are located on the type and are devoted principally to the growing of alfalfa, potatoes, and sweet potatoes. Some Sudan grass is grown and gives good yields of hay. Alfalfa yields 3 to 4 tons per acre per season. Sweet potatoes yield exceptionally well, producing 150 to 300 bushels per acre; occasionally even higher yields are reported. Potatoes produce from 100 to 200 bushels per acre.

Improved land sells for $45 to $85 an acre, and unimproved at $10 to $20 an acre.

The chief need of the Cochise gravelly sandy loam is the addition of organic matter to aid in the retention of moisture. Growing more alfalfa and turning under green-manure crops, such as alfalfa, rye, and oats, would increase the moisture-holding capacity. Frequent cultivation of intertilled crops, to maintain a mulch, would be advisable.

The results of mechanical analyses of samples of the surface soil and subsoil of the lighter textured inclusions of the Cochise gravelly sandy loam are given in the following table:

Mechanical analyses of Cochise gravelly sandy loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
510513	Soil, 0 to 18 inches	3.1	17.3	11.3	39.6	16.1	6.1	7.1
510514	Subsoil, 18 to 72 inches	.9	3.9	2.9	14.8	25.4	46.4	5.9

COCHISE FINE SANDY LOAM.

The surface soil of the Cochise fine sandy loam is typically brown to light brown in color, appearing slightly reddish brown when wet. It is rather heavy in texture, approaching a loam; is free of lime-carbonate accumulations, generally low in organic matter, and has a tendency to become compact when dry. At depths ranging from 10 to 15 inches the surface soil passes into a subsoil of moderately compact, brown or dull-brown, calcareous silty loam or clay loam. This is generally uniform in texture to a depth of 6 feet or more, though in places it contains layers of coarser or finer materials, which vary in thickness from 6 to 12 inches, but are not continuous over large areas.

As mapped in this survey, the type includes some variations. In places the surface soil is reddish brown in color. In other places small gravel and grit occur in the surface soil and subsoil. Locally the surface of the type is covered with a thin wash of recent alluvial material of the same color and character as the type.

The type is most prominently developed on the lower slopes of the alluvial fans in the vicinity of Bowie. Other areas occupy the lower slopes of the Cave Creek fan and border the shallow drainage channels throughout the alluvial fans of the area. The surface is smooth, except for shallow depressions or gullies, and the slope is sufficient to be favorable for irrigation and drainage. The type is almost entirely free of injurious accumulations of alkali salts.

At the present time the Cochise fine sandy loam is unimportant, but under irrigation it should have a relatively high agricultural value. It is friable, easily handled, and retentive of moisture. As with other alluvial-fan soils, protection against the washing out of crops would have to be provided.

The type is not under cultivation, but is used largely as grazing land. Grass was once well distributed, but has been largely destroyed by overgrazing, and its place has been taken by mesquite, cat's-claw, and rabbit brush. The land is held at $15 to $25 an acre, depending on location.

In the table below are given the results of mechanical analyses of samples of the soil and subsoil of the Cochise fine sandy loam:

Mechanical analyses of Cochise fine sandy loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
510511	Soil, 0 to 10 inches.....	0.8	3.7	3.1	20.9	28.3	35.7	8.0
510512	Subsoil, 10 to 72 inches.....	.5	2.8	2.4	16.7	20.6	42.8	14.2

COCHISE SILT LOAM.

The surface soil of the Cochise silt loam consists of 8 to 12 inches of dull-brown or grayish-brown silt loam, slightly gritty and of rather heavy texture, which becomes rather plastic when wet. The subsoil is a light grayish brown to dull-brown compact clay loam or silty clay loam, which in places is slightly stratified with seams of silt loam or sandy loam of the same color. The surface soil contains no lime carbonate, or is only slightly calcareous, to a depth of 8 or 10 inches, but the subsoil is highly calcareous and is slightly more compact than in the other types in the series. In local areas near streams the surface material has been reworked to some extent by flood waters and small quantities of recent alluvial material have been deposited as an overwash. Such areas are small and variable in texture, generally being much more friable than the typical silt loam. Small gravel or coarse sand occurs in the surface soil and subsoil in places on the higher slopes of the alluvial fans.

The type is of small extent. The largest area is about 7 miles northeast of Portal School and occupies the lower slopes of the Cave Creek fan. Smaller areas lie along drainage channels south and southeast of Bowie. Except for occasional shallow gullies, the surface of the type is smooth. The slope is favorable for irrigation and sufficient to give good surface and internal drainage. The type is free from injurious accumulations of alkali salts.

Mesquite, cat's-claw, and the high top saccaton grass constitute the principal types of native vegetation and afford good grazing for stock. (Pl. XVI, fig. 1.) None of the type is under cultivation, but with future development and irrigation it should prove valuable in the production of all crops adapted to this region.

A few houses are located on the type, and roads are more numerous than on some of the other soils in the area. Unimproved land of this type under fence is held at $10 to $25 an acre.

The results of mechanical analyses of samples of the soil and subsoil of the Cochise silt loam are given in the following table:

Mechanical analyses of Cochise silt loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
510554	Soil, 0 to 12 inches	3.0	3.4	1.6	5.7	13.8	53.9	18.7
510555	Subsoil, 12 to 72 inches	2.7	4.4	1.9	6.7	17.0	47.2	20.1

DOS CABEZAS SANDY LOAM.

The surface soil of the Dos Cabezas sandy loam consists of 8 to 12 inches of light-brown to grayish-brown calcareous sandy loam carrying a relatively large proportion of fine and very fine sand, some grit, and fine gravel. The soil is low in organic matter and is usually compact or baked when dry. The upper subsoil has about the same color as the soil, but is heavier in texture and more compact. The lower subsoil is a compact, grayish-brown, calcareous silty clay loam or silty clay, generally mottled with gray lime concretions or nodules. In a few areas the surface soil is darker brown or pinkish brown and throughout the type there are areas with a light-yellowish tint. Small fragments of "clay caliche," subsoil material cemented with lime, are encountered on the surface in places.

The largest area of the type lies south of the Southern Pacific Railroad about midway between Bowie and San Simon. Other areas are found south, southeast, and northwest of San Simon, and about 4 miles northeast of Bowie. Along the lower slopes of alluvial fans on which it occurs the surface is smooth and gently sloping; the higher lying areas are slightly dissected by shallow drainage ways. Most of the type would require little leveling to prepare it for irrigation, and with the addition of organic matter it should prove retentive of moisture and easy to handle. Drainage is well developed throughout the type.

A small proportion of the Dos Cabezas sandy loam is under cultivation. The native vegetation consists principally of creosote bush. The type is droughty, and water for irrigation is available only by pumping from wells or by diverting and storing the run-off from rains. Under irrigation the type should prove highly productive of such crops as potatoes, alfalfa, watermelons, vegetables, and small fruits. Unimproved land is held at $10 to $20 an acre, depending on location.

The table below gives the results of mechanical analyses of samples of the soil, upper subsoil, and lower subsoil of the Dos Cabezas sandy loam:

Mechanical analyses of Dos Cabezas sandy loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
510504	Soil, 0 to 8 inches	3.5	16.1	7.1	24.7	16.9	25.0	6.9
510505	Upper subsoil, 8 to 36 inches	1.6	4.5	1.9	6.8	12.1	47.2	26.0
510506	Lower subsoil, 36 to 72 inches	.3	2.2	1.0	3.8	6.7	54.0	31.9

DOS CABEZAS LOAM.

The surface soil of the Dos Cabezas loam consists of 10 to 14 inches of light yellowish brown to light grayish brown (light reddish brown when wet) calcareous loam, which contains a relatively large proportion of silt and very fine sand. A pinkish tinge generally shows in the soil when dry. The subsoil is a grayish-brown, compact, highly calcareous clay loam or silty clay loam, which contains a few small lime-carbonate nodules, but is generally uniform in color and texture to a depth of 6 feet or more. In a few areas near drainage ways the surface soil contains small quantities of gravel and grit. The type is friable, easily cultivated and maintained in good tilth, and retentive of moisture.

The Dos Cabezas loam is important both from the standpoint of extent and use, some of the best developed farms in the area surveyed being situated on the type. Several large areas of it lie south and southeast of San Simon and northeast of Bowie. The surface is generally smooth or in places slightly hummocky, owing to modification of the surface material by wind or by surface waters. A gentle slope affords good surface drainage and makes the type well adapted to irrigation. The soil takes water readily, absorbing most of the rain that falls on the surface. Some lower lying areas of the type adjoining San Simon Creek are not so well drained and are affected with small concentrations of alkali salts.

A heavy growth of creosote bush is found over most of the type, and a few small areas support a good stand of grasses. (Pl. XVII, fig. 2.) Less than 5 per cent of the type is under cultivation. The principal crops are alfalfa, wheat, and corn. Some cotton was grown on the type in 1920, but owing to late planting and an early frost little of it matured, although the stands were thrifty and promised good yields. Alfalfa is adapted to the type and produces well. It is cut five or six times a season, and gives a total yield of 4 to 6 tons per acre. Wheat yields 20 to 35 bushels and corn 40 to 50 bushels per acre. Kafir is grown to about the same extent as corn, and yields from 60 to 70 bushels of grain. Potatoes and sweet potatoes are grown for home use and yield well. The type is adapted to vegetable gardening, and home gardens produce abundantly.

Improved land of this type sells for $50 to $125 an acre, depending on location and improvements. Unimproved land may be bought at $10 to $25 an acre.

On the steeper slopes the type has a tendency to wash under irrigation. This can be largely remedied and the soil structure greatly improved by the incorporation of organic matter. Where water is available for irrigation more of the type could be used profitably in the production of alfalfa, with a consequent expansion of the dairy industry. With later development the type should prove valuable in the production of small fruits, potatoes, and vegetables.

Dos Cabezas loam, heavy phase.—The surface soil of the heavy phase of the Dos Cabezas loam consists of 10 to 15 inches of light-brown or light grayish brown calcareous clay loam. When wet this is rather plastic and has a brown or light reddish brown color. The subsoil is a light grayish brown calcareous clay loam, or silty clay loam, which contains some whitish fragments of lime-cemented "clay caliche"

and is generally somewhat mottled with gray lime accumulations. In places the surface soil is light grayish brown or gray. Over the entire phase fragments of "caliche" or lime-carbonate nodules occur more or less on the surface and in the surface soil and subsoil.

The only body of the phase in the area surveyed lies along San Simon Creek, about 7½ miles southeast of San Simon. The surface is somewhat eroded in places; otherwise it could be put under irrigation at small expense. Surface drainage is good, but subdrainage is somewhat restricted, and consequently most of the phase is affected by accumulations of alkali salts.

Part of the land has been cleared of native vegetation, consisting principally of creosote bush and mesquite, and is under cultivation. Kafir, wheat and cotton are the principal crops grown, with yields somewhat less than on the typical Dos Cabezas loam. Vegetables of excellent quality are produced on the phase, and muskmelons and watermelons yield well.

This land is adapted to the production of grain, cotton, and alfalfa and responds well to good agricultural treatment. Increased yields will generally result from the application of barnyard manure or the turning under of green-manure crops.

Dos Cabezas loam, silty alluvial phase.—The surface soil of the silty alluvial phase of the Dos Cabezas loam consists of 8 to 20 inches of light grayish brown or light-brown calcareous silt loam. The phase consists of a recent deposit of material similar to the typical surface soil of the Dos Cabezas loam, over a compact, calcareous, grayish-brown silt loam or clay loam subsoil. The soil is of mellow structure, though low in organic matter. It is variable in depth, depending largely on its location; it is deepest where surface drainage is somewhat impeded. The soil usually grades rather gradually into the more compact and older subsoil material.

This phase occurs about 3 miles south and southeast of San Simon, where it occupies three areas at the base of the steeper alluvial-fan slopes. The surface is smooth and gently sloping, and the surface drainage is somewhat slow but in no case poor. The soil takes water readily and is well adapted to irrigation. A heavy growth of creosote bush and scattering clumps of grass are found over most of the phase. A small area is in cultivation, the principal crops grown being wheat and corn. The yields obtained are similar to those on the typical Dos Cabezas loam.

Land values range from $60 to $90 an acre for improved, and $10 to $20 an acre for unimproved land.

Dos Cabezas loam, eroded phase.—The eroded phase differs from the typical Dos Cabezas loam only in that to a depth of 24 to 36 inches it is badly dissected by numerous drainage ways and washes, leaving the surface rough and uneven and characterized by alternate mounds and depressions. The surface soil and subsoil are similar in all respects to the typical Dos Cabezas loam.

The phase occupies two small areas about 5½ miles southeast of San Simon. They occur in a rather shallow depression which receives much run-off from higher lying areas during periods of storms. The slope of the land is somewhat steeper than in the adjoining soils. Drainage is good to excessive over the entire phase.

The native vegetation consists of creosote bush and various species of cacti. None of the phase is under cultivation. With proper leveling it should prove productive, but leveling for irrigation would be expensive and involve much labor.

The table below shows the results of mechanical analyses of samples of the soil and subsoil of the Dos Cabezas loam:

Mechanical analyses of Dos Cabezas loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
510536	Soil, 0 to 10 inches	0.2	1.2	0.7	13.1	29.1	45.2	10.8
510537	Subsoil, 10 to 72 inches	.8	.6	.2	2.9	17.2	53.0	25.5

IMPERIAL LOAM.

The surface soil of the Imperial loam, as occurring in this survey, consists of 10 to 14 inches of chocolate-brown to light purplish brown, slightly calcareous or noncalcareous loam, of relatively heavy texture. The subsoil is a pinkish or purplish-brown compact clay loam or silty clay loam, high in lime carbonate. In places a grayish-red clay loam mottled with gray lime material is reached at depths of 50 to 60 inches. Small gravel appears here and there as a thin layer on the surface or mixed with the surface soil. In some of the flatter, more poorly drained areas of this type alkali salts have accumulated to some extent, though rarely in quantities large enough to injure crops.

The type occupies two areas on the east side of San Simon Creek, the larger one paralleling it for a distance of several miles. The surface is smooth, except for a few deep, narrow erosions. The slope is favorable for irrigation and in most places is sufficient to give good drainage. The type consists of well-weathered water-laid deposits of mixed origin, in which materials derived from volcanic rocks appear to predominate.

The Imperial loam is largely cleared of the native vegetation, consisting principally of mesquite and cat's-claw. About one-tenth of this soil is in cultivation at the present time, and further development is dependent upon an increased supply of water for irrigation. The principal crops grown are milo, wheat, corn, and alfalfa. The yields are about those obtained on the Imperial clay.

Land values range from $60 to $100 an acre for improved land, and from $10 to $20 an acre for unimproved.

The table below gives the results of mechanical analyses of samples of the soil and subsoil of the Imperial loam:

Mechanical analyses of Imperial loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
510545	Soil, 0 to 10 inches	1.9	3.7	2.7	16.3	25.6	33.4	16.8
510546	Subsoil, 10 to 72 inches	1.7	4.8	3.1	17.5	16.1	28.6	28.2

IMPERIAL CLAY.

The surface soil of the Imperial clay consists of 8 to 14 inches of dull purplish brown to light-purplish brown or chocolate-brown plastic clay. The subsoil is a light reddish brown or purplish-brown somewhat compact clay. The surface soil is generally noncalcareous or only very slightly calcareous, while the subsoil has a high lime content. In places below depths of 50 to 60 inches the subsoil is a grayish-red or light-purplish clay loam or loam carrying soft gray lime concretions and more compact than the upper subsoil. Fine gravel occurs locally on the surface and through the upper subsoil. Alkali salts containing some sodium carbonate or "black alkali" are found in small quantities in some of the flatter areas of the type.

Two areas of the Imperial clay are mapped in this survey. They occur on the east side of San Simon Creek near the town of San Simon, and border the creek bottom for a distance of about 8 miles. The surface is smooth, except where narrow cuts 3 or 4 feet deep have been caused by run-off from the higher slopes in time of storm. The type is well adapted to irrigation, the slope being sufficient in all cases to insure good drainage.

The Imperial clay is an old valley-filling soil derived from deposits of mixed origin, in which material from volcanic rocks predominates. The material is well weathered and the subsoil is compact and highly calcareous.

Although small in extent, the type is at present one of the most important agriculturally in the area, as artesian water can be obtained over the greater part of it. It is mostly cleared of native vegetation, but mesquite, cat's-claw, and rabbit brush are found in a few localities. The principal crops are alfalfa, milo, wheat, and corn. Some cotton was grown for the first time on this type last season (1920) and yielded from one-half to three-fourths bale per acre. Alfalfa is cut five or six times a year, depending on the season, and yields of 4 to 5 tons per acre are obtained. Milo yields 60 to 75 bushels of grain, corn from 40 to 50 bushels, and wheat 30 to 40 bushels per acre.

In preparing the land for wheat it is plowed late in September or in October and then worked down by harrowing or rolling until a good seed bed is produced. It is then irrigated, and as soon as the soil is dry enough to work the grain is sown either by drilling or by broadcasting and harrowing. The fall rains are usually sufficient to carry the crop through the winter; if not, it is irrigated as occasion demands. Generally the field is pastured by young beef or dairy cattle during the winter months. The crop is either cut green for stock feed or harvested for grain.

Several farms on this type are devoted largely to hog production; the fields are divided into small tracts and sown to alfalfa, on which the hogs are allowed to pasture. Milo and corn are grown and used as a supplementary feed in fattening stock for market. Poultry and some dairy cattle are kept on nearly every ranch. Vegetables of good quality are produced largely for home use.

Well-improved farms situated on the Imperial clay are held at $75 to $125 an acre, while unimproved land sells for $20 to $30 an acre.

The addition of organic matter would make the soil easier to cultivate and increase its water-holding capacity. This can be supplied either by applying barnyard manure where available or by turning under a green-manure crop such as rye or oats. Extension of the dairy industry and the growing of more alfalfa, with the production of hogs and poultry as a side line, could well be recommended for this type. The wasteful practice of allowing the continuous flow of artesian wells should be stopped by more rigid enforcement of the law dealing with this matter.

The table below gives the results of mechanical analyses of samples of the soil, subsurface, and subsoil of the Imperial clay:

Mechanical analyses of Imperial clay.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
510547	Soil, 0 to 10 inches	1.3	3.6	2.8	14.7	14.4	25.8	37.7
510548	Upper subsoil, 10 to 56 inches	.4	3.4	2.3	9.9	8.7	24.7	50.9
510549	Lower subsoil, 56 to 72 inches	1.5	9.3	7.5	34.6	8.3	17.3	22.2

KARRO FINE SANDY LOAM.

The surface soil of the Karro fine sandy loam is a light grayish brown to light brownish gray calcareous fine sandy loam 10 to 18 inches deep. The subsoil is represented by two sections. The upper one, which extends to a maximum depth of 36 inches, consists of moderately compact light grayish brown or light-gray sandy loam or fine sandy loam, generally containing some gray nodules of lime, which give it a mottled appearance. The lower section consists of light-gray clay loam or clay of compact structure and containing much lime carbonate. This layer carries lime nodules and extends to a depth of 6 feet or more. The surface of the type is covered more or less with fragments of "caliche" and fine gravel, though in no case are they found in sufficient quantity to interfere with cultivation.

The type occupies comparatively flat land north of the Southern Pacific Railroad. Two areas lie east of San Simon Creek; the rest of the type is in an almost continuous body along the northern boundary of the area north of Olga and Karro. The surface is generally smooth and gently sloping, except in those areas bordering San Simon Creek, where the topography is slightly rolling. Over most of the type the surface drainage is good and the subdrainage moderately good. In part of the area lying about a mile north of Karro the conditions are not as satisfactory and as a result to some extent alkali salts have accumulated.

The type has little importance agriculturally, being used only as grazing land. Rabbit brush, mesquite, and a scattering growth of native grasses constitute the vegetation. The soil could be improved by incorporation of organic matter. The Karro fine sandy loam is held at $8 to $18 an acre.

Karro fine sandy loam, alluvial phase.—The alluvial phase differs from the typical Karro fine sandy loam in having a layer of recent wash, 10 to 20 inches thick, overlying the light-gray, compact, highly

calcareous subsoil of the Karro series. The color of the dry surface material varies from brown to light grayish brown; when wet it becomes dark brown. Small gravel and "caliche" fragments are scattered over the surface, giving the soil in places a slightly gravelly texture.

The phase occupies several small flat and rather poorly drained areas north and northeast of Olga. After heavy rains this land is generally covered with drainage water from the slopes. This moves away slowly and deposits part of its load of suspended material.

A good growth of grass is found over part of the phase, making it valuable as grazing land. Otherwise it has no agricultural importance. If it were put under irrigation there would probably be trouble from alkali. It is sold only in connection with other soils.

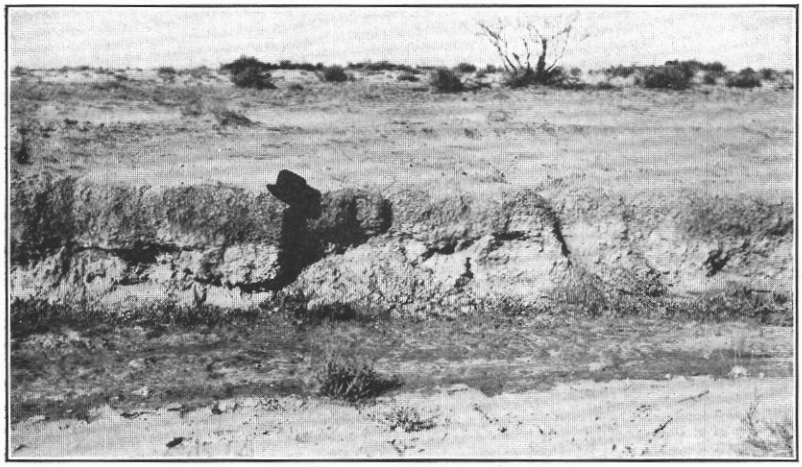
Karro fine sandy loam, heavy phase.—The surface soil of the Karro fine sandy loam, heavy phase, consists of 8 to 14 inches of a light brownish gray or pinkish-gray, calcareous, friable, fine sandy loam. It has a reddish-brown tint when wet. The upper subsoil consists of a calcareous, light pinkish brown clay loam or clay, mottled with gray. The lower subsoil is a light-gray or nearly white clay loam or clay containing numerous nodules and fragments of "caliche." Although cementation of the deeper subsoil by lime has not progressed to the point where a true hardpan has been formed over extensive areas, in a few areas, varying in size from less than an acre to 2 or 3 acres, there is a softly cemented hardpan composed largely of lime and clay. (Pl. XVIII, fig. 1.) The surface generally carries numerous nodules of "caliche" and some small gravel, but not in sufficient quantities to interfere with cultivation or greatly to modify the soil structure.

The phase is extensive and normally occurs at the upper edge of the comparatively flat plain in the trough of the valley adjacent to the base of the alluvial-fan slopes. One of the largest areas extends in a continuous body of irregular outline and varying width from near Holt to San Simon Creek, a distance of about 12 miles. Smaller areas lie north, east, and south of San Simon, where they occupy narrow ridges bordering the creek. The land is generally smooth and could very easily be put under irrigation were water available, though some of the areas bordering the creek are somewhat gullied and would require some leveling. (Pl. XVIII, fig. 2.) As a rule, the slope is sufficient for good surface drainage under irrigation, though subdrainage would generally be deficient. The greater part of the phase is free from injurious quantities of alkali.

Part of the phase supports a scant growth of mesquite or creosote bush, though most of it has only a scattering growth of rabbit brush. About 40 acres of the phase is under cultivation, the principal crops being corn and wheat. The vegetables grown for home use are of excellent quality. Grapes also appear to be adapted to the phase, several plantings for home use producing good yields.

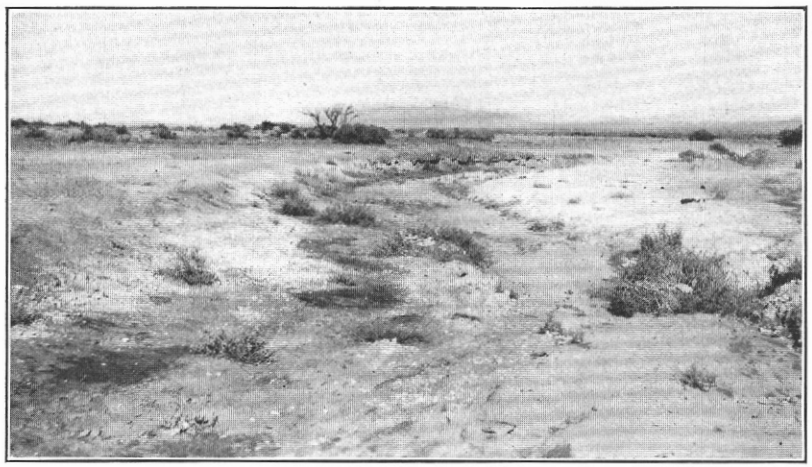
Improved land of the Karro fine sandy loam, heavy phase, is held at $60 to $80 an acre, and unimproved land can be had for $8 to $20 an acre.

The soil is easily worked and retentive of moisture, but could be greatly improved by the addition of organic matter, in which it is deficient. Though not as desirable as some of the other soils of the



S. 10989

FIG. 1.—DRAINAGE CUT IN SOILS OF THE KARRO SERIES, SHOWING WHITE LIME-CARBONATE HARDPAN OR CALICHE



S. 10987

FIG. 2.—ERODED LAND ALONG DESERT STREAM WAY IN SOILS OF THE KARRO SERIES

The white material is soft caliche or lime-carbonate hardpan

area, it should prove productive under irrigation. Care would probably have to be exercised in the use of water to prevent water-logging.

The following table gives the results of mechanical analyses of samples of the soil, upper subsoil, and lower subsoil of the typical Karro fine sandy loam and of the heavy phase:

Mechanical analyses of Karro fine sandy loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
Typical soil:		*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
510501....	Soil, 0 to 18 inches.....	1.6	8.8	4.6	23.9	12.3	32.3	17.2
510502....	Upper subsoil 18 to 36 inches.	3.0	11.7	6.6	26.6	11.5	23.4	17.2
510503....	Lower subsoil, 36 to 72 inches.	.6	3.7	3.2	19.2	13.1	28.7	31.6
Heavy phase:								
510528....	Soil, 0 to 8 inches.....	.6	2.3	2.7	31.0	21.3	30.0	12.5
510529....	Upper subsoil, 8 to 40 inches.	.0	1.0	1.4	15.0	15.0	31.0	36.5
510530....	Lower subsoil, 40 to 72 inches.	.6	5.2	4.3	19.9	11.2	29.7	29.0

KARRO CLAY LOAM.

The surface soil of the Karro clay loam consists of 10 to 14 inches of calcareous light brownish gray or light-gray clay loam, low in organic matter and plastic when wet. When dry, however, the soil is loose and friable, owing probably to the flocculating action of the lime. The subsoil is a highly calcareous light-gray loam or clay. Lime nodules or fragments of "clay caliche" are not as numerous in the subsoil of this type as in the other types of the series, though they are present on the surface of most areas in varying quantities. A faint yellowish or pinkish tint in the surface soil becomes more pronounced when wet.

The type is inextensive and of little importance. The largest area is at Karro, and smaller areas lie north of that place. Small areas also occur south, north, and northeast of San Simon. The type occupies slight depresssions or areas of restricted drainage. The surface is smooth and would require little leveling to prepare it for irrigation. Drainage is generally poor, and nearly all of the type is affected with accumulations of alkali salts in which sodium carbonate (black alkali) appears to be present.

The Karro clay loam is not valued highly for agriculture, and none of it is under cultivation. The native vegetation consists principally of rabbit brush and a scant stand of grasses, with some mesquite in the lower lying areas.

Under irrigation, one of the principal needs of this soil would be drainage. Addition of organic matter would be of benefit. Areas free of alkali should be fairly well adapted to the crops grown in this region.

Karro clay loam, alluvial phase.—The alluvial phase of the Karro clay loam consists of 10 to 20 inches of a light-brown or light grayish brown calcareous clay loam, overlying a light-gray, highly calcareous clay loam or silty clay subsoil, which contains numerous fragments of

clay "caliche" and soft gray lime nodules. The surface soils consists of recent-alluvial material deposited over the typical Karro material. It is generally somewhat browner than the typical Karro surface soil, but is similar in other characteristics. Hard fragments of "caliche" and small gravel form a thin veneer over the surface in places.

The largest area of this phase is just north of Olga. This area is comparatively flat and receives the drainage from a large area of higher lying land. Other areas lie north and northwest of Karro. The surface is smooth, except where cut by shallow drainage channels. Both surface and internal drainage are somewhat retarded, and accumulations of alkali salts are of general occurrence.

Part of the phase supports a fair stand of native grass and is used for grazing; the greater part supports only scattering clumps of creosote bush and rabbit brush. This land is not used for the production of cultivated crops, though if water were available it could very easily be put under irrigation. The presence of alkali salts and the highly calcareous condition of the subsoil would probably render it less desirable, however, than some of the other soils of the area.

The following table gives the results of mechanical analyses of samples of the soil and subsoil of the typical Karro clay loam:

Mechanical analyses of Karro clay loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
510550	Soil, 0 to 10 inches.....	0.0	1.1	1.6	10.9	17.0	40.9	29.0
510551	Subsoil, 10 to 72 inches	.2	2.0	2.4	16.2	10.0	36.3	33.4

GILA FINE SANDY LOAM.

The surface soil of the Gila fine sandy loam consists of 10 to 14 inches of light grayish brown to light pinkish brown or yellowish brown calcareous fine sandy loam. The subsoil is fairly uniform, though some stratification has taken place. In color it ranges from light brown to dull brown and in texture from silt loam to clay loam. Small gravel are scattered over the surface, and in places there are some cobblestones. The soil is low in organic matter. Water is readily absorbed, but the loss through evaporation is large.

The type is confined entirely to the northeastern part of the survey, one area being about a mile east of San Simon, another 4½ miles east, and the third and largest about 4 miles north. It occupies the more level lands at the base of the alluvial fans, where streams deposit their sediment, or else it borders the main channels of the larger streams. It is overflowed annually by streams or receives some surface wash from the higher slopes.

The Gila fine sandy loam is of small extent and of no present agricultural importance, except for the small amount of pasturage it affords. A scanty growth of grasses or mesquite constitutes the vegetation. The type is well drained and largely free of injurious quantities of alkali. Potatoes, vegetables, alfalfa, and cotton should do well on it, though on account of its porous structure crops would probably suffer from drought unless liberally watered. This land is sold only in connection with associated soils.

Gila fine sandy loam, fine-textured phase.—The surface soil of the Gila fine sandy loam, fine-textured phase, consists of 8 to 14 inches of light-brown to brown very fine sandy loam, high in lime carbonate. The texture varies within small areas, though in no case markedly, from a very fine sandy loam. The subsoil is composed of highly stratified materials differing widely in texture, high in lime, and ranging in color from brown to grayish brown. The soil is low in organic matter, though somewhat better supplied than the upland soils, and contains a great deal of mica. It absorbs moisture readily, but does not retain it as well as the Gila loam.

This phase of the Gila fine sandy loam is confined almost entirely to the bottoms of San Simon Creek in the vicinity of San Simon. One area lies 3 miles southeast of Bowie. All of the phase could be placed under cultivation without much labor, and the gentle slope and good drainage make it well adapted to irrigation. The phase is almost entirely free of injurious accumulations of alkali salts.

On account of its small extent the phase is relatively unimportant. It supports a good stand of native grasses and is used entirely for grazing. Under cultivation it should be well adapted to truck gardening, as well as to the production of grains and alfalfa.

The results of mechanical analyses of samples of the soil and subsoil of the typical Gila fine sandy loam are shown in the following table:

Mechanical analyses of Gila fine sandy loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
510552	Soil, 0 to 14 inches.....	5.2	8.1	5.3	29.7	22.3	19.3	10.5
510553	Subsoil, 14 to 72 inches....	.1	1.0	.9	11.1	13.1	44.4	29.6

GILA LOAM.

The surface soil of the Gila loam consists of 8 to 12 inches of friable brown to light-brown or light grayish brown loam, in which a pinkish tint is frequently perceptible. The subsoil consists of stratified sediments. The lighter textured strata are usually lighter in color than the surface soil, but the heavier ones correspond in color to the surface materials. The subsoil material is moderately compact, but has undergone no pronounced alteration or cementation from weathering. Both surface and subsoil materials contain much lime, which is uniformly distributed. The surface soil is generally quite micaceous and somewhat variable in texture, approaching a silt loam in places. The variations, however, cover small areas and could not be shown separately on the soil map.

The type is confined almost entirely to the alluvial bottoms of San Simon Creek, with one area on the lower slopes of the Cave Creek fan. The surface for the most part is slightly relieved by ridges and gullies, which generally parallel the course of the streams, though in recent time San Simon Creek has cut its channel several feet below the level of the surface and the type is becoming quite badly dissected in places by lateral drainage ways. Both surface drainage and sub-

drainage are now good; before the lowering of the channel of San Simon Creek, drainage in the principal areas was somewhat retarded, with the result that large parts of the type carry large quantities of alkali salts. The land is subject to periodic overflow. Further lowering of the channel of the creek will prevent this.

Less than 1 per cent of the type is under cultivation; the rest supports a good growth of grasses or mesquite. Where cultivated the type is highly productive of wheat, oats, and corn, and with future development should prove equally well adapted to other crops grown in this region.

Before being placed under irrigation, most of the land would require considerable leveling and some protection against washing from summer floods. It is held at practically the same value as the soils adjoining.

The table below gives the results of mechanical analyses of samples of the soil, and the upper, middle, and lower subsoil of the Gila loam:

Mechanical analyses of Gila loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
510538	Soil, 0 to 10 inches	0.1	0.6	1.4	18.0	18.8	44.9	16.5
510539	Upper subsoil, 10 to 30 inches	.1	.2	.4	8.3	19.5	37.3	34.5
510540	Middle subsoil, 30 to 36 inches	.5	3.8	4.6	24.9	13.2	27.0	26.2
510541	Lower subsoil, 36 to 72 inches	.0	.6	2.2	31.0	17.8	24.0	24.6

PIMA FINE SANDY LOAM.

The surface soil of the Pima fine sandy loam is a dull-brown or grayish-brown, calcareous fine sandy loam, 10 to 14 inches deep. The subsoil is of practically the same color as the surface soil, of loose friable structure, and usually of similar or slightly heavier texture. In places, however, it is distinctly stratified. On the higher slopes near the mouths of the canyons cobblestones are more or less mixed with the soil material. A few gravelly areas too small to be shown separately on the map are also included. As mapped, the Pima fine sandy loam includes areas in which the Pima material occurs as an overwash of recent-alluvial material, 4 feet or more deep, over red or reddish-brown old valley-filling material.

The type is confined to three small areas. The largest one is about 10 miles southeast of San Simon, another lies near the mouth of the canyon of Cave Creek, and the third occurs about 5½ miles northeast of Portal School. The land is generally slightly gullied, but could be placed under irrigation at relatively small expense. Following heavy storms the type is subject to overflow or wash from the adjacent mountains. Surface and internal drainage are well established, making the type suited to irrigation.

About 3 per cent of the type is under cultivation. Good yields of alfalfa, corn, wheat, and oats are obtained. A few fruit trees, princi-

pally cherries, peaches, and apples, are on the type and produce excellent yields in favorable seasons. The native vegetation consists principally of mesquite, cat's-claw, and creosote bush. This type is generally considered more valuable than the associated soils. The Pima fine sandy loam could be materially improved in structure and water-holding capacity by the incorporation of organic matter. The type should prove well adapted to the production of truck crops and small fruit, as well as grain and forage.

Pima fine sandy loam, gravelly phase.—The surface soil of the Pima fine sandy loam, gravelly phase, consists of 8 to 12 inches of dull-brown or grayish-brown, calcareous gravelly fine sandy loam. The subsoil is for the most part dull-brown or grayish-brown friable gravelly loam, but lacks uniformity of texture. The gravel is composed of many kinds of rock and is generally angular or subangular. Near the mouths of canyons waterworn bowlders are numerous throughout the soil profile.

The phase occurs near the mouths of the larger canyons and in areas where the streams leaving the mountains spread out over the more gentle alluvial-fan slopes. The largest area is at the mouth of the canyon of Cave Creek; another of less importance is near the base of the Cave Creek fan; a small area lies 9 miles north of Portal School; and a fourth about 4 miles northeast of San Simon.

The topography varies from slightly undulating to smooth and gently sloping. Near drainage ways the surface is generally slightly gullied, but in most places it can be leveled for irrigation at small expense. The drainage is good in all instances, and the land is entirely free of alkali salts.

The native vegetation, consisting principally of mesquite and creosote bush, has been cleared from about 4 per cent of the phase and placed under irrigation. Though the soil is not retentive of moisture, and on the steeper slopes has a tendency to wash, it is used successfully for the production of tree fruits. The plantings are still young, but those in bearing are producing fruit of excellent quality in abundant quantity. Apples, peaches, and cherries are the principal fruits grown; grapes and small fruits adapted to this section probably could be grown with equal success. The soil should prove well adapted to vegetable crops. Alfalfa and oats yield well, though not as abundantly as on some of the heavier soils.

The gravelly phase of the Pima fine sandy loam, when in producing orchards, is held at $500 to $700 an acre. Unimproved land is held at $15 to $20 an acre.

This phase is generally well situated as regards air drainage and consequent freedom from frost, and is therefore adapted to fruit production. Fruit is produced only in isolated communities in this region and has a ready market at fancy prices. The content of organic matter of the soil is low and should be increased, especially in orchards. The phase appears to be much better suited to the production of fruits and vegetables than of grain and hay.

The results of mechanical analyses of samples of the soil and subsoil of the typical Pima fine sandy loam are given in the following table:

Mechanical analyses of Pima fine sandy loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
510519	Soil, 0 to 14 inches.....	2.4	6.3	3.9	23.3	24.3	27.6	12.8
510520	Subsoil, 14 to 72 inches	1.9	7.0	4.8	24.6	24.9	23.6	13.2

SAN PEDRO CLAY LOAM.

The surface soil of the San Pedro clay loam consists of 6 to 12 inches of calcareous, light-brown to dark-brown clay loam. The subsoil includes two horizons. The upper section is composed of very dark gray or black clay, slightly mottled with gray, the mottling being caused by soft lime nodules. The lower subsoil is a very dark gray or drab-colored clay, highly mottled in the same way as the upper layer. The substratum below 6 feet generally consists of brownish-gray clay loam mottled with rusty-brown iron stains. In places the color of the surface soil is distinctly reddish brown. Such areas commonly border the higher terraces which lie above overflow.

The San Pedro clay loam is confined to the San Simon Cienega, which lies about 15 miles southeast of San Simon. The area is nearly flat and much of it is poorly drained, but the lower or northern part, where San Simon Creek has cut a channel about 10 feet deep, is well drained. In this section the movement of subsoil waters from the bordering alluvial fans to the channel of the creek in places has carried away much of the underlying material, forming small caves or underground passage ways, some of which have fallen in, forming gullies several feet deep. Except for such areas the type could be easily placed under irrigation, though artificial drainage would have to be supplied in most cases.

The San Pedro clay loam owes its origin to material which has been carried in suspension in run-off from the bordering fans and deposited under conditions of very poor drainage. At the present time much of the area is below the ground-water level and for most of the year is in a submerged or swampy condition. Though most of the type is free of injurious accumulations of alkali, a few spots contain rather high concentrations.

A luxuriant growth of native grasses covers most of the type, giving it a high value as pasture and hay land. It is entirely under fence and is used largely for fattening range stock, or, when the outside range is good, as hay land. The yield of hay reaches 1½ tons per acre under favorable conditions. The type is not sold separately, but is generally considered more valuable than the associated soils.

The San Pedro clay loam is well supplied with organic matter. Under cultivation it should be adapted to the production of vegetables requiring a heavy soil. It could also be used advantageously for dairying. One of the chief needs of the type is drainage.

San Pedro clay loam, light-textured phase.—The surface soil of the San Pedro clay loam, light-textured phase, consists of 8 to 12 inches of calcareous pinkish-brown or light grayish brown very fine sandy loam or silt loam. The subsoil is a black or grayish-black clay,

slightly mottled with gray lime accumulations, and containing softly cemented lime nodules. Along the margin of the areas bordering the higher terraces, the subsoil in places grades into slightly reddish brown material at a depth of 60 inches or more. The surface soil is somewhat variable in texture and in places approaches a sandy loam. Small gravel is present in a few places, but not in sufficient quantities to interfere with cultivation.

This phase is confined to the San Simon Cienega and occurs as narrow marginal areas on both sides of the typical San Pedro clay loam. It consists principally of a recent wash from the adjacent terraces. The surface is smooth and sufficiently sloping to afford free run-off, but the subdrainage is restricted. Small areas of the phase are highly impregnated with alkali salts, and support only a growth of alkali-tolerant vegetation.

Where alkali is absent there is a growth of mesquite, creosote bush or native grasses. The phase is not cultivated, but is used as grazing land. It affords somewhat better pasture than the uplands. The phase is sold only in connection with other soils.

The chief need of this soil is drainage, after which the addition of organic matter would be beneficial. The phase should prove well adapted to the production of vegetables, small fruits, and also grain and hay crops.

In the table below are given the results of mechanical analyses of samples of the soil, upper subsoil, and lower subsoil of the typical San Pedro clay loam:

Mechanical analyses of San Pedro clay loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
510531	Soil, 0 to 8 inches.....	0.0	7.8	2.5	7.9	4.1	47.4	30.6
510532	Upper subsoil, 8 to 14 inches	.1	3.4	1.1	5.2	4.3	31.8	54.6
510533	Lower subsoil, 14 to 72 inches	.9	2.4	1.0	2.7	3.4	29.4	60.1

ROUGH STONY LAND.

Along the margin of the survey are occasional areas, consisting mainly of rocky buttes or the lower mountain slopes, that rise abruptly from the valley to an elevation of 1,000 feet or more above the adjoining fan slopes. Such areas are too rough and stony for cultivation and have been mapped as Rough stony land. In places there is a thin covering of residual soil material over the rock, but in general this has been removed by wind or rain, leaving the rocks exposed to further weathering. The rocks include granite, gneisses, limestone, and rocks of volcanic origin. Bowlders and smaller rock fragments are common over the surface, especially near the base of the slopes.

The largest areas of Rough stony land are in the southwestern part of the survey. Other areas lie northeast and east of San Simon and southwest of Bowie.

The native vegetation, consisting principally of a sparse stunted growth of cacti and creosote bush, has little grazing value. Some grasses grow on the more gently sloping areas or in pockets where

soil has accumulated. A stunted growth of juniper is found in some of the ravines or areas protected from the heat of the midday sun. This land has no agricultural value aside from the grazing it affords.

RIVERWASH.

Riverwash consists mainly of deposits of gravel, cobblestones, and small quantities of finer soil materials. It supports no vegetation and is frequently overflowed.

Riverwash is confined entirely to the channels of the larger streams which have their course down the slopes of the alluvial fans.

As these streams frequently overflow their banks and deposit sediments they gradually build up their channels until they occupy ridges. This process may continue until during an unusually heavy run-off the stream breaks its banks, seeks a lower level, and establishes a new channel, leaving the old channel to fill gradually with sediments. Riverwash, which is inextensive, has no agricultural value.

ALKALI.

The San Simon area is situated in a region where, owing to low rainfall and slight leaching of the material composing the earth's crust, the soluble products of mineral decomposition are commonly concentrated in areas of poor drainage. When present in excessive quantities, these soluble compounds are injurious to plant growth. Many of the materials composing them are quite essential or are stimulating to plant growth, if present in small quantities. These compounds are known as "alkali," but few are chemically of alkaline reaction.

As the result of weathering or decomposition of the different rocks composing the mountains and of the transported alluvial material carried from them, these soluble chemical compounds have in the course of time been formed and carried from the steep, comparatively well leached alluvial fan slopes to the flatter, more poorly drained areas in the axis of the valley. The alkali salts, as found in the San Simon area, are therefore largely transported and do not have their origin in any particular area or soil formation of unusual concentration. The problem under irrigation will, therefore, consist largely in the removal of the existing salt concentrations, without regard to their original source.

In many previous soil surveys the areas of different grades or degrees of concentration of alkali have been outlined on the map, the degrees of concentration being indicated by appropriate symbols. This system being based in part upon evidences indicated by apparent condition or reaction of field crops, is successful in regions where the soils are largely under cultivation, but becomes quite hazardous to attempt in arid regions where much of the land is still in virgin desert condition. Accordingly a less detailed classification was made in this survey.

In the San Simon area the extent and boundaries of the alkali-affected areas were determined by field tests, using the electrolytic-bridge method, and the results shown upon the soil map. The red

dot indicates the location of the sample, and is followed by a figure indicating the average concentration of total salts in terms of percentage of salts in the air-dry soil to the depth of 6 feet. The alkali-affected areas, as nearly as could be determined, are inclosed within red lines and indicated by the symbol A, while the soils that contain less than 0.20 per cent of salts in the 6-foot section and are regarded as free from injurious concentrations have been shown by a minus sign preceding the figures.

The alkali-affected lands in the San Simon area are confined to the comparatively flat, poorly drained soils bordering San Simon Creek. Beginning at a point where the creek enters the area surveyed, about 17 miles southeast of San Simon, there is a belt of alkali-affected land extending, with two narrow interruptions, northwestward to the northern limits of the survey. Where it begins this belt has a width of one-fourth mile, but east of San Simon it broadens out, attaining a maximum width of about 6 miles at the northern boundary of the survey. In all, the alkali-affected land embraces about 30 square miles.

Within the soil profile the point or horizon of highest salt concentration varies, depending on the nature of the subsoil and the position of the underground water table. Where subdrainage is well established and the water table is below 15 or 20 feet, the alkali salts are generally concentrated in the second or third foot. However, where the ground water is at or near the surface, as is the case in the San Simon Cienega, the maximum concentration occurs in the upper 6 inches of soil. In the lower part of the cienega, where there is some water movement over the surface, the salts are removed in the drainage water, but are found highly concentrated along the margins as the result of evaporation.

Alkali concentrations in this area are variable within relatively short distances, so that the percentages shown on the accompanying map may not always represent conditions occurring between two separate borings, except in a general way.

Concentrations of alkali salts in soils are injurious to plant growth when they prevent absorption of soil moisture by the plant or have a toxic effect on the tissues of the plant. Such concentrations vary in amount for different salts and for different textural and other physical conditions of the soil, as well as for different plants; the various species of plants being more tolerant of some kinds of salts than of others, and also differing in tolerance to the total of salts. It is, therefore, impossible to state, except in general terms, what concentration of alkali will be injurious to plant growth without making an exhaustive study of the nature of the salts and their effect on different plants under all local soil conditions.

Among the common alkali salts, sodium carbonate, or "black alkali," is the most injurious to all species of plants, and in general where more than 0.08 per cent of black alkali is present in connection with other salts, injury results to crop growth. All plants are rather susceptible to injury in the seedling stage, but become more tolerant with age. Alfalfa especially is very susceptible to injury by black alkali in its early stages, but after becoming established it will withstand about the same concentrations as wheat. Decreased crop yields will generally result when more than 0.20 to 0.40 per cent of

alkali is present in the 6-foot soil section, if black alkali is included in the salts.

Among the chlorides and sulphates of sodium and magnesium, commonly known as white alkali, magnesium sulphate is generally considered the least injurious, followed by sodium sulphate and sodium chloride. Some of the soluble salts of calcium and potassium occur here and there in very small quantities. The limits for unaffected plant growth in the presence of the common white alkali salts vary with the kind of crop and soil, but in general concentrations of between 0.40 and 0.80 per cent of white alkali result in decreased crop yields. The concentration at which plant growth will be checked or prohibited depends on a number of conditions, chief of which are the character of the salts, the nature of the soil, the kind of plant, and the location in the soil profile of the horizon of alkali concentrations. No positive statement can, therefore, be made, but in general with greater concentration than from 0.60 to 1 per cent of salts in the air-dry soil the production of cultivated crops is impracticable unless the salts are localized in the soil profile below the zone of root development. A very much smaller quantity would entirely prohibit crop production if the salts were concentrated in the surface 1 foot or 6 inches.

The table below gives the alkali analyses of two samples of surface soils representative of alkali conditions in this area:

Alkali analyses of two soils from the San Simon area, Arizona.

(Parts per million.)

Constituent.	Quantity.		Constituent.	Quantity.	
	Sample No. 510,501.	Sample No. 510,502.		Sample No. 510,501.	Sample No. 510,502.
Ions:			Conventional combinations:		
Na	2,678	8.6	$CaSo_4$	1,945	1,453
Ca	572	609	$Ca(HCO_3)_2$	.....	728
Mg	120	12	$MgSO_4$	594	.....
So_4	3,560	1,023	$Mg(HCO_3)_2$	.....	72
Cl	1,063	Trace.	Na_2SO_4	2,533	.....
HCO_3	3,050	2,160	$NaHCO_3$	4,200	21.37
CO_3	0.0	0.0	NaCl	1,771	.....
NO_3	Trace.	640	$NaNO_3$	Trace.	870
Total	11,943	5,260	Total	11,043	5,260

NOTE—Sample No. 510501, Dos Cabezas clay loam, 0 to 12 inches, sec. 24, T. 14 S., R. 31 E.
Sample No. 510502, San Pedro clay loam, 0 to 12 inches, sec. 27, T. 15 S., R. 32 E.
Analyses made by R. S. Holmes.

Among the cereals, barley is generally considered the most tolerant to alkali salts, followed by oats, wheat, and corn. Rye is a very valuable crop on alkali land, as it produces forage and green manure on soils too high in alkali for most ordinary crops. Kafir and other of the grain sorghums are also quite resistant, withstanding about the same alkali concentration as barley.

The legumes are as a whole sensitive to alkali, especially in the seedling stage. The two most resistant are alfalfa and sweet clover, the latter especially being recommended as a legume for alkali land when alfalfa or some other leguminous forage crop will not grow.

The grasses as a family are resistant to alkali, the salt grass and tussock grass being among the most tolerant native plants known. Brome grass and timothy, among the cultivated grasses, are moderately resistant to alkali.

The principal root and vegetable crops adapted to alkali soils are onions, asparagus, celery, and radishes. Alkali impairs the keeping quality of potatoes and also reduces the yield. The sugar beet is sensitive to alkali in the seedling stage, but tolerates large quantities after becoming established, though large concentrations of sodium chloride have a deleterious effect on quality.

Among the methods of reclaiming alkali land, establishing good drainage is generally of first importance. In the soils closely bordering San Simon Creek the need for artificial drainage has been largely obviated by the recent natural deepening of the creek channel. With sufficient irrigation water to flood thoroughly the surface the salts could in nearly all cases be removed in the drainage water or leached below the feeding zone of plant roots. Where natural drainage of surface and subsoil is impeded, artificial means, such as tiling or the construction of deep open ditches, would have to be resorted to.

Another essential factor in reclaiming alkali soils consists in reducing evaporation. The necessity of this is obvious, since soluble salts, taken into solution, are carried by soil waters from one place to another, and are deposited in places from which the soil moisture evaporates. The most practical methods of preventing evaporation are cultivation, shading the soil, or the establishing of a good mulch by adding organic matter. By maintaining a loose layer of earth over the surface the capillary action is broken and soil moisture is retained below the surface, where evaporation is very much retarded.

The growing of alkali-resistant crops, deep plowing, and flushing of the soil, thus removing salts concentrated on the surface, are all practical methods of reclaiming alkali soils, which are described in detail in numerous publications.[3]

SUMMARY.

The San Simon area includes the bottom and terrace lands of the valley trough along San Simon Creek, and the greater part of the adjoining fan slopes of the valley which lie in Cochise County, Ariz. The area is roughly the shape of a figure "7." One leg of this "7" extends north from near Portal School on the south to a point about 6 miles north of San Simon; the other thence west to a point about 3 miles beyond Bowie. It has an area of about 448 square miles, or 286,720 acres. The greater part of the area is smooth enough for irrigation with but little leveling, and drainage is well established, except in local areas.

Elevations within the valley range from 3,500 to 4,800 feet above sea level.

San Simon Creek is the principal drainage way of the area, but is dry during most of the year, except in places where the ground water reaches the surface.

[3] Harris, F. S., Textbook of Soil Alkali, pages 154–190 (New York, 1920).
Tinsley, J. D., Drainage and Flooding for the Removal of Alkali, N. Mex. Sta. Bul. 43 (1902), 29 pages.
Means, T. H., Reclamation of Alkali Soils in Egypt, U. S. D. A., Bur. of Soils, Bul, 21 (1903), 48 pages.

The most thickly populated parts of the survey are near San Simon and Bowie, the greater part of the area being very sparsely settled. The population consists mostly of native-born Americans. Bowie and San Simon are the only towns in the area.

The Los Angeles-New Orleans line of the Southern Pacific Railroad traverses the northern part of the area, and the Arizona Eastern Railroad operates a branch line from Bowie, traversing the northwestern part of the area for a short distance. The El Paso & Southwestern Railroad passes within a short distance of the southern part of the area and furnishes transportation for this section.

The climate is warm in summer and mild in winter. The rainfall varies considerably over the area, averaging 6.18 inches at San Simon and 19.58 inches at Paradise, which lies a short distance outside the area surveyed. The mean annual temperature at San Simon is 61.8° F. Snow falls during the winter on the higher peaks bordering the valley, and hail is of occasional occurrence. The average date of the last killing frost in the spring at San Simon is February 22, and the average first in fall November 26, giving an average growing season of 277 days.

The early agriculture of the area consisted of stock raising. In 1910, upon the discovery of artesian water, the raising of cultivated crops was commenced, but the principal products produced in excess of home needs are still cattle and hogs. Hay, potatoes, fruit, and poultry products are shipped in small quantities. The area seems well adapted to the production of garden vegetables, potatoes, cereals, and alfalfa, also fruit in areas reasonably free of frosts.

Farm buildings are generally temporary structures, adobe being used extensively as building material. The farms are operated largely by owners, and little outside labor is employed.

Water for irrigation is the limiting factor in crop production, and farming is confined to soils where water is available.

The soils differ widely in origin, color, physical properties, lime content, drainage, and crop adaptation. They are classified into three groups—old valley-filling soils, recent-alluvial soils, and miscellaneous materials. The old valley-filling group is of greatest importance from the standpoint of area and use. The recent-alluvial soils are of minor occurrence and little used agriculturally. The miscellaneous materials are entirely nonagricultural.

Eighteen soil types, a number with phases, are mapped in this area, in addition to Rough stony land and Riverwash. The soil materials are of mixed origin, derived mainly from granite, schist, sandstone, limestone, and volcanic rocks. They have been transported to their present location mainly by the agency of water, and occur mostly on alluvial fans of moderate slope and smooth topography. When irrigated the soils are productive and adapted to a wide range of crops.

Irrigation is generally essential for the successful maturing of crops. The present source of water supply is limited to artesian wells. Water of fair quality is available, but not in sufficient quantity to irrigate very extensive areas.

The areas with injurious alkali accumulations in the survey are small, being confined largely to the recent-alluvial soils along San Simon Creek and to some of the more poorly drained old valley-filling soils.

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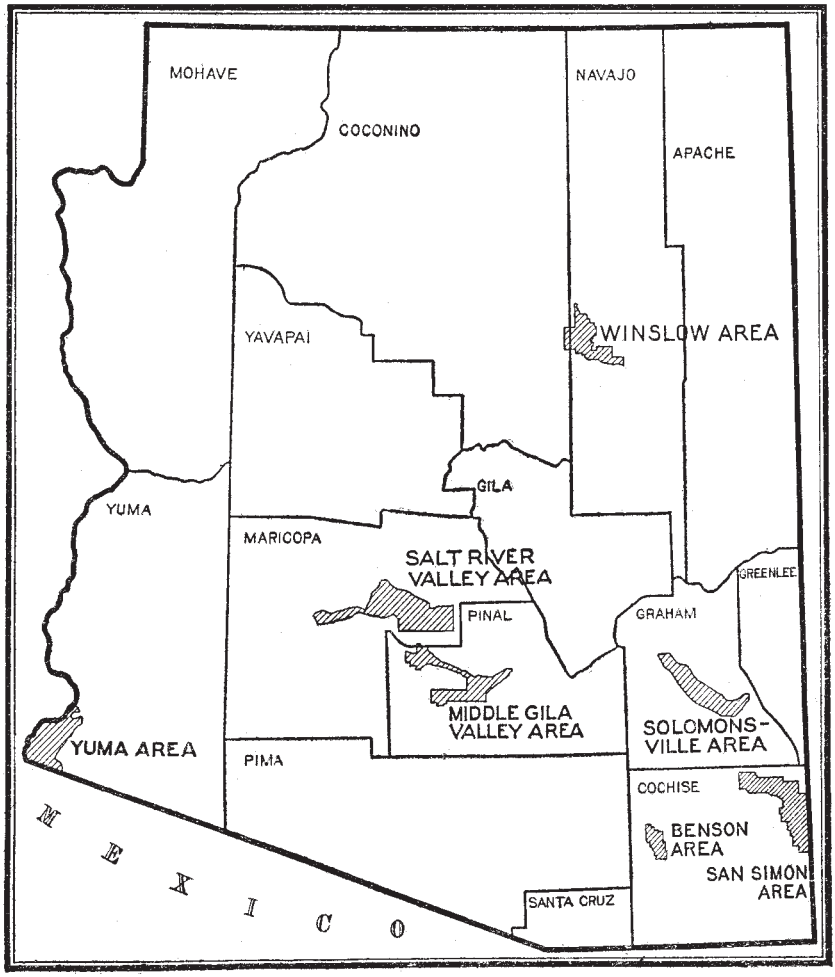

Areas surveyed in Arizona, shown by shading

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Office of the Assistant Secretary for Civil Rights
1400 Independence Avenue, SW
Washington, D.C. 20250-9410;

(2) fax: (202) 690-7442; or

(3) email: program.intake@usda.gov.

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