Series 1935, No. 16 Issued December, 1940

Soil Survey

The Visalia Area California

By

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and
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United States Department of Agriculture

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SOIL SURVEY OF THE VISALIA AREA, CALIFORNIA

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Area inspected by MACY H. LAPHAM, Inspector, District 5

United States Department of Agriculture in cooperation with the University of California Agricultural Experiment Station

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AREA SURVEYED

The Visalia area is in the northwestern part of Tulare County, Calif., in the eastern part of the San Joaquin Valley. Geographically it is near the center of the State (fig. 1). San Francisco is about 200 miles to the northwest, Los Angeles about 162 miles to the south, Fresno 40 miles to the northwest, and Bakersfield 60 miles to the southeast.

Tulare County has a total area of about 4,856 square miles, but the eastern part, including more than 3,000 square miles, is situated in the foothills and mountains of the Sierra Nevada. The Visalia area comprises approximately the northern half of the western, or valley, part of the county, and the southern half of the valley land is covered by the Pixley area (*12*).[2] The northern boundary of the Visalia

[1] The Soil Survey Division was transferred to the Bureau of Plant Industry July 1, 1939.
[2] Italic numbers in parentheses refer to Literature Cited, p. 96.

area follows the Tulare-Fresno County line to a point in the lower foothills about 4 miles east of Orange Cove. The eastern boundary follows an irregular line paralleling the mountains in the lower foothills at a distance of a few miles east of Yettem, Lemoncove, Lind Cove, and Lindsay. East of Strathmore it extends a few miles farther east and includes the northern part of Frazier Valley. The southern boundary is the line between Townships 20 and 21 south. Waukena and Strathmore are close to the southern boundary. The western boundary follows the county line. In general the area is bounded on the north by Fresno County, on the east by the rough mountainous lands of Tulare County, on the south by the Pixley area (Tulare County), and on the west by Kings County. It ranges from about 20 to 30 miles in width, from east to west, and from 30 to 35 miles in length, from north to south. Its total area is 850 square miles, or 544,000 acres.

FIGURE 1.—Sketch map showing location of the Visalia area, Calif.

The area is included in the earlier reconnaissance soil survey of the middle San Joaquin Valley (*8*). It is joined on the northwest by the Fresno area (*14*), and on the west a small part joins with the much earlier surveyed Hanford area (*10*). A part of the area in the eastern and southeastern parts was included in an earlier soil survey of the Portersville area (*13*).

PHYSIOGRAPHY AND RELIEF

Practically all of the Visalia area is on the floor of San Joaquin Valley. At the first glance it appears to be very nearly level, but the land has considerable slope toward the west. The part of the foothill and mountainous belt on the east included in the survey is of very small extent, although this belt extends 50 to 60 miles east of the area to the crest of the Sierra Nevada. The mountains are composed largely of granitic rocks, although isolated bodies of basic igneous rocks occur in places. The finer textured rocks form heavy-textured soils (clay loams and clays), whereas the granites produce light-textured soils (sandy loams). All the soils of the foothill belt contain many stones or include rock outcrops. The elevation of this belt ranges from 300 to 1,000 feet above sea level. In most places the hills rise very abruptly from the valley floor, although alluvial fans occupy many of the slopes.

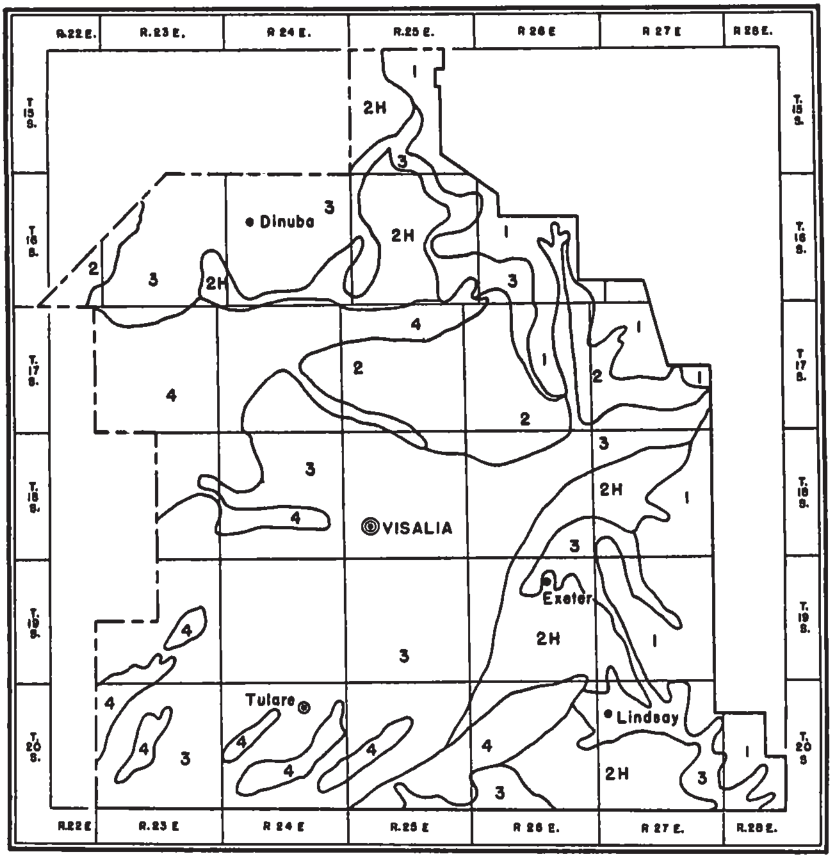

FIGURE 2.—Sketch map showing physiographic features of the Visalia area, Calif.; 1, Foothills and mountains; 2, terraces; 2H, terraces with hog wallows; 3, alluvial fans; 4, basins.

The area includes four broad physiographic belts: (1) Foothills and mountains, (2) the old hardpan terraces of hog-wallow microrelief, (3) the smooth gently sloping alluvial fans and flood plains along the streams from the Sierra Nevada, and (4) the flat basinlike areas of "alkali" soils that occur between the alluvial fans and generally extend out onto the level valley floor (fig. 2). These broad physiographic belts conform to those occupied by the major soil groups.

A number of streams and drainageways drain into the area rather than through it. In seasons of extreme floods, they drain into the Tulare Lake bed to the southwest. The Kings River cuts diagonally across the extreme northwestern corner of the area, but as it is entrenched in a channel it does not contribute much in the way of drainage or of alluvial fill. The Kaweah River enters from the mountains east of Woodlake, but within a short distance it divides into a number of channels including the St. Johns River and Elbow Creek, which extend north of Visalia, and Cameron Creek and Outside Creek, which extend south of Visalia toward Tulare. Many of these old channels are now used during the early part of the summer for the conveyance of irrigation water. Except during periods of flood, all the surface waters of the Kaweah River are diverted and used for irrigation, but a large quantity of water sinks into the sands of the delta to replenish the underground reservoir and is later pumped to the surface for irrigation. At one time the water table of the delta of the Kaweah River was very close to the surface, and this favored the growth of grasses, willows, and cottonwood trees, but extensive pumping for irrigation has lowered the water table to a considerable depth, except in local areas where it is replenished from nearby streams. Smaller streams, such as Sand Creek at Primero, Yokohl Creek east of Exeter, and Lewis Creek east of Lindsay, extend into the area from the lower foothills, but all soon lose their waters by absorption in the alluvial soils.

The Kaweah River fan is made up mainly of soils of the Tujunga, Hanford, Cajon, Foster, Visalia, and Chino series, all which are alluvial outwash from granitic sources. The Kings River, in the extreme northwestern part of the area, has carried into the area most of the materials of the Tujunga and Greenfield soils, and the smaller streams have contributed mixed materials to the alluvial soils, whose present differences depend primarily on the kind of parent material and drainage conditions.

One comparatively small area of soil developed on wind-modified alluvial materials occurs west of Dinuba and has a rolling subdued dunelike surface. In the counties northwest of the Kings River this condition is more extensive. Basinlike bodies of soils containing saline and alkali salts occur in the lower flatter areas between the alluvial fans of the Kings and Kaweah Rivers and also of the Tule River, which lies outside the Visalia area to the south. Water stands on these soils after rains, as a result of surface drainage from the higher lying soils. Such basinlike areas, occupied by the Fresno, Traver, and Lewis soils, are east of Traver, west of Lindsay, and in the western part of the area.

The hardpan soils developed on the old alluvial fans and terraces are known locally as red land, hog-wallow land, or red-hardpan land. They occupy terraces a few feet above the surrounding alluvial soils. Viewed from a distance, the land appears flat, but closer observation discloses a hog-wallow microrelief, characterized by a series of low mounds and intervening depressions. The mounds range from 10 to 30 feet in diameter and from 2 to 4 feet in height. These red-land terrace areas are drained by intermittent stream channels, but water generally stands in the undrained depressions for a considerable period after heavy rains, owing to the presence of the underlying impervious hardpan. The parent soil materials consist of old alluvial deposits laid down during periods of heavy run-off from the Sierra Nevada during or following the Pleistocene period. These old remnants of alluvial fans and terraces occur along all the east side of the San Joaquin Valley, where they give rise in this area to soils of the San Joaquin, Exeter, and Madera series.

NATIVE VEGETATION

Most of the native vegetation is that of a dry grassland. In the foothills the native cover primarily is grasses and associated plants, such as alfileria, bromegrass, and wild oats, with some brush, scattered live oaks, and a few buckeyes. The Lassen soils, which are derived from fine-textured igneous rock, support no trees, but a growth of bur-clover springs up following winter rains. The San Joaquin, Exeter, and Madera soils of the red-hardpan terraces have a native cover of grasses and alfileria, chickweed, and bur-clover. A few live oak trees grow near drainageways, but, in general, these soils are treeless.

The soils of the alluvial fans along the streams, where ground water is available at a reasonable depth, support live oak, willow, and cottonwood trees, together with the native grasses previously mentioned, but many of the trees have been removed in order to make way for crops. In some districts the lowering of the water table by pumping has caused the death of many oak trees. Water grasses grew on the delta of the Kaweah River when the water table was high. Some saltgrass is present in spots that contain salts.

The saline and alkali soils normally support a cover of salt-tolerant vegetation, such as saltgrass, inkweed, and some saltbush in places. Chickweed and bur-clover spring up on the spots containing less salts or following heavy rains when the salts may be washed temporarily deeper into the soil. Most of the spots that contain a very high percentage of salts, especially "black alkali," are barren of any vegetation.

SETTLEMENT AND POPULATION

The first attempt at settlement of the area now included in Tulare County, of which there is any record, was made by a party of 15 men under the leadership of one Woods, who came from the town of Mariposa. These men, about December 1850, located on the south bank of the Kaweah River 7 miles east of the present city of Visalia. In the spring of 1851 they were massacred by the Indians. Early in 1852, a second group from Mariposa set out for the "Four Creeks Country," as the country around the Kaweah River was known, and the log cabin of the massacred party of the previous year. Who were at the place prior to the arrival of these parties is not known, but probably many hunters, traders, and prospectors had traveled through this section and knew the country well.

The early history of Tulare County centers principally about the history of Visalia, which at that time was but another name for the Four Creeks Country. In 1853 Visalia became the county seat, and it has since remained the principal town, with a population of 7,263 in 1930. The city of Tulare, situated on the main inland railroad and highway route between San Francisco and Los Angeles, has a population of 6,207. The towns of Dinuba, Exeter, Lindsay, Porterville, Strathmore, and Woodlake are important agricultural and shipping centers.

The total population of Tulare County in 1890 was 24,574; in 1900, 18,375; in 1910, 35,440; in 1920, 59,031; and in 1930, 77,442. The 1930 census reports the urban population as 28,304 and the rural population as 49,138. In some of the western parts of the area the population has diminished during the last two decades, but in the central and eastern parts, along the base of the Sierra Nevada foothills, the population has increased rapidly. Exeter, Lindsay, Strathmore, and Porterville are the important towns of the Citrus Belt and reflect the success of the citrus industry. Of the total population, 61,366 are native white persons, 5,809 are foreign-born whites, 819 are Negroes, and 9,448 are of other races, including 7,076 Mexicans, 1,486 Japanese, 351 Indians, and 179 Chinese.

TRANSPORTATION AND MODERN CONVENIENCES

The Visalia area is well supplied with transportation facilities. Main and branch lines of the Southern Pacific Company and of the Atchison, Topeka & Santa Fe Railway serve it well. The main San Joaquin Valley line of the Southern Pacific extends through the western part, and branch lines connect with Dinuba, Visalia, and the other towns of the eastern part. Two branch lines of the Atchison, Topeka & Santa Fe in the eastern part serve Orange Cove, Cutler, Dinuba, Exeter, and other towns. An electric line passes through Elderwood, Woodlake, Lemoncove, Lind Cove, and a number of places near the foothills. United States Highway No. 99 parallels the main line of the Southern Pacific through Tulare and the western part of the area, and the Orange Belt Highway extends through Strathmore, Lindsay, and Exeter. Paved highways serve all sections and extend into the mountains to the Sequoia and General Grant National Parks.

Electric power is available throughout the area, and natural gas is becoming available for farm use. Schools, churches, and many other social institutions are conveniently located. Motorbus transportation is supplied for school pupils throughout the entire area.

MARKETS

Much of the agricultural produce is marketed outside the area. Dried and canned fruits, raisins, wines, and citrus fruits are shipped long distances and distributed throughout the world. Table grapes and fresh fruits are marketed throughout the State and other parts of the country. Dairy products, hay, meats, and truck crops are used locally or marketed in Fresno, Los Angeles, and San Francisco. A considerable part of the cream produced in the Tulare district is shipped to Los Angeles. Much of the produce, especially the citrus, poultry, and swine products, is sold through cooperative marketing organizations.

CLIMATE

The climate of the Visalia area is typical of that of the middle San Joaquin Valley, in that it is distinctly semiarid. The year is divided into two general seasons—winter, during which most of the rainfall occurs, and summer, which is hot and dry. The spring and fall seasons are mainly transitional, with fairly warm days and cool nights. The rainless summers with low humidity provide ideal conditions for the drying of fruits and raisins, as well as the handling of other fruits and crops. The mild winters are advantageous for the growing of truck crops and citrus fruits. Because of the rainless hot summers, irrigation must be practiced for all summer crops. Small grains are grown without irrigation during winters when the rainfall is normal. These general climatic conditions, with low rainfall, have produced a marked effect on the soils, especially being responsible for their prevailing light color and unleached character.

The average annual rainfall ranges from about 7½ inches in the extreme southwestern part of the area to about 16 inches in the foothills. In the agricultural district as a whole the mean is about 9 inches. Visalia has a mean annual rainfall of 9.06 inches; Angiola, just outside the southwestern corner of the area, has 6.90 inches; and Lemoncove, situated at the base of the foothills, has 14.06 inches. Three Rivers, situated about 8 miles east of Lemoncove and outside of the area, has a mean annual rainfall of 19.21 inches. Most of the rainfall comes between November and March. The annual rainfall generally is insufficient for the production of any crops except grains and winter and spring grasses, and practically all crops other than these are irrigated.

Table 1 gives the mean monthly and annual precipitation for a number of Weather Bureau stations in this general region, and table 2 gives the temperature data for the same stations.

TABLE 1.—*Mean monthly and annual precipitation at several stations in and near the Visalia area, Calif.*

Station	Elevation	Length of record	January	February	March	April	May	June	July	August	September	October	November	December	Annual
	Feet	*Yr.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In*
Angiola	208	37	1.36	1.21	1.23	0.56	0.38	0.05	0.00	0.01	0.27	0 28	0.59	0 96	6.90
Visalia	334	48	1.85	1.59	1.60	.82	.49	.06	(1)	.01	.24	.34	.79	1.27	9.06
Lindsay	384	23	2.12	1.82	1.88	.05	.62	.11	(1)	(1)	.19	.37	.89	1.38	10.33
Porterville	464	48	1.93	1.70	1.77	1.01	.67	.09	.01	.01	.21	.42	.86	1 43	10.11
Lemoncove	600	42	2.48	2.73	2.53	1.35	.84	.14	.00	.01	.32	.54	1.31	1.81	14.06
Three Rivers	840	27	3.64	3.57	3.11	1.94	1.21	.20	.04	.04	.48	.81	1.70	2.47	19.21
Springville	4,050	30	6.69	5.54	5.16	3.18	1.92	.45	.05	.23	.60	1 30	3.10	4.36	32 58
Giant Forest	6,360	15	5.67	6.80	4.31	5.14	1.90	1.06	.08	.09	.35	1.44	4.17	6.18	37.19

[1] Trace.

TABLE 2.—*Mean monthly and annual temperature at several stations in and near the Visalia area, Calif.*

Station	Elevation	Length of record	January	February	March	April	May	June	July	August	September	October	November	December	Annual
	Ft.	*Yr.*	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*
Angiola	208	37	44.3	50.8	54.2	60.1	66.6	73.3	80.7	78.7	71.9	62.1	51.4	44.0	61 4
Visalia	334	48	45.7	51.3	54.5	59.8	66.6	73.9	80.5	78.8	72.3	63.8	53.9	46.3	62.3
Lindsay	384	23	45.5	51.2	55 6	61.0	67.0	74.6	80.8	79.1	72 3	63.2	52.9	46.0	62.4
Porterville	464	48	47.3	51.6	56.0	61.7	68 7	76 7	83.0	81.2	74.2	64.7	54.7	47.2	63.9
Lemoncove	600	42	47.0	52.1	56.2	61.5	67.8	75.8	81.9	80.0	73.6	65.3	54.7	46.9	63.5
Three Rivers	840	27	45.1	50 0	54.2	59.1	65.3	72 8	79.4	77.7	71.2	62.5	53.0	46.1	61 4
Springville	4,050	30	38.8	40 9	43.8	48.2	54.6	62.7	70.5	69.3	62 5	53.8	46.8	39.7	52.7
Giant Forest	6,360	15	33.4	35.4	38.5	41.7	48.4	56.9	65.6	63.6	58.5	50.5	42.2	35.5	47.5

The summers are very hot, with maximum temperatures reaching 114° F. at times. In general the winters are fairly mild, with considerable sunny weather. The sections close to the foothills are the warmest, and those at some distance from the foothills and at the lower elevations are the coldest. The daily range in temperature is great, especially in the early summer, when the range may be as much as 45°.

So-called frost-free locations are a very important factor for agricultural production in this locality, especially for the large acreage in citrus fruits. The distribution of the citrus-fruit orchards is confined to belts in which the lowest temperatures are seldom below the frost line, although some plantings are on the valley lands where the danger from frost is much greater. In general, the citrus plantings are confined to the slopes of the so-called thermal belt along the foothills, where the air drainage is favorable and the temperatures are higher than on the flatter land. People contemplating the setting out of citrus trees should make a careful study of the local frost and air-drainage conditions. Orchard heating is not so widely practiced as in some other parts of the State less favorably located, but, as a general rule, most orchards are prepared for heating, should a heavy frost occur.

The percentage of sunshine is very high, especially in the summer. Fogs form in the winter, especially during the early morning, but they are low and confined principally to the lower land west of the citrus-fruit district. The humidity is very low during the summer but is much higher during the winter. The United States Weather Bureau station reports 215 clear days and 118 partly cloudy days at Visalia in 1933.

The prevailing winds are from the northwest, but they never attain high velocity. Winter rains often are preceded or accompanied by southerly winds.

Table 3, compiled from records of the Weather Bureau, gives frost data for several stations in Tulare County.

TABLE 3.—*Frost data from several stations in and near the Visalia area, Calif.*

Station	Length of record	Average date of latest killing frost	Average date of earliest killing frost	Average frost-free period	Latest killing frost recorded	Earliest killing frost recorded
	Years			*Days*		
Angiola	38	Mar 22	Nov. 11	234	May 20	Oct. 12
Visalia	36	Mar. 10	Nov. 28	263	May 4	Oct. 26
Lindsay	24	Mar. 20	Nov 13	238	Apr. 22	Oct. 25
Porterville	35	Mar 9	Nov. 25	261	Apr. 18	Oct. 10
Lemoncove	37	Feb. 26	Nov 29	276	May 11	Oct. 24
Three Rivers	28	Mar. 22	Nov 15	238	May 10	Oct. 23
Springville	10	May 8	Oct. 21	166	June 4	Oct. 5
Giant Forest	10	June 6	Oct. 7	123	June 30	Sept. 8

AGRICULTURE

The course of agricultural development in this area has been very similar to that in other parts of the San Joaquin Valley. The first settlers were more interested in mining than in agriculture, but gradually the raising of livestock began along the bottom lands of the Kaweah River. Most of the ranchmen grazed their livestock in the mountains during the summer. Soon after the establishment of ranches, grain farming began in the valley. Landholdings necessarily were large, because the yields were often low, owing to the scant rainfall.

Grain growing was supplanted in later years by the production of orchard fruits, vines, and intensively cultivated crops, with the aid of the waters of the Kaweah and Kings Rivers for irrigation. Thousands of wells were drilled subsequent to 1900, in order to obtain underground water for the development of more irrigated land for intensive cropping. As a result the underground water table is dropping rapidly, because more water is being pumped out than is coming in to replenish the underground supply. In 1909 the census reported 739 irrigation pumping plants in Tulare County, and these increased to 3,758 in 1920, and to 7,964 in 1930. Together with other enterprises, these plants irrigated 265,404 acres in 1909, 398,662 acres in 1919, and 410,683 acres in 1930. More than 50 percent of these plants are located in the Kaweah delta. Crops were harvested from 250,100 acres of irrigated land in 1934.

According to the 1935 Federal census, of the 3,107,840 acres in Tulare County, 1,138,465 acres, or 36.6 percent, were in farms. The average size of the farms was 166.3 acres. Land available for crops (cropland and plowable pasture) was reported as 534,372 acres, and 572,873 acres were classed as pasture (woodland and other).

Of the 6,846 farms in the county in 1935, owners and part owners operated 4,746, tenants 1,515, and managers 585. This is a slight increase in tenant-operated farms since 1930.

The 1930 census reported $1,378,096 spent for fertilizers in 1929 on 1,287 of the 7,154 farms in the county, $8,052,787 for farm labor on 4,942 farms, and $2,015,760 for feed on 3,858 farms.

As a result of this extensive development of irrigation, together with the favorable climatic and soil conditions, many different crops are grown in Tulare County. Table 4 gives the estimated acreages of fruits grown in the county, as reported for the years 1927, 1932, and 1937.

TABLE 4.—*Estimated acreages of fruits and nuts (bearing trees) in Tulare County, Calif., in stated years*

Fruits	1927 [1]	1932 [1]	1937 [2]	Fruits	1927 [1]	1932 [1]	1937 [2]
	Acres	*Acres*	*Acres*		*Acres*	*Acres*	*Acres*
Almonds	300	461	303	Oranges (Valencia)	11,111	11,101	10,513
Apples	732	308	334	Oranges (others)	245	906	754
Apricots	2,876	1,319	932	Olives	6,085	6,203	5,560
Avocados	4	4	4	Peaches (clingstone)	4,238	5,660	3,821
Cherries	30	5	6	Peaches (freestone)	3,000	2,912	4,214
Figs (Kadota)	250	671	520	Pears (Bartlett)	491	39	21
Figs (others)	3,850	5,080	2,411	Persimmons	47	120	85
Grapes (raisin)	58,227	37,395	37,239	Pomegranates	-------	-------	415
Grapes (table)	19,358	17,496	16,745	Plums	5,129	3,196	2,264
Grapes (wine)	4,556	5,178	3,570	Prunes	6,644	8,253	5,279
Grapefruit	852	784	814	Quinces	-------	-------	17
Lemons	1,326	1,341	1,120	Walnuts	1,030	1,975	2,165
Limes	-------	-------	9				
Nectarines	-------	-------	286	Total	155,988	136,108	122,057
Oranges (navel)	25,497	25,701	22,626				

[1] From (unrevised) estimates of California fruit and nut crop acreages for the years 1927 to 1932, issued by the California Department of Agriculture (*4*).

[2] From (revised) estimates of California fruit and nut crop acreages as of 1937, issued by the California Cooperative Crop Reporting Service (*5*).

Table 5 gives the acreages of irrigated crops in Tulare County and in the Visalia area in 1929.

TABLE 5.—*Acreage of irrigated crops in Tulare County and in the Visalia area, Calif., in 1929* [1]

Crop	Tulare County	Visalia area	Percent of total in Visalia area	Crop	Tulare County	Visalia area	Percent of total in Visalia area
	Acres	*Acres*	*Percent*		*Acres*	*Acres*	*Percent*
Alfalfa	54,663	41,366	75.7	Citrus fruits	37,117	27,469	74.0
Pasture	16,734	10,606	63.4	Deciduous fruits	28,406	23,805	84.0
Small grains	10,089	3,267	32.4	Figs	4,340	3,670	84.6
Miscellaneous field crops	12,169	8,053	66.2	Olives	5,631	4,579	81.3
Cotton	69,534	17,174	24.7	Walnuts	2,783	1,976	71.0
				Grapes	75,487	58,219	77.4

[1] Field survey made by C. H. Holley, for the California Department of Public Works, Division of Water Resources.

According to value, citrus fruits rank first, dairy products second, cotton third, cattle fourth, table grapes fifth, raisins sixth, canning peaches seventh, prunes eighth, poultry and eggs ninth, with olives and drying peaches following. The total acreage of fruits, vineyards, and planted nut trees in 1935 was 123,370 acres, according to the Federal census.

CITRUS FRUITS

Tulare County ranks fourth in total acreage of citrus fruits in the State, being exceeded by Orange, San Bernardino, and Los Angeles Counties. Navel oranges were grown on approximately 22,626 acres, Valencia oranges on 10,513 acres, lemons on 1,120 acres, and grapefruit on 814 acres in 1937. The citrus-fruit district is situated at the eastern edge of the valley along the foothills in the vicinities of Orange Cove, Lemoncove, Exeter, Lindsay, and Strathmore, extending south into the district around Porterville and Terra Bella, which are in the Pixley area. The elevation of this district ranges from 380 to 700 feet above sea level. It is known as the thermal belt because of better air drainage, higher temperatures, and less frost hazards in the winter. Approximately 74 percent of the citrus acreage is in the Visalia area.

Citrus fruits are grown on soils having a wide range in texture and depth. In locating citrus plantings the first thing considered is local climatic conditions, such as frost hazard and air drainage, and the second is the water supply.

At present nearly all of the citrus orchards in this area are irrigated from wells, many of which furnish water in such small quantities and at so great an expense that insufficient quantities of irrigation water are used in many orchards. It has been proved that the deeper medium-textured soils return the best yields of fruit and that the trees live longer. The total quantity of irrigation water used ranges from 24 to 30 inches a year, applied at the rate of 4 or 5 inches an irrigation, with six or seven irrigations a season. The furrow system of applying water is the method most commonly used, although in a few orchards the overhead sprinkling system is used with good results. During the summer the loss from evaporation is high, owing to the low humidity.

It is a common practice to grow mustard in the orchards or to allow the natural growth of weeds during the winter. In some orchards leguminous cover crops are grown, and the cover crop or natural weed cover generally is plowed under in early spring.

The agricultural extension service in Tulare County recommends the following program for maintaining the fertility of the citrus orchards: From 5 to 8 tons an acre of manure (depending on the quality of the manure and the amount of cover crop grown), plus 1 pound, more or less, of nitrogen a tree, according to the size of the tree and the previous fertilizer practice. It is suggested that the manure be broadcast in late summer or fall, shortly before the soil is to be worked, and that the chemical fertilizer be broadcast during the fall or early winter, in order to allow the rains to carry it down into the soil. One pound of nitrogen is supplied by 5 pounds of ammonium sulfate, or by 6½ pounds of nitrate of lime or nitrate of soda. Phosphoric acid and potash have not given profitable returns where they have been tested by the agricultural extension service and by growers.

Heaters are available in most orchards, to protect the trees from frost, although many growers do not have to use them if the orchards are in protected sites where air drainage is good. Bearing orange orchards will yield from 50 to 300 packed boxes an acre. The average acre yield for navel oranges in Tulare County (1922–27), according to the California Citrus League, was 138.4 packed boxes. This average yield might have been higher if all the orchards had been furnished with an ample water supply. The prevalence of mottle leaf also has lowered the average yield. With the control of mottle leaf, by the use of zinc, and with an ample water supply, no doubt the average yield could be considerably increased. In studies carried on by the University of California cooperating with the State Division of Water Resources (*1*), it was found that with an acre yield of 138 boxes and a price to the growers of $2.19 a packed box, the return would pay preharvest costs of $190 an acre, harvest costs at 24 cents a packed box, interest at 6 percent on an average investment of $750 an acre, $34.10 an acre for irrigation water, and additional profits over the labor income to the operator. At the present time the cost of irrigation water ranges from $25 to $66 an acre.

PEACHES AND APRICOTS

Tulare County ranks fourth in the State in the total acreage devoted to peaches, being exceeded by Sutter, Stanislaus, and Fresno Counties. The acreage in peaches in Tulare County in 1937, as estimated by the California Cooperative Crop Reporting Service, was 8,035 acres. About two-thirds of the peaches are clingstone and one-third freestone varieties. The principal clingstone varieties are the Orange Cling, Phillips Cling, Paloro, and Tuskena (Tuscan); and the chief freestone varieties are the Muir, Elberta, and Lovell. Most of the peach-growing districts are on the lighter textured deep alluvial soils of the Foster, Cajon, and Chino series in the vicinities of Visalia and Tulare. Scattered plantings are west of Dinuba and also in the Exeter district on the soils of the Tujunga and Exeter series. On the hardpan soils very few peaches are grown, with the exception of a few early market varieties of light yield, such as the Mayflower and Hale Early. In general, good soils are necessary in order to maintain high yields of peaches at a low cost. Foster sandy loam, Cajon sandy loam, Tujunga sandy loam, Foster fine sandy loam, and Cajon fine sandy loam are ideal for peach culture. Plantings of clingstone varieties have gradually increased, and of the freestone varieties have decreased somewhat, during the last 10 years. The average yield of peaches, as determined by studies of the agricultural extension service in Tulare County, is 7.72 tons an acre. Peach orchards are irrigated by the basin or by the furrow method. The irrigation season extends from March to September. Practically no fertilizers are used except barnyard manure. Cover crops, consisting generally of mustard or weeds, are sometimes grown during the winter. In some orchards, annual yellow sweetclover (*Melilotus indica*) is grown as a cover crop to be plowed under in February or March.

The acreage of apricots is decreasing very rapidly, having declined from 2,876 acres in 1927 to 932 in 1937. Tilton and Blenheim are the principal varieties. Apricots are grown in the same districts as are peaches, principally in the vicinities of Visalia and Tulare and between Dinuba and Kingsburg. Best results are obtained from plantings on the sandy loam soils of the Hanford, Tujunga, Cajon, and Foster series. In general, the apricot orchards are managed in much the same way as the peach orchards.

PRUNES AND PLUMS

Plantings of prunes and plums are centralized on the delta of the Kaweah River in the vicinity of Visalia. The acreage has been decreasing. The Cooperative Crop Reporting Service reported 5,279 acres of prunes and 2,264 acres of plums in 1937. Approximately 80 percent of the prunes are of the Agen (French) variety. Shipping plums are chiefly of the Santa Rosa variety, with some of the Beauty, Climax, and Tragedy varieties. The general field practices are very similar to those used for other deciduous fruits, very little fertilizer being used, with applications of barnyard manure and an occasional cover crop. Prunes and plums grow best on medium-textured soils of the Hanford, Tujunga, Cajon, and Foster series that are free of salts.

FIGS

The acreage of figs grown in this area has gradually increased in recent years. In 1937, about 2,961 acres in the county were devoted to figs, of which 521 acres were of the Kadota variety and the rest of the Mission, Adriatic, and Smyrna varieties. Most of the plantings are in the Ivanhoe and Exeter districts on the hardpan soils of the San Joaquin, Madera, and Exeter series, although scattered plantings are on nearly all of the soils that are free of salts.

OLIVES

The acreage of olives has remained fairly constant for a long time. It is centralized in the citrus-fruit districts of Lemoncove, Woodlake, Exeter, Lindsay, and Strathmore. In 1937, about 5,560 acres, the largest acreage in any county in the State, were devoted to olives. Like citrus fruits, olives are planted on many different soils. The trees are long-lived and comparatively free from pests and diseases. They are grown under no established fertilizer practice. Much of the fruit produced is marketed through a packing company in Lindsay.

WALNUTS

The acreage in walnuts increased from about 1,080 acres in 1927 to 2,165 acres in 1937. Probably 75 percent of the trees are of the Franquette variety, and the rest are of the Eureka and Mayette varieties. Most of the walnuts are grown close to the Kaweah and Kings Rivers on the deep sandy alluvial soils of the Tujunga, Cajon, Visalia, Hanford, and Foster series. A considerable acreage is on Tujunga sand, which has a very low water-holding capacity, but the roots of walnut trees extend deeply into the soil, so that they are able to draw moisture and plant nutrients from a large volume of soil. The trees do not thrive on the hardpan soils of the San Joaquin and Madera series.

GRAPES

Tulare County ranks second to Fresno County in the total acreage of grapes grown in California and also in the United States. During the period 1916–23 the expansion in plantings of raisin grapes was very extensive in the San Joaquin Valley, but during the last 10 years the acreage has decreased. The California Cooperative Crop Reporting Service reported a total acreage of 82,141 acres in grapes in 1927 and 57,554 acres in 1937. About 77 percent of the acreage is in the Visalia area.

The grapes include raisin, table, and juice varieties, although some varieties can be used for all three purposes, for example the muscat. The principal raisin grapes include the muscat varieties and Sultanina (Thompson Seedless); the table varieties are the Emperor, Malaga, Flame Tokay, and Cornichon; and the juice grapes include the Alicante Bouschet, Mission, Zinfandel, Alphonse Lavalle (Ribier), and Carignane.

The long dry summers are ideal for the maturing and drying of raisin grapes. The value of the raisins shipped from Tulare County during 1930 was estimated at approximately $1,700,000 and of table grapes at approximately $1,800,000. Many of the grapes are used in the manufacture of sweet wines, such as muscatel, sherry, angelica, and port. Dry wines are produced to only a very small extent.

Raisin grapes generally are grown on the sandier soils, such as Delhi loamy sand, Tujunga sandy loam, Tujunga sand, Greenfield sandy loam, and Greenfield sandy loam, shallow phase, of the Kingsburg-Dinuba district in the northwestern part of the area. Yields of raisins from full-bearing vineyards range from 1 to 2 tons an acre. The price of raisins has fluctuated greatly (from 1.5 to about 13 cents a pound) during the last 20 years. Cost of production varies widely. Studies carried on by various agencies show figures that range from $75 to more than $100 an acre.

Yields of table grapes range from 4 to 6 tons an acre. The Emperor is the most popular variety. The vineyards of table grapes are somewhat scattered. These grapes are grown chiefly on the Exeter, Madera, and San Joaquin soils of sandy loam or loam texture in the Exeter district. Very little cultivation is practiced, except in places where irrigation water is so expensive that it is necessary to keep its use down. Applications ranging from 3 to 6 tons of manure are the general rule, with a winter cover crop of wild mustard or, occasionally, sweetclover. About 300 pounds of ammonium sulfate an acre are used by some growers with good results. Malaga grapes appear to do better on the medium-textured soils, but the Flame Tokay does better on the somewhat heavy-textured soils.

The juice or wine grapes are grown in various parts of the area, on a wide variety of soils ranging in texture from very sandy loam to clay loam. They are not grown on the adobe clay soils to any extent. Since the revival of the wine industry, vineyards have expanded greatly, especially those having grapes of the wine varieties. Wineries are now located in a number of places in the county, so that additional markets are provided for juice grapes as well as for those which are also sold under the classes of table grapes or raisins.

ALFALFA

Approximately 76 percent of the alfalfa in Tulare County is grown in the Visalia area. According to the 1935 census, 40,322 acres in the county in 1934 produced 160,822 tons of hay. The acreage has remained fairly constant for a number of years but was reduced between 1929 and 1934. Here and there the fields are plowed and put into cotton, corn, or other field crops, but generally they are returned to alfalfa after a year or two of clean cultivation. Alfalfa is grown west of Visalia and in the Tulare, Paige, and Waukena districts. Because it is used to feed the dairy cattle, very little is shipped out of the county.

The chief requirements for alfalfa are a deep soil that will absorb water readily and is easy to irrigate by the flooding system. For this reason the soils of the Cajon, Foster, Visalia, and Chino series are suited to the culture of alfalfa. An annual supply ranging from 2 to 4 acre-feet of irrigation water is required, and the usual practice is to irrigate by means of strip border checks at intervals ranging from 14 to 21 days, between April 1 and October 1.

Chilean is the principal variety of alfalfa, and Peruvian is grown to less extent. Alfalfa generally is planted between September 15 and November 15, and allowed to remain for a number of years or as long as the stand is good. Where not pastured, alfalfa is cut for hay about once each month, and the acre yields range from 4 to 10 tons, with an average of about 5 tons a year from five or six cuttings. Under present conditions, in the southwestern part of the area, many dairymen are now paying $10 an acre for pumped water, and some alfalfa growers have changed to cotton as they feel that the cost of water has reached the economic limit for the production of alfalfa.

COTTON

About 75 percent of the acreage devoted to cotton in Tulare County is outside of the Visalia area. Some farmers have changed from alfalfa to cotton in the district west of Tulare where the pumping lift has greatly limited the use of land for crops that require large quantities of water.

Yields of cotton in the southern San Joaquin Valley range from ¾ to 2½ bales an acre. On good land the better growers expect 1½ bales. By agreement, planting is restricted to the Acala variety. From 20 to 30 acre-inches of irrigation water are used for cotton. The common practice is to give a heavy irrigation before planting, followed by three or four irrigations during the growing season. Most of the cotton grown in the Visalia area is produced on Chino fine sandy loam, Chino silty clay loam, and Chino clay loam. This is no doubt due to favorable location with regard to the cost of water rather than to a definite soil adaptation. Most of the soils of the Foster, Cajon, Hanford, Visalia, and Chino series give good results, particularly the medium-textured types. The best soils for cotton are deep soils, which are comparatively free of salts, and which hold a moderate amount of moisture. As a general rule fertilization is not a problem. Ammonium sulfate is used to some extent, and it has materially increased yields on the sandier soils.

SMALL GRAINS

The acreage of small grains in this area is not large. The large grain-growing districts of the county are in the southeastern part near Terra Bella and Ducor, and near Richgrove in the southern part. Grain crops are grown almost entirely without irrigation. Small patches of irrigated barley are grown for feed and forage in the Tulare and Visalia districts. Yields are very good, but grain crops must be limited to land where water is cheap—either under gravity flow or from wells with low lifts.

Dry-farmed grain and hay yields depend on the amount and distribution of the limited rainfall. The common practice is to summer-fallow 1 year in every 3. From 10 to 18 bushels of grain an acre are the usual yields. A belt of summer-fallowed grain land occupies the San Joaquin and Porterville soils east of Seville and Orange Cove.

OTHER FIELD CROPS

Egyptian corn, feterita, milo, and kafir are grown under irrigation in small plantings, especially in the western part of the county. They are planted in the early summer and harvested in the fall. There is considerable local demand for these grain sorghums as feed for poultry and hogs. Acre yields range from 1,000 to 3,500 pounds. Sorghums are grown to some extent for silage. Medium-textured soils of the Foster, Cajon, and Chino series give very good results with these crops. Scattered patches of corn are grown for silage in connection with dairying in the Visalia and Tulare districts. Most of these patches are on the darker colored alluvial soils of the Foster and Chino series. The low humidity and hot summers of the area are not favorable for the production of corn. A few black-eyed beans are grown but not on a commercial scale. Some oats and vetch are grown for forage. Flax is a new crop, which is attracting some attention, but to date it should be considered in the experimental stage.

The acreage in truck crops has remained fairly small and varies from season to season. Potatoes have been grown to some extent on the stream delta soils, but at present the acreage is very small. Fresh peas for shipment are grown in the Ivanhoe district. Tomatoes and squash are grown in scattered plantings along the edge of the foothills where the frost danger is low. Watermelons, cantaloups, and Casaba and Persian muskmelons are grown mainly on the sandy soils of the Greenfield, Dinuba, Cajon, and Tujunga series in the vicinities of Dinuba and Kingsburg.

According to a survey made for the California Department of Public Works, 16,734 acres of pasture land were irrigated in the county in 1929, of which 10,606 acres were in the Visalia area. To a considerable extent this land supports wild grasses. The land is flooded during the early summer while the flow in the rivers is large. Most of the pasture is on soils of the Chino, Fresno, Lewis, and Traver series, which contain sufficient salts to render them unfit for cultivated crops.

LIVESTOCK

Tulare is one of the foremost counties of the State as regards dairying, which is centralized in the districts west of Visalia and Tulare. Some dairying is carried on southwest of Dinuba. These districts annually ship out more than $4,000,000 worth of dairy products in the form of butter, cream, and milk. The dairy districts in general are in the alfalfa-growing sections of the county, as alfalfa is the most important part of the ration of dairy feed. A considerable acreage in these districts is devoted to sorghums and corn for silage. The amount of concentrates fed, including barley, beet pulp, and cottonseed meal, is not large but is increasing. Probably 90 percent of the dairy cows are of the Holstein-Friesian breed, and the rest are Jerseys and Guernseys. Large creameries are located in these districts, and in addition large quantities of cream are shipped daily to Los Angeles. Recently some of the farmers have shifted from dairying to cotton growing, owing largely to the increased cost of pumping because of the lowering water table.

The raising of beef cattle is confined mainly to the irrigated pasture land composed of salt-affected soils and to the strip of lower foothills along the eastern edge of the area. Feeders are imported from outside the area and finished on grass supplemented by cottonseed meal and grains. Breeding of beef cattle is carried on principally on the higher mountain ranches, which lie outside the boundaries of this area. The cattle ranches are large, probably averaging more than 2,000 acres each. The chief range feed is alfileria, wild oats, bromegrass, and bur-clover. The amount of range feed is governed by the annual rainfall; in years of low rainfall the sandier soils provide the best pasture, but in seasons of heavy rainfall the heavier textured soils provide the most. In normal years, the "alkali" plains, composed of the Traver, Fresno, and Lewis soils, provide very little pasture, as the grasses dry up early in the summer, but in years of high rainfall these soils furnish fair feed. Hereford is the principal breed of beef cattle, and small numbers of Aberdeen Angus and Shorthorns are kept.

Within the last 10 years the number of hogs in the county has been greatly reduced. The 1920 census reported 60,828, the 1930 census reported 29,420, and the 1935 census only 23,484. Hampshire and Duroc-Jersey are the principal breeds, with a few Poland China and Chester White. Hogs generally are not kept on the dairy farms but are handled as a separate business. Sheep raising is of comparatively little importance.

To a considerable extent the poultry business is combined with other farming activities in this area, and probably poultry raising could be profitably expanded. As a separate business it is mainly centralized near Porterville. This is mainly an egg-producing district, and White Leghorn is the principal breed of chickens. Marketing is done chiefly through a local poultry association. In selecting a poultry site, care should be exercised to obtain a sandy soil that is well drained. Such soils are available on the deltas and alluvial fans of the streams issuing from the mountains.

SOIL-SURVEY METHODS AND DEFINITIONS

Soil surveying consists of the examination, classification, and mapping of soils in the field.

The soils are examined systematically in many locations. Test pits are dug, borings are made, and exposures, such as those in road or railroad cuts, are studied. Each excavation exposes a series of distinct soil layers, or horizons, called, collectively, the soil profile. Each horizon of the soil, as well as the parent material beneath the soil, is studied in detail; and the color, structure, porosity, consistence, texture, and content of organic matter, roots, gravel, and stone are noted. The reaction of the soil [3] and its content of lime and salts are determined by simple tests.[4] Drainage, both internal and external, and other external features, such as relief, or lay of the land, are taken into consideration, and the interrelation of soils and vegetation is studied.

The soils are classified according to their characteristics, both internal and external, especial emphasis being given to those features influencing the adaptation of the land for the growing of crop plants, grasses, and trees. On the basis of these characteristics soils are grouped into mapping units. The three principal ones are (1) series, (2) type, and (3) phase. Areas of land, such as coastal beach or bare rocky mountainsides that have no true soil, are called (4) miscellaneous land types.

The most important group is the series, which includes soils having the same genetic horizons, similar in their important characteristics and arrangement in the soil profile, and developed from a particular type of parent material. Thus, the series includes soils having essentially the same color, structure, and other important internal charac-

[3] The reaction of the soil is its degree of acidity or alkalinity expressed mathematically as the pH value. A pH value of 7 indicates precise neutrality, higher values indicate alkalinity, and lower values indicate acidity.

[4] The total content of readily soluble salts is determined by the use of the electrolytic bridge. Phenolphthalein solution is used to detect a strong alkaline (basic) reaction. Lime (calcium carbonate) is detected by application of hydrochloric acid.

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teristics and the same natural drainage conditions and range in relief. The texture of the upper part of the soil, including that commonly plowed, may vary within a series. The soil series are given names of places or geographic features near which they were first found. Thus, Foster, Chino, Greenfield, Visalia, and Hanford are names of important soil series in this area.

Within a soil series are one or more soil types, defined according to the texture of the upper part of the soil. Thus, the class name of the soil texture, such as sand, loamy sand, sandy loam, loam, silt loam, clay loam, silty clay loam, and clay, is added to the series name to give the complete name of the soil type. For example, Foster fine sandy loam and Foster sandy loam are soil types within the Foster series. Except for the texture of the surface soil, these soil types have approximately the same internal and external characteristics. The soil type is the principal unit of mapping, and because of its specific character it is usually the soil unit to which agronomic data are definitely related.

A phase of a soil type is a variation within the type, which differs from the type in some minor soil characteristic that may have practical significance. Differences in relief, stoniness, and the degree of accelerated erosion frequently are shown as phases. For example, within the normal range of relief for a soil type, there may be areas that are adapted to the use of machinery and the growth of cultivated crops and others that are not. Even though there may be no important difference in the soil itself or in its capability for the growth of native vegetation throughout the range in relief, there may be important differences in respect to the growth of cultivated crops. In such an instance the more sloping parts of the soil type may be segregated on the map as a slope or hilly phase. Similarly, soils having differences in stoniness may be mapped as phases, even though these differences are not reflected in the character of the soil or in the growth of native plants.

The soil surveyor makes a map of the county or area, showing the location of each of the soil types, phases, and miscellaneous land types, in relation to roads, houses, streams, lakes, section and township lines, and other local and natural features of the landscape.

SOILS AND CROPS

The soils of the Visalia area have developed under conditions of light rainfall and therefore have features that are characteristic of a semiarid region. The content of organic matter is low, and the reaction is distinctly basic in nearly all of the soils, most of which are calcareous.[5] Sodium salts, such as chlorides, sulfates, and carbonates, have accumulated in many of the lower flatter areas. In

[5] The term "basic" is used in this report as synonymous with "alkaline" as used by chemists. It denotes, not an excess of soluble salts ("alkali"), but an alkaline reaction. (See footnote 3, p. 17.) The term "alkaline" is purposely avoided because of the popular conception of its meaning. "Calcareous" means containing lime in sufficient quantity to be detected by application of dilute hydrochloric acid. "Noncalcareous" means not containing lime in sufficient quantity to be so detected. A soil may contain an abundance of available calcium and yet not be calcareous in the foregoing sense. The term "lime" refers to calcium carbonate and not to calcium in other compounds.

general, the soils of the area are well supplied with most of the plant nutrients, with the exception of nitrogen, which is deficient. In a few places, the phosphates are in comparatively insoluble form and are less readily available.

The surface soils differ considerably in texture. Those soils whose parent materials are derived from coarse-textured rocks, such as granites, have a sandy texture (sandy loam), whereas those whose parent materials are derived from fine-textured rocks have a heavy texture (clay loam or clay). Differences in the mode of formation, degree or stage in development, drainage, and parent materials have had their effect in producing different soils.

The soils of the area occur in several distinct physiographic belts, in which definite relationships exist between the physiographic landscape and the soil (fig. 2, p. 3), as noted previously, with reference to the foothill and mountainous district and the valley district, which is subdivided into alluvial fans, hardpan terraces, and the basinlike saline and alkali lands.

In table 6 the soils are grouped into major groups on the bases of physiography, mode of accumulation of parent materials, and age, and into soil series on the bases of similarities in color and mineralogical composition.

TABLE 6.—*Grouping of soil series in the Visalia area, Calif.*

Soil group	Brown soils developed from—		Light-gray or light brownish-gray soils developed from—		Dark brownish-gray or dark-gray soils developed from—	
	Granitic parent material	Basic igneous parent material	Granitic parent material	Mixed parent material	Granitic parent material	Basic igneous parent material
Soils developed on bedrock materials of the foothills	Vista.	Lassen. Las Posas.				
Soils developed on recent or young alluvial-fan or flood-plain materials	Hanford. Greenfield.	Honcut. Farwell.	Tujunga. Cajon.	---------	Visalia. Foster. Chino.	
Soils developed on wind-modified alluvial-fan materials	------------	------------	Delhi.			
Soils developed on older alluvial-fan materials	Ramona.	Porterville.	Dinuba.	---------	---------	Hovey.
Hardpan soils developed on old alluvial fans and terraces	San Joaquin. Exeter Madera.	Yokohl. Seville.				
Saline and alkali soils developed under poor drainage	------------	------------	Traver. Fresno. Waukena.	Lewis.		

In the following pages the soils of the Visalia area are described in detail, and their agricultural relationships are discussed; their location and distribution are shown on the accompanying soil map; and their area and proportionate extent are given in table 7. The profiles and characteristics of a few of the more important soils are shown in figure 3.

SOIL TYPE	PROFILE	COLOR	TEXTURE	STRUCTURE	CONSISTENCE AND DENSITY	REACTION
Vista sandy loam	A (0–14)	Brown	Sandy loam	Granular	Friable	Neutral
	B (14–24)	Light reddish brown	Loam	Medium cloddy	Slightly compact	Slightly basic
	C (24)		Granite	Bedrock		
Greenfield sandy loam	A (0–24)	Light brown	Sandy loam	Slightly granular	Friable	Neutral
	B (24–42)	Light reddish brown	Loam	Small, irregular-shaped clods	Slightly compact	Neutral to slightly basic
	C (42)	Light brown	Sandy loam	Single-grained to slightly granular	Friable	Neutral
Porterville adobe clay	A (0–12)	Dark chocolate brown	Clay	Adobe	Hard when dry	Slightly basic
	B (12–40)	Dark chocolate brown	Clay	Large adobe blocks	Very hard when dry	Calcareous
	C (40)	Reddish brown	Clay	Cubical	Fairly hard	Highly calcareous
San Joaquin loam	A (0–10)	Light reddish brown	Loam	Somewhat granular when moist	Friable when wet, fairly hard when dry	Neutral to slightly acid
	B_1 (10–20)	Light reddish brown	Clay	Prismatic	Compact	Neutral to slightly basic
	B_2 (20–38)	Reddish brown	Hardpan	Massive	Rocklike	Slightly basic
	C (38)	Brown	Loam	Fairly massive	Moderately compact	Slightly basic
Lewis fine sandy loam	A (0–3)	Light gray	Fine sandy loam	Single-grained vesicular	Friable	Calcareous
	B_1 (3–12)	Dark brownish gray	Clay	Columnar	Very compact	Alkaline
	B_2 (12–28)	Brown	Clay loam	Blocky	Compact	Calcareous alkaline
	B_3 (28–46)	Yellowish brown	Loam	Somewhat blocky	Fairly compact	Highly calcareous
	B_4 (46–54)	Yellowish gray	Clay loam	Massive	Dense	Highly calcareous
	C (54)	Light brown	Clay loam	Fairly massive but breaks up into blocks	Compact	Highly calcareous
Fresno fine sandy loam	A (0–9)	Light gray	Fine sandy loam	Single-grained slightly vesicular on top	Friable when wet, fairly hard when dry	Alkaline
	B_1 (9–20)	Light gray	Loam	Cloddy	Compact	Alkaline
	B_2 (20–38)	Light gray	Hardpan lenses	Massive	Hardpan	Alkaline
	C (38)	Dull gray	Sandy loam	Single-grained between hardpan lenses	Compact	Alkaline

FIGURE 3.—Profiles and characteristics of a few of the more important soils of the Visalia area, Calif.

TABLE 7.—*Acreage and proportionate extent of the soils mapped in the Visalia area, Calif.*

Soil type	Acres	Percent	Soil type	Acres	Percent
Vista sandy loam	3,200	0.6	Chino clay loam, shallow phase (over Fresno soil material)	9,856	1.8
Vista sandy loam, rock-outcrop phase	8,064	1.5	Delhi loamy sand	2,432	.5
Lassen stony adobe clay	5,824	1.1	Porterville adobe clay	15,104	2.8
Las Posas stony clay loam	7,808	1.4	Porterville adobe clay, stony phase	3,264	.6
Tujunga sand	8,064	1.5	Hovey adobe clay	1,344	.2
Tujunga sand, gravelly phase	832	.2	Dinuba sandy loam	6,528	1.2
Tujunga sandy loam	9,536	1.7	Ramona loam	2,240	.4
Cajon sandy loam	27,008	5.0	San Joaquin sandy loam	26,176	4.8
Cajon fine sandy loam	24,640	4.5	San Joaquin loam	21,696	4.0
Hanford sandy loam	9,344	1.7	San Joaquin clay loam	10,816	2.0
Foster sandy loam	13,248	2.5	Exeter loam	17,344	3.2
Foster fine sandy loam	34,624	6.4	Exeter loam, gravelly phase	1,152	.2
Foster fine sandy loam, shallow phase (over Fresno soil material)	5,952	1.1	Exeter clay loam	768	.1
Foster loam	2,432	.5	Madera sandy loam	2,752	.5
Visalia sandy loam	7,168	1.3	Madera loam	23,488	4.3
Visalia sandy loam, shallow phase (over San Joaquin soil material)	1,984	.4	Madera clay loam	3,520	.7
Visalia sandy loam, shallow phase (over Fresno soil material)	1,664	.3	Yokohl clay loam	1,792	.3
Honcut sandy loam	3,072	.6	Yokohl clay	768	.1
Honcut sandy loam, gravelly phase	256	(1)	Seville adobe clay	5,184	.9
Honcut loam	1,536	.3	Traver fine sandy loam	30,208	5.6
Honcut silty clay loam	2,304	.4	Traver loam	1,344	.2
Greenfield sandy loam	11,968	2.2	Waukena fine sandy loam	3,392	.6
Greenfield sandy loam, shallow phase	11,200	2.1	Lewis fine sandy loam	10,240	1.9
Farwell fine sandy loam	1,856	.3	Lewis clay loam	13,312	2.5
Chino fine sandy loam	22,400	4.1	Fresno fine sandy loam	24,640	4.5
Chino sandy loam	768	.1	Rough stony land	40,768	7.5
Chino silty clay loam	29,376	5.4	Riverwash	128	(1)
Chino clay loam	7,616	1.4	Total	544,000	

[1] Less than 0.1 percent.

SOILS DEVELOPED ON BEDROCK MATERIALS OF THE FOOTHILLS

Soils developed on bedrock materials of the foothills have rolling, hilly, or mountainous relief and rest on the parent bedrock at a depth ranging from a few inches to 4 feet. They are classified in the Vista, Lassen, and Las Posas series. Rough stony areas, in which very little or no soil material has developed, owing to rough steep slopes and large quantities of stone, are classified under the group of miscellaneous land types, as rough stony land.

VISTA SERIES

The surface soils of members of the Vista series are light brown, brown, or reddish brown. The reddish-brown shade is somewhat more pronounced when the soils are wet. The texture is coarse, and small angular quartz fragments are numerous. Grass roots fill the soil, although the organic-matter content is low. The soils are not calcareous but are neutral to mildly basic in reaction (pH 7.2 to 7.8).[6] With pressure, they break down readily to a friable condition. The thickness of the surface soils ranges from a few inches to about 3 feet, depending on the amount of soil material accumulated on slopes or removed by erosion.

The subsoils, where typically developed, are reddish brown and in most places are of somewhat heavier texture than the surface soils, and slightly to moderately compact. When wet they do not appear

[6] Reaction, in terms of pH values, as given in this report are based on LaMotte or Soiltex field tests.

to be very compact, but they dry fairly hard and break into irregular-shaped clods. Coarse angular fragments of parent granitic rocks, present in considerable quantity, give the subsoils a coarse sharp texture and mask the heavier texture to considerable extent. The subsoils do not contain sufficient lime to produce effervescence when tested with dilute acid but have a pH value of 7.2 to 8. A thin layer of brownish-red or red gritty clay loam overlies the parent granitic bedrock in most places. Probably one-third of the Vista soils show slight development of a soil profile, with indistinct horizons of illuviation and eluviation, owing to progressive removal of soil material by erosion.

The Vista soils are developed in place on the weathered underlying granitic bedrock. They occupy hilly to rolling relief and are characterized by some rock outcrops. Where the surface cover of grass or brush is removed, erosion is fairly active, but, as the soils of this series in this area are utilized mainly for pasture, erosion is not so destructive as in other parts of the State where the same soils are cultivated. Surface run-off is fairly rapid, and subdrainage generally is good. The soils contain no accumulated saline salts. Originally they had a cover of oak, brush, and grasses, but the brush and trees have been removed to some extent by man and by fires.

Vista sandy loam and Vista sandy loam, rock-outcrop phase, are mapped in a narrow belt along the eastern edge of the area. These soils were included in the earlier reconnaissance of the middle San Joaquin Valley with the Holland series, from which they differ in basic reaction and some other characteristics.

Vista sandy loam.—Vista sandy loam, locally called a granite soil, has a rich-brown surface soil and subsoil. The subsoil rests on granitic bedrock at a variable depth. Large angular quartz particles are very prominent and give the material a sharp feel. The surface soil is very friable and absorbs moisture very readily, but it has only a moderate water-holding capacity because of its coarse texture and does not become sticky when wet. The subsoil is of about the same texture or slightly heavier than the surface soil. It does not include a claypan or hardpan, but bedrock occurs at a depth ranging from a few inches to about 3 feet, with an average of about 2 feet. The organic-matter content is comparatively low. Drainage is rapid, and tilled fields are eroded in some places. Irrigation is difficult on some of the steeper slopes. Irrigation and cultivation should follow the contours.

This soil occurs as a marginal belt in the foothills below the mountainous area. The typical soil is not very extensive, but the rock-outcrop phase occupies a large acreage. In Frazier Valley a few included areas are somewhat heavier textured than typical.

Only a small part of Vista sandy loam is used for cultivated crops, owing to the use of the available water for irrigation on the more level land of the valley. In places where the soil is sufficiently deep and the slopes are not too steep, this is an excellent soil for irrigated crops. The organic-matter content should be built up on the farmed land, and care should be used in tillage and irrigation so as not to accelerate erosion. A few citrus trees are grown, with excellent results, on the better spots of this soil.

Grain does not return very high yields, owing to the scant rainfall. With normal winter rainfall, native grasses provide good spring pasture, although they dry up fairly early in the summer, owing to the lack of summer rainfall.

Vista sandy loam, rock-outcrop phase.—The rock-outcrop phase of Vista sandy loam consists of shallow areas of Vista sandy loam ranging in depth from 6 to 18 inches to the granitic bedrock. Large boulderlike outcrops of granitic bedrock occupy from 25 to 50 percent of the surface so that cultivation of any sizable areas is impossible. This soil occupies hilly to steep areas in the foothills of the Sierra Nevada. It is associated with typical Vista sandy loam, from which it differs in the large proportion of rock outcrops and boulders and in its rougher and steeper relief.

A few spots, 1 or 2 acres in extent, that lack the boulders and outcropping bedrock, have about the same value for cultivated crops as typical Vista sandy loam, but, taken as a whole, soil of the rock-outcrop phase is used only for pasture. In years of normal rainfall the stand of native grasses is fairly good. It consists of alfileria, bromegrass, and wild oats, although these grasses dry up fairly early in the summer, owing to lack of available moisture. The land supports a scattered growth of medium to small oak trees.

LASSEN SERIES

The surface soils of members of the Lassen series are dark brown or dark chocolate brown, generally of heavy texture, and they break when dry into large blocks. The 8- or 10-inch surface layer is well filled with roots and has a secondary breakage into smaller fragments from one-fourth to one-half inch in diameter. This approaches the so-called dry-bog structure but is not so well developed as in the Porterville soils. These soils show considerable variation in reaction, but all are mildly to strongly basic (pH 7.5 to 9). Some of the darker spots are calcareous.

The subsoils are dark chocolate brown, heavy in texture, and break into large blocks of adobe structure. In most places they are slightly calcareous. At a depth ranging from 12 to 30 inches, the subsoil material rests on the parent material, which is derived from fine-grained bedrock of serpentine or gabbro-diorite. In most places lime coats the bedrock, and it also occurs in seams and cracks. The soil materials contain a considerable quantity of stones.

The Lassen soils are formed in place on the disintegrated and decomposed underlying basic igneous bedrock materials. They occupy hilly to rough relief with fairly steep slopes, on which drainage is well developed. Erosion is not serious, although a few channels leading to gullies have formed on the steeper slopes. The soils are devoid of trees, the native cover being grasses, which do fairly well in seasons of normal rainfall but are poor in subnormal years. These soils occupy isolated hills along the eastern edge of the valley. Where eroded and washed down as alluvium on the fans they give rise to soils of the Porterville series.

In the earlier reconnaissance of the middle San Joaquin Valley, these soils were included with the Olympic soils. The Olympic series now includes only soils that have developed under a heavier rainfall than that of this section, with resulting differences now recognized in soil characteristics. Lassen stony adobe clay is the only member of the Lassen series mapped in this area.

Lassen stony adobe clay.—Lassen stony adobe clay is dark-brown or dark chocolate-brown clay, which carries a considerable quantity of large stones, both on the surface and embedded in the soil material. Bedrock occurs at a depth ranging from 15 to 24 inches. This soil has the structural dry-bog characteristics of Porterville adobe clay, in that it forms irregular blocks on drying, which break down to smaller fragments. In general, lime coatings are visible on the top of the bedrock, which consists of fine-grained basic igneous rock. The heavy texture of the soil makes it difficult to work, even after the stones have been removed. The surface stones have been removed from small areas that are farmed, but this has proved very costly even though the crops, such as winter squash and peas, are highly specialized, and the slopes are comparatively frost-free. In general, the utilization of this soil is very limited, owing to its position above sources of irrigation water, its excessive stone content, and its shallowness. In years of normal rainfall it supports a good growth of bur-clover and provides considerable grazing, but the grass cover is poor in years of low rainfall.

This soil occupies fairly steep slopes on hills along the eastern edge of the valley. Most of the areas are bordered on the upper side by steep rocky slopes, which have been classified as rough stony land, and on the lower side by heavy-textured soils of the Porterville series developed on alluvial outwash materials.

On Smith Mountain and on the western end of Stokes Mountain are two included small areas without an excessive quantity of stones, in which the soil is much deeper than in areas of the typical soil. The soil in these areas would have been separated as a distinct type had it been more extensive. This included soil consists of dark-gray calcareous clay resting on soft marly bedrock at a depth ranging from 4 to 6 feet. These areas occupy fairly smooth flat-topped ridges, on which there are a few stones but not sufficient to interfere with tillage. Some figs, citrus fruits, and olives are grown on these areas, with fairly good results. Grain does well when the rainfall is ample.

LAS POSAS SERIES

Soils of the Las Posas series are a pronounced reddish brown, light reddish brown, or dull red, and when wet they appear more intensely red. Fragments of fine-grained igneous and metamorphosed rock parent material occur throughout the soil mass. Worm and insect casts are abundant, and, in most places the soils are well filled with roots. The surface soils have a coarse-granular structure and a fair to low content of organic matter. The reaction is neutral to mildly basic (pH 7 to 8), but the soil material is not calcareous. The surface soil ranges from 6 to 18 inches in thickness. It grades into a light-red or brownish-red subsoil of about the same or slightly heavier texture, which in most places is slightly to moderately compact. The material in this layer has a pH value of 7.4 to 8.2, but it does not effervesce when tested with acid. The fine-grained igneous parent material is reached at a depth ranging from 6 to 30 inches.

The parent bedrock generally is broken and fractured at the top to a depth ranging from 4 to 12 inches.

The Las Posas soils are residual or primary soils developed in place from the weathered products of the underlying bedrock, mainly amphibolites in this area. Stone and rock outcrops are common on rolling to fairly steep slopes. Erosion is active on the steeper slopes when the native grass cover is removed or grazed too heavily. Surface drainage is well developed. The native vegetation consists mainly of bromegrass, alfileria, and wild oats on the north slopes. There are also a few oak trees.

The material of the Las Posas soils gives rise to soils of the Honcut series where washed down and redeposited on alluvial fans.

The Las Posas soils are related to the Lassen soils and were included with the Holland and the Olympic soils in the earlier reconnaissance.

Las Posas stony clay loam.—Las Posas stony clay loam is a pronounced reddish-brown or dull-red residual soil, which occupies rolling to hilly relief on the foothills, with fairly steep slopes in places. The surface soil is predominantly stony clay loam, in which the stones differ considerably in size and quantity. In places areas ranging from 10 to 20 acres in size can be tilled. The subsoil in general consists of heavy clay loam and rests on the parent bedrock at a depth ranging from 12 to 30 inches and averaging about 21 inches. The bedrock is composed of amphibolites and similar types of fine-grained igneous or metamorphosed igneous rock material. The organic-matter content of the soil is low.

The water-holding capacity of this soil is comparatively high, but the rainfall has a tendency to run off the surface because of the excessive slope. Erosion is fairly active on the steeper slopes after the native cover is removed. Many of the trees have been removed, but the native grasses have not been plowed up, as the land is used for grazing. The value of this soil for agricultural purposes is governed by steepness of the slope, the depth of soil, and the quantity of stone. Small patches are tillable, but, in general, the land is suited only to pasture.

This soil is located in the foothills east of Lindsay and Elderwood and north of Lemoncove.

A nontypical area, included with this soil in mapping, is about 1 mile northeast of Woodlake, in which the surface soil is dark-red clay resting on bedrock at a depth ranging from 14 to 30 inches. This included area occupies a gentle slope which has a fairly smooth surface. It would have been differentiated as a distinct soil type had it been more extensive. Although shallow, it has more value for cultivated crops than has typical Las Posas stony clay loam, and it is utilized for the production of citrus fruits. The surface is sufficiently smooth to be favorable for irrigation and tillage operations.

SOILS DEVELOPED ON RECENT OR YOUNG ALLUVIAL-FAN OR FLOOD-PLAIN MATERIALS

The characteristics of the soils developed on recent or young alluvial deposits of the valley differ, depending on the parent material, drainage, and general age. Large areas of these deposits are on the flood plains and deltas of the Kings and Kaweah Rivers, and on small alluvial fans along the edge of the foothills. The soils of the Tujunga, Cajon, Hanford, Foster, Visalia, and Honcut series are soils of recent deposition, whereas the soils of the Greenfield, Farwell, and Chino series have slightly older profiles, with slight compaction and accumulations of colloidal clay in the subsoils.

All these soils are developed on deep unconsolidated alluvium that is permeable to roots and moisture. In general, most of the soils are suitable for a wide range of crops, and nearly all are planted to alfalfa, cotton, deciduous fruits, and, to less extent, several other crops. All have smooth surfaces and supported a native vegetation consisting of grasses, scattered oaks, cottonwood, and willows.

TUJUNGA SERIES

The soils of the Tujunga series have light-gray or light brownish-gray noncalcareous highly micaceous surface soils that are low in organic matter, of single-grain structure, loose, and friable. They appear browner when moist. The subsoils are of about the same color and are as loose and friable as the surface soils but in many places are coarser textured. Both the surface soils and subsoils have a pH value of 7 to 7.5. They break down to a mass of individual soil grains when pulverized.

The soil material is very recent alluvium washed from the granitic hills in the Sierra Nevada and deposited along the flood plains of the streams issuing from the hills and mountains to the east. The relief is that of a gently sloping alluvial fan. The native cover originally consisted of grasses, willows, and cottonwood, all which has been cleared from the finer textured soils, and the land is now in crops. Drainage is excellent, except in the areas near the stream channels where the land may be subject to overflow. Some areas receive annual additions of fresh alluvium deposited after heavy storms.

Tujunga sand, with a gravelly phase, and Tujunga sandy loam are mapped. The agricultural values of these soils differ considerably. The gravelly phase of Tujunga sand is only slightly better than riverwash; whereas Tujunga sand is much better, and Tujunga sandy loam is an excellent soil, although somewhat low in organic matter.

These soils were included to a considerable extent with the coarse-textured Hanford soils in the earlier reconnaissance. They differ from the Cajon soils, in that they are not calcareous, and from the Hanford soils, in their lighter color and generally lower organic-matter content.

Tujunga sand.—Tujunga sand consists of light-gray highly micaceous sand, which extends to a depth of several feet without much change except in texture. The subsoil in many places contains considerable gravelly material. Both surface soil and subsoil contain very little organic matter and have a low water-holding capacity. A few spots occur along the Kaweah River, where the 3-inch surface layer is darker than typical.

Tujunga sand occurs mainly along the Kaweah and Kings Rivers as a very recently deposited soil, and small bodies border the sloughs farther from the present channels. The surface is gently sloping but smooth. The soil close to the present stream channels is subject to overflow when the streams are in flood, but this rarely occurs.

The use of this soil is limited to some extent by its low water-holding capacity, yet, owing to its favorable depth and permeability, deep-rooted crops, such as alfalfa and walnuts, do well in places where sufficient water is available for irrigation. A few walnut groves are doing very well, but they use from 5 to 7 acre-feet of water a season. Where water is expensive or available in only small quantities the growing of these crops is not advisable. Heavy applications of manure and the use of cover crops have proved beneficial in building up the soil. A few vineyards are located on this soil. Under dry-farming practices, Tujunga sand has little value in this section, owing to the low rainfall.

Tujunga sand, gravelly phase.—Tujunga sand, gravelly phase, differs from typical Tujunga sand in that it is very coarse-textured and very leachy. The material is light-gray gravelly sand or stony sand. This soil occurs along the Kaweah River north of Lemoncove and is of very recent deposition. It contains practically no organic matter. The areas are cut by stream channels and subject to some deposition or washing during floods. The land supports some brush, a few cottonwood trees, and a very scant cover of grasses, which afford a little pasture. This soil has practically no value for crops.

Tujunga sandy loam.—The surface soil of Tujunga sandy loam is light-gray or light brownish-gray micaceous sandy loam with some inclusion of fine sandy loam material, and the subsoil has about the same color and texture. When wet the soil appears brown. This soil is loose and friable and in general extends without much change, except for stratification, to a depth of several feet. West of Dinuba this soil is locally termed "white ash land," owing to its light color. It absorbs water readily and has a fairly good water-holding capacity. The organic-matter content is low, but the soil seems to be fertile. It does not contain appreciable quantities of lime carbonate or injurious mineral salts. Where this soil joins the Dinuba soils small areas are included, which are underlain by hardpan at a depth ranging from 6 to 7 feet.

This soil occupies gently sloping alluvial fans. A large body lies southeast of the Kings River, and smaller bodies are scattered over the area. The land is easy to irrigate and till, and, because of its favorable depth and the ease of penetration by roots and moisture, it is held in high regard for deep-rooted crops. All the land is under irrigation and is used for the production of intensive crops, such as alfalfa, orchards, and vineyards. A large acreage is devoted to peaches and to Sultanina (Thompson Seedless) and muscat grapes. Melons do well, and all crops return excellent yields under proper management.

CAJON SERIES

The soils of the Cajon series have light grayish-brown or light brownish-gray surface soils, in places approaching light gray, but assuming a light-brown color when moist. The surface soils are friable, highly micaceous, and break up readily to a fine-grain structure. They are slightly to moderately calcareous and have a low content of organic matter. The subsoils are about the same color as the surface soils, and they are made up of stratified sediments high in mica. They have no compact or hard layers and, like the surface soils, are feebly to moderately calcareous and low in organic matter. The lower part of the subsoil, below a depth ranging from 4 to 5 feet, is, in places, slightly mottled with rusty-brown spots, probably because of restricted drainage in the past, and it contains less lime than the material above.

The Cajon soils are recent alluvial soils derived from granitic parent materials. They occupy gently sloping smooth alluvial fans that in a few places near stream channels are subject to overflow or erosion. At one time the water table was close to the surface on the deltas of many of the streams, but now, after years of pumping from wells for irrigation, the water table is low. Slight to moderate quantities of salts are present in some spots. Most of the salty areas have a saltgrass cover, but the salt-free areas have a native cover of willows, cottonwood, and grasses. Much of this land is cleared and, where salts are not present in injurious quantities, produces excellent yields of many different field and orchard crops.

The Cajon soils are associated with the Foster soils, from which they differ in their lighter color, better drainage, and lower organic-matter content. They differ from the related Tujunga soils in their higher lime content and from the Hanford soils in a higher lime content and lighter color. They were included mainly with the Hanford soils in the earlier reconnaissance. Cajon sandy loam and Cajon fine sandy loam are mapped.

Cajon sandy loam.—The surface soil of Cajon sandy loam is an extremely friable light grayish-brown or light-brown sandy loam that is highly micaceous and contains a slight or moderate amount of lime. At a depth ranging from 12 to 20 inches the material becomes lighter in color. Both the surface soil and the subsoil lack any compaction and break readily to a single-grain structure.

The sandy texture of the soil makes it extremely easy to till. It is not sticky when wet and is readily penetrated by water and roots. It normally holds from 10 to 13 percent of moisture after an irrigation except in places where the lower part of the subsoil has a coarse sandy texture and holds a very small amount of moisture for crop use. The value of this soil for agriculture depends to a considerable extent on the quantity of salts present. More than two-thirds of it is free of salts, but the rest has a slight to moderate content. Where the chlorides and sulfates of sodium predominate, reclamation is favored by the sandy texture and seems feasible, but some areas north of Goshen contain sodium carbonate ("black alkali") and are extremely difficult to farm or to reclaim. The organic-matter content is comparatively low and should be built up by applying manures and by growing cover crops.

This soil occupies gently sloping alluvial fans or low broad alluvial ridges extending into the valley. It is easily irrigated and tilled, and erosion is not a problem. Both surface drainage and subdrainage are now good, but at an earlier time a high water table prevailed in some areas.

Cajon sandy loam is extensive on the alluvial fan of the Kaweah River and as outwash from the Kings River north of Traver. It is associated with Tujunga sand, Cajon fine sandy loam, Foster sandy loam, and Foster fine sandy loam. A number of small bodies, about 4 miles southeast of Tulare, are included that have a loamy sand surface soil and a lower water-holding capacity than the typical soil.

Practically all of the salt-free areas are in crops. Alfalfa is grown on the largest acreage, although a considerable acreage is in raisin grapes. Both alfalfa and grapes yield well, and other crops that thrive are peaches, walnuts, and melons. A number of field crops are grown successfully in connection with dairy farming, for which this soil is widely used.

Cajon fine sandy loam.—Cajon fine sandy loam has a surface soil of light grayish-brown friable calcareous highly micaceous fine sandy loam, which grades into a light brownish-gray subsoil at a depth of 12 to 18 inches. The subsoil is similar to the surface soil except that it contains stratified layers of coarser material in places. The soil material below this is sandy loam or fine sandy loam which has about the same color and physical characteristics but which is mottled in places with rusty iron stains. This soil is of recent alluvial accumulation and differs from the related Foster fine sandy loam in the lighter or browner color and in the lower organic-matter content.

The soil is extremely permeable to roots and moisture to a depth of more than 6 feet and is easy to manage under a wide range in moisture content. The water-holding capacity is good, and a comparatively large quantity of available moisture is released for plant growth.

About three-fourths of this soil is free of soluble salts, with slight or medium quantities present in the rest. Where present, most of the salts are sodium chloride or sulfate ("white alkali"), although, here and there, is a little sodium carbonate ("black alkali"). The organic-matter content is comparatively low, but the soil is productive for most crops. This soil occupies gently sloping smooth alluvial fans, which are favorable for irrigation and tillage operations. Drainage, for the most part, is good, except in the lower lying areas.

Extensive areas of this soil are on the alluvial fan of the Kaweah River south of the Venice Hills, from which they extend southwestward to a point about 3 miles west of Tulare. The soil is associated with Foster fine sandy loam and is one of the most extensive soils of the area.

A long narrow strip in Yokohl Valley differs from the typical soil in that it is lighter gray and of variable texture. Close to the stream channel this body has a coarse sandy loam texture, but it becomes finer textured with distance from the stream. This area is much less valuable for crops than typical Cajon fine sandy loam.

With the exception of some bodies that contain salts, all of Cajon fine sandy loam is used for irrigated crops, including alfalfa, grapes, peaches, vegetables, cotton, general field crops, and, with the exception of citrus fruits, nearly all the crops commonly grown. Its location subjects it to damage from frost, and it is not used for citrus fruits. This soil rates high as a general agricultural soil.

HANFORD SERIES

The surface soils of members of the Hanford series are light grayish-brown, light-brown, or brown, becoming medium-brown when wet. They are highly micaceous, normally contain coarse sandy particles of granitic rock material, are somewhat granular, loose, and friable, and have a low content of organic matter. The subsoils are very similar to the surface soils, except that they contain a little less organic matter, are lighter colored in places, and are made up of stratified loose alluvial sediments, which extend to a depth of 6 feet or more. Neither the surface soils nor the subsoils are calcareous, and they have a pH value of 7 to 7.5.

The Hanford soils consist of recent alluvial materials washed from the granitic areas of the Vista soils and deposited on gently sloping alluvial fans. Erosion is not active, except in some places at the bases of hills, where the land is subject to run-off from adjacent steeper slopes and where fresh soil material may be deposited or small channels may be cut during storms.

The native vegetation originally consisted of grasses, oaks, and a few shrubs, all which has been cleared, and the land is now in crops.

The Hanford soils are similar to the Visalia soils but are browner. They differ from the related Greenfield soils in that they are younger in development and lack any compaction or accumulation of colloidal clay in the subsoil. Hanford sandy loam is mapped in this area.

Hanford sandy loam.—The surface soil of Hanford sandy loam is light-brown, light grayish-brown, or brown sandy loam that contains considerable coarse granitic fragments of the parent material. The subsoil in most places is a little lighter colored than the surface soil, but the texture and other characteristics of the two layers are about the same. The soil material below this to an undetermined depth is loose stratified alluvium of coarse sandy loam or sandy loam texture. The soil material has been washed from the areas of granitic rocks in the Sierra Nevada foothills and mountains east of the valley, and it is locally referred to as granitic alluvium, granitic wash, or decomposed granite alluvial soil.

This soil is easy to till under a wide range in moisture content, as it does not contain a large proportion of colloidal clay particles. It absorbs water readily and retains a good supply for the use of plants. Because of the friable subsoil, water penetrates readily after rains or irrigations. This is of particular importance in growing deep-rooted crops, as nothing retards the penetration of either roots or moisture. Typical Hanford sandy loam, as mapped in this area, contains no injurious accumulations of salts. The organic-matter content is somewhat low, with a correspondingly low content of nitrogen, but this is readily built up by the use of cover crops and animal manures.

This soil occupies gently sloping smooth alluvial fans and is easy to till and irrigate. Very little leveling is required to prepare the soil for irrigation. Erosion is not active, except in a few small areas where the Hanford soil joins the hill slopes and receives run-off after rains from the adjoining Vista soils. Both surface drainage and subdrainage are well developed. The native vegetation has been cleared from all this land, and it is all in crops.

Areas of Hanford sandy loam are scattered over the entire area, but none of the individual bodies is large. The more typical bodies are along the foothills, and the larger ones are near Exeter, north of Orosi, east of Seville, and in the vicinity of Naranjo.

The agricultural use of this land depends on the availability and cost of irrigation water. Good yields of a wide variety of citrus fruits, deciduous fruits, grapes (pl. 1), truck crops, and general farm crops are obtained when an ample supply of irrigation water is available. Some of the alluvial-fan slopes of Hanford sandy loam provide excellent air drainage, which is necessary in selecting a site for the growing of citrus fruits. Ordinarily a greater quantity of irrigation water is used on this soil than on the shallower hardpan soils, but the trees are more vigorous and are much longer lived. Manure, alfalfa hay, or straw, with the addition of ammonium sulfate as an auxiliary supply of nitrogen, are used to maintain and build up the organic content in the soil in the citrus groves.

East of Strathmore in Frazier Valley south of the main road, a small area is mapped with Hanford sandy loam, but it differs from the typical soil in that the surface soil rests on calcareous hardpan at a depth ranging from 3 to 4 feet. If this soil were more extensive, it would be differentiated as a phase. Part of this included soil contains some salts and at present is used for pasture. The salt-free part no doubt could be used for field crops under irrigation. This body is subject to overflow from local natural drainage channels.

FOSTER SERIES

The surface soils of members of the Foster series are typically dull gray or dark brownish gray when dry, and when wet they are darker gray. They are highly micaceous, extremely friable, and, for the most part, of fine granular structure. They are slightly to moderately calcareous and have a moderate but higher content of organic matter than most of the other soils of the area.

At a depth ranging from 10 to 20 inches the surface soil in most places grades into light grayish-brown material containing less organic matter and lime, which is friable and of about the same texture and consistence as the surface soil. The lower part of the subsoil may be noncalcareous and somewhat mottled with rusty-brown stains, owing to an earlier condition of poor drainage.

The Foster soils are recent alluvial soils occupying alluvial fans or flood plains. The soil material has had its source in granitic rocks and has been accumulated under restricted drainage, accompanied by a high water table and a growth of moisture-loving plants. Drainage now is excellent in most places, owing to the lowering of the water table by pumping for irrigation. These soils occupy gently sloping areas, are generally free from erosion, but locally are in some danger of overflow.

The native vegetation originally consisted of grasses, willows, cottonwoods, oaks, and brush, but nearly all of the land has been cleared and the soils now are farmed to alfalfa, cotton, corn, and several other crops. In some places these soils contain small quantities of so-called black alkali.

Southwest of the city of Visalia, the Foster soils are associated with the Chino soils, from which they differ in having more friable and less calcareous subsoils. They apparently represent a younger stage in development than the Chino soils.

Foster sandy loam, Foster fine sandy loam, Foster fine sandy loam, shallow phase (over Fresno soil material), and Foster loam are mapped in this area. With the exception of the fine sandy loam, shallow phase (over Fresno soil material), they are excellent soils (where free of salts) for the production of alfalfa and general crops.

Foster sandy loam.—The surface soil of Foster sandy loam is dull brownish-gray slightly calcareous micaceous sandy loam, although in places the texture is as coarse as a loamy sand. When wet the surface soil is dark gray or nearly black. At a depth ranging from 14 to 20 inches, the soil material is not so dark but is light grayish-brown or light brownish-gray sandy loam, coarse sandy loam, or fine sandy loam. The material in this layer is calcareous, but it becomes less calcareous at a depth ranging from 5 to 6 feet, where it generally is sandy loam and in places is mottled with rusty-brown or yellow stains. The material shows no compaction to a depth of more than 6 feet, as it is a fairly recent deposition from the Kaweah River.

Owing to the fairly high content of sand, this soil is very easy to manage, absorbs moisture well, and has a fairly good water-holding capacity. Roots can penetrate to a great depth. Typically, the soil contains practically no salts but contains sufficient lime for the growth of lime-loving crops. The organic-matter content is fairly high, and the supply of mineral plant nutrients seems to be good. This soil occupies smooth, gently sloping alluvial fans, and it is easy to irrigate and till. Drainage is excellent, but at one time the underground water was so close to the surface that agriculture was limited to grasses and shallow-rooted crops.

Foster sandy loam is scattered over the alluvial fan of the Kaweah River, chiefly northeast and west of Tulare, southwest of Goshen, and southwest of Visalia, in association with Foster fine sandy loam and the soils of the related Cajon series, from which it differs in its darker color.

Nearly all of this soil is farmed to alfalfa and general field crops, for which it seems to be well suited. It is an excellent soil for alfalfa, which yields from 6 to 9 tons an acre in places where water is available for irrigation. Most of the alfalfa is used as feed for dairy cattle.

Foster fine sandy loam.—Foster fine sandy loam has a calcareous and highly micaceous dull brownish-gray or dark brownish-gray surface soil. The texture of the soil varies little but is of uniformly fine smooth silty character. The surface soil becomes darker when wet but dries to a somewhat lighter color than do some of the Foster soils mapped elsewhere in the State. At a depth ranging from 8 to 15 inches, the surface soil grades into light grayish-brown calcareous fine sandy loam that normally contains some brown and yellow mottlings in the lower part. This is a recent water-deposited soil coming from material of granitic origin. The entire soil mass is friable, and the surface soil breaks up somewhat granular when crushed.

Foster fine sandy loam has a very desirable texture for tillage, and it is absorptive and retentive of moisture. No compaction or hard layers exist in the subsoil, and moisture and roots can penetrate it easily. The content of organic matter is moderate, the supply

Vineyard on Hanford sandy loam, near Orosi.

Orange orchard on San Joaquin soil.

of available plant nutrients seems to be good, and the lime content is sufficient for the growth of lime-loving plants, such as alfalfa. Most of the soil is free of soluble salts, and probably less than 10 percent of it carries a slight amount of salts. Most of the salty areas contain a small quantity of so-called black alkali, causing the soil to puddle and bake fairly hard on drying. Alfalfa seems to do fairly well on the areas having a slight concentration of salt, but cultivated crops show the effect of the salty condition.

The land is smooth and favorable to irrigation. The soil originally supported a growth of water-loving grasses, willows, and cottonwood, and had a high water table, but as the water table has been lowered by pumping, drainage now is excellent.

This is the most extensive soil in the area, occupying 6.4 percent of the total land area. Large bodies are on the Kaweah River fan in the vicinity of Visalia. The land is adapted to a wide range of crops. Alfalfa is the most important, but many field crops, grapes, and fruits are grown with success.

Foster fine sandy loam, shallow phase (over Fresno soil material).—Foster fine sandy loam, shallow phase (over Fresno soil material), consists of a 2- to 3-foot layer of typical Foster fine sandy loam deposited on Fresno soil material. The surface soil is dark brownish-gray micaceous calcareous fine sandy loam with a typical Foster subsoil of somewhat lighter colored stratified soil material.

The underlying Fresno material consists of a 1- or 2-foot layer of light-gray calcareous fine sandy loam or loam resting on the lime-cemented Fresno hardpan, which is only partly indurated. The hardpan lenses are 1 or 2 inches thick.

The surface soil is retentive of moisture and easily tilled, but penetration of moisture and roots is limited by the more impervious Fresno soil and hardpan, which underlie this soil. In most places drainage is retarded and salts are accumulated in the lower part of the subsoil, causing the material to have an alkali-spotted appearance.

Areas of this shallow soil occur along the St. Johns River northwest of Visalia in association with Fresno fine sandy loam. In places the soil is variable in texture and is cut by stream channels. Most of it is used for pasture at present. Its use for cultivated crops is governed by the depth to the underlying Fresno soil materials, which contain soluble salts. The deeper areas no doubt could be used, under irrigation, for general field crops.

Foster loam.—The surface soil of Foster loam consists of gray or dark-gray calcareous loam with a comparatively high organic-matter content. The upper subsoil layer is drab grayish-brown friable loam and grades into somewhat lighter colored variably textured sediments, that contain less lime and generally are mottled with brown and yellow rusty stains. This soil consists of recent alluvial-fan material of granitic origin that has accumulated under poor drainage.

This soil absorbs moisture readily, has good water-holding capacity, and is easy to till and irrigate. It contains very little soluble salts, but it is well supplied with lime and other plant nutrients. Drainage now is excellent, but at one time the water table was close to the surface.

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Foster loam is not very extensive. The principal bodies are in the vicinity of Visalia and north of Waukena, associated with areas of other Foster soils.

Alfalfa, cotton, corn, and other field crops, as well as many fruits, give excellent results on this soil. Its present agricultural rating is high.

VISALIA SERIES

The surface soils of members of the Visalia series are dull brownish gray or dull grayish brown, but when moist they appear darker. They are highly micaceous and not calcareous. The soils lack definite structure and break down to a more or less single-grain mass when pressure is applied. The subsoils differ very little from the surface soils except for a lighter grayish-brown or more pronounced color with, in places, a little brown and yellow mottling, and generally a somewhat coarser texture. The line of demarcation between the surface soil and subsoil, which occurs at a depth ranging from 8 to 20 inches, is not very distinct. The substratum is light grayish-brown loose unconsolidated granitic sandy loam, which is essentially identical in its general characteristics to the subsoil. The pH value of both surface soil and subsoil ranges between 7.0 and 7.5.

These soils are recent alluvial outwash from granitic materials in the hills and mountains to the east. They have developed under a cover of grasses and other plants where considerable moisture is present. The native cover consists of grasses, willows, and cottonwood. These soils occupy somewhat lower and flatter alluvial fans than the soils of the related Hanford series, and they were not so well drained in former years, although no injurious quantities of alkaline or saline salts have accumulated.

The Visalia soils were included with the Foster and the Hanford soils in the earlier reconnaissance. They are now recognized as different from the Foster soils in that they are not calcareous, and from the Hanford soils in their darker color, lower position, and less well developed drainage. Visalia sandy loam, together with a shallow phase covering two distinct conditions of subsoil, is mapped in this area.

Visalia sandy loam.—Visalia sandy loam has a surface soil of dull brownish-gray or dull grayish-brown sandy loam that includes considerable coarse sandy material in places. The surface soil material is highly micaceous and does not contain an appreciable quantity of lime. Unweathered fragments of granitic rock, the size of fine gravel and coarse sand, occur through the soil mass. At a depth ranging from 10 to 20 inches the soil material becomes somewhat browner but otherwise differs little from the surface soil. This material continues to a depth of more than 6 feet. Some of the local residents refer to Visalia sandy loam as black granitic alluvium, as it is darker colored than the related Hanford sandy loam.

Visalia sandy loam has a favorable texture for tillage and is not so sticky when wet as are soils containing more clay. Owing to its favorable depth and permeability, it absorbs water readily and is easily penetrated by roots. The organic-matter content is somewhat higher than in the related Hanford soils, and the soil is desirable for a wide range of field crops.

Visalia sandy loam consists of deposits of alluvium along old stream channels where there has been considerable moisture. The smooth surface is favorable to irrigation, and drainage is now excellent. Scattered bodies occur along the eastern margin of the area, the largest along Cottonwood Creek and in the vicinity of Lemoncove. This soil is not so extensive as Hanford sandy loam.

Visalia sandy loam is used, under irrigation, for a wide variety of crops, including citrus fruits where air drainage is good and likelihood of damage from frost is slight. Grapes and deciduous fruits are grown on the lower areas. This soil is adapted to the production of alfalfa, truck crops, and field crops, but where climatic conditions are favorable it is used for citrus fruits, some of the largest yields of which are reported on this soil, and the trees are vigorous and long-lived. Less fertilizer is used than on the other soils of the area.

Visalia sandy loam, shallow phase (over San Joaquin soil material).—Visalia sandy loam, shallow phase (over San Joaquin soil material), consists of a superficial alluvial deposit of Visalia sandy loam material over an older subsoil similar to that of the San Joaquin soils. It has a 1- to 4-foot layer of typical dull brownish-gray micaceous sandy loam soil underlain by reddish-brown San Joaquin soil of sandy loam or loam texture, which, in turn, at a depth ranging from 2 to 6 feet below the surface, rests on the red hardpan characteristic of the San Joaquin soils. In places the surface soil is fine sandy loam. The surface configuration, slope, tillage properties, water-holding capacity, and general fertility of this soil are very similar to these features of typical Visalia sandy loam, but subdrainage is restricted by the buried San Joaquin hardpan. Where not cultivated, the land supports a cover of native grasses.

The largest bodies of this character occur on the outer margin of the alluvial fill of Cottonwood Creek, where it joins with the San Joaquin soils, and along Yokohl Creek north of Merryman. This soil is not very extensive.

The areas of deeper soil of this character are used for essentially the same crops as is typical Visalia sandy loam. In areas where the San Joaquin hardpan is closer to the surface, the soil does not have quite so wide an adaptation, especially for field crops or deciduous fruits. A considerable acreage of it is devoted to grapes, with very good results.

Along the St. Johns River southeast of the Venice Hills is a small included area, which has a surface soil of dark brownish-gray micaceous noncalcareous sand or fine sand, resting on the San Joaquin hardpan soil at a depth ranging from 2 to 3 feet. It supports a cover of willows, saltgrass, and other native grasses and at present is used for pasture. Owing to its coarse texture, danger of overflow, and channel-cut surface, this area has very little value, if any, for the common cultivated crops.

Visalia sandy loam, shallow phase (over Fresno soil material).—The areas of Visalia sandy loam, shallow phase (over Fresno soil material), have a 2- to 5-foot layer of micaceous dark brownish-gray fine sandy loam that rests on unrelated material of the Fresno soils. The lower part of the Visalia material, in most places, is a 12- to 20-inch layer of calcareous gray or light-gray fine sandy loam or clay loam, which rests directly on the Fresno type of only partly indurated calcareous hardpan. The surface soil is distinctly an overwash of Visalia material. It is smooth, permeable, retentive of moisture, and fertile, but the lower part of the subsoil absorbs water very slowly, owing to the compact and cemented Fresno hardpan layer. A condition of poor drainage may develop if the land is heavily irrigated. In most places the lower part of the subsoil contains some salts, which may accumulate in injurious quantities.

The largest area of this character is about 2½ miles southeast of Tulare, and smaller ones are near Prairie Center School and about 4 miles northwest of Visalia. These bodies occupy a combined area of 2.6 square miles. Nearly all of the land is in field crops. Cotton yields about 1 bale an acre.

HONCUT SERIES

The Honcut soils range in color from light brown in the sandier types to brown or reddish brown in the heavier textured types. The surface soils are friable, are easily tilled, and offer no obstructions to the penetration of roots or moisture. They contain a fair to low amount of organic matter, and their reaction is mildly basic (pH 7.2 to 8.0), though they are not calcareous. The subsoils generally are slightly redder or lighter in color than the surface soils, and in the loam and silty clay loam types they are, for the most part, slightly heavier textured and slightly compact. The heavier textured soils show evidence of some colloidal accumulation, owing to development of a soil profile, and the materials break into angular clods or blocks. The subsoils are mildly basic (pH 7.5 to 8.0) but not calcareous. The soil material continues to a depth of 7 to 8 feet with very little change.

The Honcut soils have their source in alluvial outwash from the hills occupied mainly by basic igneous rocks and the Las Posas soils. They occupy sloping alluvial fans in small valleys in the hills bordering the main valley area. Here and there, the narrow valleys are subject to a certain amount of cutting and filling during heavy storms. Drainage in most places is good and in some places on the steeper alluvial fans is excessive.

The native cover consists of grasses and possibly included some oaks at one time, but the land is now treeless.

The Honcut soils were included with the Hanford soils in the mapping and classification of the earlier reconnaissance because of their relatively small extent. Honcut sandy loam, with a gravelly phase, Honcut loam, and Honcut silty clay loam are mapped.

Honcut sandy loam.—The surface soil of Honcut sandy loam is light-brown friable sandy loam, which in some places contains a little gravel but not enough to decrease the water-holding capacity. The surface soil grades into the subsoil without any marked change in color, texture, or degree of compaction. The substratum consists of loose unconsolidated sandy loam, together with some gravel. Very little mica or quartz is in the soil material.

This soil is easily tilled and absorbs and retains moisture well. It is not calcareous but has a mildly basic reaction (pH 7.2 to 7.7). It has a fair content of organic matter, seems to be well supplied with plant nutrients, and shows no evidence of accumulated salts.

It occupies smooth, gently sloping, alluvial fans and is irrigated easily. Both surface drainage and subdrainage are excellent.

The town of Lindsay is surrounded by an area of this soil, about 2½ square miles in extent, all of which is in citrus fruits. Yields of citrus fruits are among the highest on any soil in the area, and from 150 to 300 packed boxes of navel oranges are obtained under good cultural practices. Many citrus groves on this soil are from 35 to 40 years old. The fertility of the soil is maintained by the use of barnyard manure, together with applications of ammonium sulfate or other nitrogenous fertilizers. An application of about 5 pounds of ammonium sulfate, representing 1 pound of nitrogen, to each tree is recommended. Most growers of citrus fruits grow cover crops of mustard and weeds, which they plow or disk into the soil.

Honcut sandy loam is also an excellent soil for a wide range of other orchard fruits, grapes, and field crops, in places where irrigation water is available. A small area of Honcut sandy loam in Frazier Valley east of Strathmore is used for pasture.

Honcut sandy loam, gravelly phase.—The gravelly phase of Honcut sandy loam has a surface soil of light-brown gravelly sandy loam or, in places, gravelly sand. The subsoil and substratum are of similar or coarser texture. The material, which is of very recent deposition, occurs along present stream channels, and its source is mainly from fine-grained rocks, such as amphibolites. This soil is low in organic matter and is very leachy.

The land is subject to overflow and erosion, and, owing to its unfavorable position and coarse texture, has no agricultural value at present, except for pasture. It supports a native growth of cottonwood and sycamore, together with some grasses.

Bodies border Limekiln Creek north of Lemoncove and Lewis Creek east of Lindsay. The total area is very small.

Honcut loam.—Honcut loam has a surface soil of rich-brown loam, which is underlain, at a depth ranging from 15 to 28 inches, by reddish-brown slightly compact clay loam or loam. At a depth of 4 to 6 feet the soil material consists of variably textured alluvium extending to an undetermined depth. The soil contains a small quantity of flat schistose rock fragments, which do not interfere materially with cultivation or lower the water-holding capacity. In some places the subsoil is redder and more compact than typical and has developed a blocky structure, with considerable colloidal staining on the faces of the structural aggregates.

This soil absorbs water readily and is easily tilled. Most of the bodies occur as sloping alluvial fans in narrow canyons along the margins of the foothills. They are subject to overflow and erosion during storm periods. Two bodies east and south of Lindsay are not subject to overflow or erosion, and some of the best citrus orchards in the area are located on them. Where protected from overflow and erosion and irrigated, Honcut loam is an excellent soil for a wide range of crops.

Honcut silty clay loam.—The surface soil of Honcut silty clay loam is rich-brown or, in some places, pronounced reddish-brown noncalcareous silty clay loam, which in most places contains a few schistose gravel fragments. At a depth ranging from 15 to 24 inches, the subsoil material becomes slightly compact and breaks into irregular-shaped blocks. This material is light reddish brown and shows some evidence of a slight colloidal accumulation. Neither the surface soil nor subsoil contains appreciable quantities of lime or soluble salts, although the soil material is basic in reaction.

Honcut silty clay loam occupies sloping alluvial fans in small valleys and ravines along the foothills. A good cover of grass springs up following rains. Moisture is absorbed fairly readily, although run-off is considerable and some erosion follows heavy rains, owing to the slope and the run-off from surrounding hills. Where protected from erosion, Honcut silty clay loam is adapted to a fairly wide range of crops under irrigation. A number of excellent citrus orchards border the valley, where irrigation water is available and the danger from frost is slight.

Honcut silty clay loam is associated with the Las Posas soils in small narrow areas, the largest of which are east of Exeter and Lindsay and in the vicinity of the Venice Hills.

The soil in a small body of Honcut silty clay loam 2 miles east of Woodlake and in two small bodies 3½ miles northeast of Strathmore differ from the typical soil in having a heavier texture. These areas represent undifferentiated areas of Honcut clay. The surface soil in this inclusion is brownish-red or dark chocolate-brown noncalcareous clay, and the subsoil is brownish-red fairly compact noncalcareous clay. The surface of these included areas is smooth, and the land is easy to irrigate, but, owing to the heavy texture, the soil absorbs water slowly. Citrus fruits are grown with good results, but some of the other crops do not respond so well, owing to the heavy texture of the soil.

GREENFIELD SERIES

The surface soils of members of the Greenfield series are light brown or brown. The brown color is intensified when the soils are wet. They are extremely friable when moist but bake to some extent on drying. They absorb water readily, are easy to till, and are easily penetrated by plant roots. Sharp angular quartz and feldspar fragments and flakes of mica are conspicuous. The organic-matter content is low. The soils are not calcareous but have a pH value of 7.0 to 7.5. The subsoils, which begin at a depth ranging from 20 to 28 inches, are slightly compact, are a lighter reddish brown or lighter yellowish brown, are only slightly heavier textured than the surface soils, and are readily penetrated by moisture and roots. The subsoils are not calcareous but have a pH value of 7.0 to 7.5. When broken out, the soil material takes the form of irregular-shaped lumps that can be pulverized easily. The lower part of the subsoils, beginning at a depth ranging from 40 to 50 inches, are light-brown friable micaceous noncalcareous sandy loam.

The Greenfield soils are developed on alluvial materials washed from the Vista soils and the granitic hills to the east and redeposited on broad alluvial-fan slopes. Erosion is not a problem on these soils because of the very gentle slope and sandy texture. Run-off is slight, and rainfall is readily absorbed. Subdrainage in most places is excellent, and no injurious quantities of salts have accumulated.

The native vegetation consisted of live oaks, shrubs, and grasses. All these have been removed, and now all the land is in orchards, vineyards, and other intensive crops.

The Greenfield soils apparently represent a young stage in soil development, midway between that of the Hanford and Ramona soils. Their subsoils are more compact than those of the Hanford soils but do not have the dense heavy texture of those of the Ramona soils. In the earlier reconnaissance the Greenfield soils were included in mapping, to a considerable extent, with the Madera soils, owing to the fact that in many places the soil rested on a hardpan. Such areas have been differentiated in this area as a shallow phase of Greenfield sandy loam. The Greenfield soils normally are productive and are suited to a wide variety of crops, but Greenfield sandy loam, shallow phase, is somewhat restricted in its uses.

Greenfield sandy loam.—The surface soil of Greenfield sandy loam is light-brown or brown friable noncalcareous sandy loam that contains considerable mica and sharp angular particles of quartz and feldspar. The subsoil, at a depth ranging from 20 to 28 inches, becomes slightly compact, light reddish brown, and somewhat heavier textured than the surface soil. The parent material, beginning at a depth ranging from 40 to 50 inches, is highly micaceous sandy loam, and in most respects it appears very similar to the surface soil. This soil is spoken of as granitic alluvium because it has its source in granitic rocks and occurs as a deposit of alluvium.

The texture of this soil is favorable to tillage operations. The soil absorbs and holds water well, and, owing to the favorable depth and the consistence of the subsoil, water and roots penetrate the lower layer easily and freely. The chemical reaction is slightly basic. The organic-matter content is low, and, for intensive crops, heavy applications of barnyard manure would be beneficial. Both surface drainage and subdrainage are excellent, and salts have not accumulated in injurious quantities.

Practically all of this soil is farmed, under irrigation, to a wide variety of crops. Raisin grapes of the Sultanina variety are grown on the largest acreage and yield from 1.5 to 2 tons of raisins an acre. Other crops that give excellent results are peaches, figs, prunes, truck crops, and alfalfa. The soil is excellent for citrus fruits, but it is situated where the danger from frost is a deterrent to growing such fruits.

This soil is extensive. Most of it is south of Smith Mountain in the vicinities of Dinuba and Sultana.

Greenfield sandy loam, shallow phase.—The surface soil of Greenfield sandy loam, shallow phase, is identical with that of typical Greenfield sandy loam; that is, it is light-brown micaceous noncalcareous sandy loam. At a depth ranging from 20 to 28 inches, the soil material changes to reddish-brown slightly compact fine sandy loam or loam. This rests on a brown hardpan at a depth ranging from 2 to 4 feet and averaging about 3 feet. The hardpan is cemented by silica and iron, but it contains seams of lime carbonate. It is similar in most respects to the hardpan of the Madera soils, but in probably 25 percent of the area it seems to be harder than the Madera hardpan and approaches the San Joaquin hardpan. This hardpan ranges from 4 to 16 inches in thickness with a probable average thickness of 8 inches. Below the hardpan is light-brown or light yellowish-brown sandy loam, which has a fairly massive structure in places but can be crushed easily in the fingers. The material of this layer, which ranges from 12 to 30 inches in thickness, is calcareous in most places. Below this there is another hardpan layer. Well pits show the hardpan layers, with alternating layers of softer soil material, extending to a depth ranging from 30 to 40 feet. This shallow soil is associated with typical Greenfield sandy loam and represents an overwash of young alluvium giving rise to Greenfield sandy loam over an older eroded hardpan soil.

In regard to tillage, water-holding capacity, fertility, and organic-matter content, this soil is similar to typical Greenfield sandy loam, but subdrainage is restricted somewhat by the hardpan, which retards the penetration of water and causes a high water table when excessive quantities of irrigation water are used.

The largest areas of this soil are in the Dinuba, Monson, and Cutler districts, where the principal crops are grapes, especially of the Sultanina and muscat varieties, in addition to Alicante Bouschet and Zinfandel wine grapes and table grapes of the Malaga and Emperor varieties. South and west of Lindsay, areas of this soil are used for the production of citrus fruits and table grapes. The value of this soil for field crops, such as alfalfa and cotton, is governed by the depth to the hardpan. A few acres of these crops are grown in places where the hardpan lies at a depth ranging from 4 to 5 feet and where irrigation water can be obtained at a low cost. Deciduous fruits, such as peaches, do well on the deeper areas of this soil.

FARWELL SERIES

The Farwell soils have brown or rich-brown surface soils that contain a moderate quantity of organic matter, are, for the most part, granular and friable, and are underlain by subsoils of similar or lighter brown color, which are distinctly calcareous. The subsoils are permeable, slightly compact, and but slightly, if at all, heavier in texture than the surface soils. These are young alluvial soils occupying smooth alluvial-fan slopes. The parent materials are derived mainly from basic igneous rocks.

Farwell fine sandy loam.—The surface soil of Farwell fine sandy loam is brown friable noncalcareous fine sandy loam to a depth ranging from 12 to 30 inches. It grades into a light grayish-brown slightly compact calcareous fine sandy loam subsoil that extends to a depth of more than 6 feet.

This soil is associated with Honcut sandy loam and Honcut loam along Lewis Creek. Three bodies west of Lindsay are planted nearly exclusively to citrus trees. The soil in an area about 3½ miles east of Lindsay has a slight content of soluble salts.

This soil is easy to till and to irrigate, owing to its favorable position and texture, but it does not have so high an agricultural value as the Honcut soils, because some salts are present in places in the lower part of the subsoil.

CHINO SERIES

The 10- to 12-inch surface soils of members of the Chino series are dull brownish gray or dull gray, micaceous, and calcareous, although in a few areas the content of lime is low. The soils are dark when wet, generally dark gray, and they break to a cloddy or fine-granular tilth. When dry the clods appear lighter in color than when the material is crushed. The organic-matter content is only moderate. The upper part of the subsoils is dark brownish gray or dull gray, slightly or moderately compact, and somewhat heavier textured than the surface soils. When wet it is dark gray. The material breaks into irregular-shaped blocks that are somewhat cubical. Lime occurs in soft nodules and in seams. This layer ranges from 15 to 20 inches in thickness. The material grades into light brownish-gray or light yellowish-gray highly calcareous material, which is fairly soft, owing to the higher lime content. It is of about the same or slightly lighter texture than the material in the overlying layer. It extends to a depth ranging from 40 to 50 inches where it grades into light-brown or light grayish-brown friable soil material mottled with rusty iron stains. The lime content decreases with depth.

These are young alluvial soils developed from granitic material. They occupy comparatively flat or gently sloping alluvial fans that originally had a heavy cover of grasses and valley oaks. Until about 20 years ago the ground water table was close to the surface, but it now stands at a depth ranging from 30 to 80 feet, and drainage conditions are improved. All the land is now in crops, mainly cotton, alfalfa, corn, and general field crops. In some places salts are present in slight quantities or in spots, and slick spots containing black alkali, or sodium carbonate, occur here and there. These soils are associated with the Foster soils, from which they differ in having older, heavier textured, and more compact subsoils with accumulated lime. Chino fine sandy loam, Chino sandy loam, Chino silty clay loam, Chino clay loam, and Chino clay loam, shallow phase (over Fresno soil material), are mapped in this area.

Chino fine sandy loam.—The surface soil of Chino fine sandy loam is dull brownish-gray calcareous highly micaceous fine sandy loam, which when wet is decidedly gray or dark gray. At a depth ranging from 10 to 24 inches, this material changes to dark brownish-gray (dark-gray when wet) calcareous slightly compact loam or silty clay loam, in which lime is segregated in soft nodules and seams and in old root channels. The material in this layer breaks into irregular-shaped blocks. Below this, in most places, is a transitional zone of light brownish-gray uniformly calcareous slightly compact loam, which has a massive structure and ranges from 20 to 30 inches in thickness. The underlying parent material is light-brown or light yellowish-brown friable fine sandy loam or sandy loam, of granitic origin. Rusty-brown stains are numerous in most places. The lime content decreases with depth, and in places lime is lacking at a depth of 6 feet. Chino fine sandy loam is a youthful soil developed on alluvial-fan material accumulated under conditions of poor drainage and derived from granitic sources.

Texturally this soil is ideal. The surface soil holds a fairly large quantity of water, and the land is easy to till and irrigate. The heavier textured subsoil holds considerable moisture but has a slight tendency to retard its penetration. The surface soil is somewhat variable in its content of lime, but everywhere lime is sufficient for lime-loving crops. The organic-matter content is somewhat higher than in most of the soils of the area, with the exception of the Foster soils. This soil seems to be well supplied with plant nutrients and generally is practically free of injurious soluble salts, although in a few places the subsoil carries sufficient salts to retard the growth of crops. Such areas should be planted to salt-tolerant crops, as it is very difficult to remove the salts from the heavy-textured subsoil by leaching.

Chino fine sandy loam occupies smooth alluvial fans, and practically no leveling is needed for irrigation. Drainage is now good, as the water table, which stood close to the surface about 25 years ago, has been lowered by pumping. This soil is associated with the Foster soils on the lower end of the Kaweah River delta, where it occupies a somewhat lower elevation. The largest bodies are southwest of Visalia, in the vicinities of Tulare and Tagus. A large area about 2 miles south of Goshen includes spots in which the subsoil is somewhat lighter textured than typical. Small ridges of sandy loam texture, too small to separate on a map of the scale used, occur in this vicinity.

Chino fine sandy loam is an excellent soil for alfalfa, cotton, and other general field crops. Yields of alfalfa and cotton are high. The acreage of grapes and deciduous fruits is small, but good yields are obtained.

Chino sandy loam.—Chino sandy loam is very similar to Chino fine sandy loam except that it has a surface layer, ranging from 10 to 30 inches in thickness, of grayish-brown or brownish-gray highly micaceous coarse sandy loam that is very slightly calcareous. Below this is the highly calcareous and generally heavier textured subsoil. The lime is segregated in soft nodules and in seams. The lower part of the subsoil and the substratum are lighter in color and texture and contain less lime than the upper part of the subsoil and in most places are mottled with rusty iron stains. Owing to its coarser texture, this soil contains less organic matter and holds considerably less moisture than Chino fine sandy loam. Most of it is free of soluble salts, and drainage is excellent.

A small body of this soil lies west of Tulare, adjoining an area of Chino fine sandy loam on a slightly elevated ridge. In this district the surface layer appears to consist of overwash. One area about 2 miles southeast of Lind Cove has a lighter textured subsoil, and parts of it are spotted with salts.

Chino silty clay loam.—The surface soil of Chino silty clay loam is gray calcareous loam, which is darker colored when wet but appears fairly light-colored when viewed across a field. The surface soil breaks up fairly granular and is darker when crushed. At a depth ranging from 15 to 24 inches, the subsoil consists of dull-gray slightly to moderately compact clay loam or silty clay loam, with lime segregated in soft white nodules and in large seams. This material dries to a lighter color than the surface soil and breaks into cubical aggregates. At a depth of about 30 inches the subsoil is pale yellowish-gray highly calcareous silty clay loam or silty loam. This material is not so compact as the overlying material, and the calcium carbonate is more evenly distributed than it is in the overlying material. This layer grades into a light grayish-brown fairly friable and permeable fine sandy loam or sandy loam substratum, in which the lime content decreases with depth. Considerable rusty-iron mottling occurs at the lower depths. Chino silty clay loam is developed on granitic alluvial-fan or flood-plain materials under restricted drainage.

Chino silty clay loam has a moderately high water-holding capacity and is easy to till. The subsoil has a high water-holding capacity but, owing to its compaction, has a tendency to retard the absorption of moisture to some extent. The organic-matter content of this soil is relatively high in comparison with other soils of the area. The soil is free of injurious concentrations of soluble salts, except in a few small spots. Here the soil is light-colored, bakes hard on drying, and is very slowly penetrated by moisture. Considerable sodium carbonate, known as black alkali, occurs in these white spots. Heavy applications of sulfur or gypsum will help to increase permeability of the soil, so that the salts can be washed out more readily. The surface is smooth, and most of the land is easy to irrigate and till. The water table is now well below the root zone, although at one time it was at so slight a depth that only shallow-rooted crops could be grown successfully. Many of the native oak trees are dying as a result of the lowered water table.

Chino silty clay loam is extensive in the lower end of the Kaweah River delta in the southwestern part of the area. A large area is northeast of Goshen, and scattered bodies are farther east on the delta and in the vicinity of Prairie Center School.

Most of this soil is in alfalfa, cotton, corn, sorghums, and other field crops, for which the soil rates high. Under good cultural practices high yields of all these crops can be obtained under irrigation.

Chino clay loam.—The surface soil of Chino clay loam is gray or dull-gray clay loam or heavy clay loam that generally is not calcareous, although it contains an abundance of available calcium. It appears dark gray or black when wet, but when crushed in the dry state it is fairly light-colored. The material is rather granular when moist, but when dry hard clods are formed. Below a depth ranging from about 14 to 20 inches, the subsoil is light brownish-gray moderately compact clay loam with a high concentration of lime in the form of soft white nodules and in seams. The soil breaks into angular blocks of somewhat cubical shape. This material grades into a browner soil material which is lighter textured and in which the lime is more evenly distributed. The substratum consists of light-brown or brown mottled variably textured alluvial sediments that are noncalcareous in places at the lower depths.

Chino clay loam is very easy to till under optimum moisture conditions, but it is fairly sticky when wet and plows up cloddy when air-dry. The subsoil absorbs water slowly, and care must be used in irrigation, in order that the moisture may penetrate to sufficient depth.

The organic-matter content is relatively high, in comparison with the other soils of the area, and the general fertility and content of plant nutrients are considered high. Injurious accumulations of soluble salts are not present. The very smooth surface is favorable to tillage and irrigation. Drainage is now good. Native oaks are dying as a result of the lowered water table, which was close to the surface at one time.

Chino clay loam is associated with the other Chino soils on the lowest parts of the Kaweah River delta. It is most extensive in the district between Waukena and Paige in the extreme southwestern part of the area, but isolated bodies are north of Visalia on Elbow Creek, east of Tulare, and in the vicinity of Prairie Center School.

A few spots have the heavier textured subsoil of Chino clay loam, shallow phase (over Fresno soil material), especially where areas of the typical soil adjoin areas of the shallow phase. Two small bodies, in which the texture of the surface soil is clay, are about 2 and 3 miles southwest of Paige. These would be mapped as Chino clay, had they been more extensive.

To a considerable extent Chino clay loam is now used for the growing of cotton, yields of which range from 1½ to 2½ bales an acre. Alfalfa yields from 6 to 7 tons, and corn, sorghums, and other field crops do well. Fruits are not grown generally, owing to the low position of the land and consequent danger of frost.

Chino clay loam, shallow phase (over Fresno soil material).— The surface soil of Chino clay loam, shallow phase (over Fresno soil material), consists of dark-gray noncalcareous or very slightly calcareous clay loam or silty clay loam, which is fairly well filled with roots, relatively high in organic matter, and of medium-granular structure. The upper subsoil layer begins at a depth ranging from 10 to 20 inches and consists of light brownish-gray or dull brownish-gray moderately calcareous only slightly compact clay loam. The next lower layer, beginning at a depth ranging from 20 to 24 inches, is light brownish-gray compact clay loam having a heavy accumulation of lime in large nodules and seams. This material breaks down into small cubes ranging from ½ to 2 inches in diameter, which are fairly hard when dry. At a depth ranging from 3 to 5 feet, this material, in turn, rests on light-gray compact semi-cemented, or moderately cemented, lenses of calcareous hardpan alternating with layers of more friable soil material. This hardpan is very similar to that underlying the Fresno or Lewis soils.

The high water-holding capacity and organic-matter content of the surface soil is very desirable for general crops, but the compact subsoil restricts the penetration of water and the extension of plant roots. The lower part of the subsoil in places contains sufficient salts to develop a dangerous condition if allowed to accumulate at the surface.

The shallow phase (over Fresno soil material) of Chino clay loam occupies smooth alluvial flood plains that are cut by many sloughs, and small areas are subject to flooding in years of heavy rainfall. The original swampy condition has been corrected by the pumping of underground water for irrigation.

Areas of this soil border the St. Johns River northwest of Visalia, Cottonwood Creek southwest of Seville and Yettem, and Elk Bayou and Outside Creek east of Tulare. More than 80 percent of the soil is uncleared of its original cover of oaks and grass and is still being used for pasture, and some native grass is cut for wild hay. Where floodwaters are available from the various creeks, the pastures are irrigated in late spring or early summer, with good results. Good yields of cotton, corn, and other field crops are obtained on the better areas. There are some good fields of alfalfa, but in most places the stand is not so long-lived as on the Foster, Cajon, Tujunga, or Hanford soils.

SOILS DEVELOPED ON WIND-MODIFIED ALLUVIAL-FAN MATERIALS

West of Dinuba is a small body of soils developed on wind-modified alluvial-fan materials. These soils are classified as members of the Delhi series. Their parent material is very similar to that of the Tujunga soils with which they are associated.

DELHI SERIES

The members of the Delhi series have light grayish-brown or brown surface soils, which are darker brown when wet. They have a coarse texture, contain very little colloidal material, break into a single-grain structure, are friable and easily tilled, and absorb water readily. They are of mixed mineralogical character but contain much material of granitic origin, as indicated by the large proportion of quartz and mica particles. The sand grains are subangular or rounded and contain from 10 to 15 percent of black grains, which can be drawn out by means of a magnet. The soils have a very low organic-matter content and are not calcareous but are of slightly basic reaction. The surface soils range from 12 to 20 inches in thickness. The upper subsoil layers are somewhat browner than the surface soils, generally slightly compact, but of sandy texture and permeable. They are noncalcareous and in general are otherwise similar to the surface soils. The lower subsoil layers, at a depth ranging from 36 to 48 inches, are moderately compact and consist of brown loamy sand or sand containing yellow or reddish-yellow mottled seams or streaks. When dug out, the lumps can be pulverized in the fingers. This material is noncalcareous and is low in organic matter. It extends to an undetermined depth.

The Delhi soils consist of wind-modified alluvial deposits that probably represent materials of the Hanford, Tujunga, and Greenfield soils, which were moved by the wind into ridges of undulating to dunelike form. Most of these have been leveled to some extent, and the surface is now gently undulating or fairly smooth, although some slight movement by wind must be guarded against. Water erosion is not active, except during heavy rains when some washing takes place on the unleveled spots, but this generally is an advantage rather than a detriment. Most of the rainfall is absorbed so that run-off is slight. Owing to the deep sandy character of the soil, drainage is excellent in most places, and no salts have accumulated.

The native vegetation consisted of grasses and low shrubs, but most of the land is now cleared and devoted to crops.

These soils were included with the Oakley soils in the earlier reconnaissance. Delhi loamy sand is the only type of the Delhi series mapped in this area.

Delhi loamy sand.—Delhi loamy sand conforms essentially to the soils of the Delhi series as described. As it is sandy and contains only a small percentage of the finer soil particles, the soil can be tilled under practically all moisture conditions. The lower part of the subsoil is slightly to moderately compact, but moisture and roots penetrate the soil to a good depth. It absorbs water very readily but is a very poor soil for dry farming because of its low water-holding capacity. The content of organic matter is low, but the supply of mineral plant nutrients seems to be good. For best results in the growing of intensive crops, such as truck crops, the content of organic matter and nitrogen should be built up by incorporating large quantities of manure. This soil does not contain injurious concentrations of salts.

The relief is gently undulating in most places, owing to previous action by the wind. This does not materially affect tillage or irrigation, although some care should be used, in order that gullies may not start, in allowing irrigation water to run in large streams down the faces of the slopes. Some movement of the soil by wind occurs in places where the land is barren of vegetation or if it is plowed during windy periods.

About 3.8 square miles of Delhi loamy sand are mapped in a strip extending from the Fresno County line in a southwesterly direction about 2 miles west of Dinuba and in an area in the vicinity of Kings River School about 3½ miles east of Kingsburg. Probably 75 percent of this soil is planted to varieties of muscat and Sultanina grapes, which are used for raisins, shipped fresh as table grapes, and used to less extent for juice. The soil seems well adapted to raisins and yields from 1 to 2 tons an acre. Other crops well adapted to this soil are melons, sweetpotatoes, and peaches. Truck crops and alfalfa are grown on a small acreage.

SOILS DEVELOPED ON OLDER ALLUVIAL-FAN MATERIALS

Soils developed on older alluvial-fan deposits, which have undergone considerable change by soil-development agencies accompanied by the formation of fairly compact heavier textured subsoils are represented by members of the Porterville, Hovey, Dinuba, and Ramona series. The Porterville soils have chocolate-brown surface soils and compact subsoils with a high accumulation of lime. The Hovey soils have profiles similar to the Porterville soils but are dark gray. The soils of both series are developed from parent materials composed of outwash from fine-textured basic igneous rocks. The Dinuba series includes light-gray soils with moderately dense calcareous subsoils containing silty calcareous hardpan lenses at a depth ranging from 4 to 6 feet below the surface. The parent material is alluvial outwash of granitic origin. The Ramona soils are brown soils with compact brown subsoils and are developed on granitic materials. Owing to their heavier textures and compact subsoils, the soils of this group are not so desirable for a wide range of crops as most of those in the groups previously described.

PORTERVILLE SERIES

The surface soils of members of the Porterville series are dark chocolate brown or dark rich reddish brown and are heavy textured. They range in thickness from 8 to 24 inches. They have a typical adobe structure and shrink on exposure to dry weather, forming blocks from 12 to 16 inches in diameter. These blocks are broken down progressively by secondary cracking, in the upper 4 to 8 inches, into small angular fragments, resulting in a loose structural condition, which causes the soil material to sink under foot. This condition is locally referred to as dry bog. These soils absorb water fairly readily, considering their heavy texture, and they granulate easily when water is applied. If puddled by tillage when wet the surface soils form dense hard blocks on drying, which are difficult to break. The surface soils are basic in reaction and in some places slightly calcareous. They have a low organic-matter content.

The subsoils are dark chocolate brown or dull reddish brown, but they contain gray soft nodules of accumulated lime. The heavy texture is masked by the flocculating effect of the lime. The material breaks into large blocks but lacks the secondary breakage of the material in the surface soil. The lime content increases with depth. The lower subsoil layer generally is reddish-brown or yellowish-brown highly calcareous clay. The material in the upper part of this layer breaks into cubes from 1 to 2 inches in diameter, and that in the lower part, which is very highly calcareous, in places is grayer and lacks any definite form of breakage. In some places the lower part of the subsoil, at a depth ranging from 4 to 6 feet, consists of soft marly material. Moisture penetrates the subsoils fairly well, considering their heavy texture, but roots do not go very deep, which may be due to the high concentration of lime.

Soils of the Porterville series are developed on transported alluvial-fan and valley-slope materials that are derived from basic igneous rocks. The surface soils are basic in reaction, and the subsurface layers are highly calcareous. These soils seem to be developing toward a profile with a lime-cemented hardpan similar to that of the Seville soils. They occupy alluvial or colluvial slopes just below steep hills that are underlain by fine-textured basic igneous rocks and occupied by the Lassen soils. The surface configuration ranges from smooth but fairly steep slopes at the bases of the hills to very smooth and relatively flat terraces in the lower areas, where most of these soils are bordered by soils of the San Joaquin series, to which they bear no relationship.

The native vegetation consists of grasses and a few shrubs but no trees. Surface run-off may be excessive at the upper margin of the fans and slopes and results in some erosion, but in general erosion is a minor problem. Subdrainage is fairly well developed in most places, considering the heavy texture of the subsoils.

Porterville adobe clay and Porterville adobe clay, stony phase, are mapped in this area. They differ from the related Hovey soils in that they are chocolate brown and occupy better drained fan slopes. The Porterville is an old series of soils recognized in the early detailed and reconnaissance surveys under this name. In this area the included stony bodies, as well as the bodies underlain by hardpan, are differentiated.

Porterville adobe clay.—The surface soil of Porterville adobe clay is dark chocolate-brown clay, has a pronounced adobe structure, and breaks, on drying, into large blocks that range from 12 to 16 inches in diameter and, in turn, with continued drying, the blocks break into small angular fragments and granules. The subsoil is dark chocolate brown and retains the large blocky structure. Lime is accumulated in large gray nodules and becomes more abundant with depth. In most places, the lower part of the subsoil is reddish-brown or yellowish-brown highly calcareous clay, the upper part of which has a somewhat cubical structure, and the lower part is massive. This soil locally is known as dry bog because of the pronounced coarse-granular breakage, which allows an animal walking over it to sink into it even when the material is dry. The parent soil materials have their origin in fine-textured basic igneous rocks.

Porterville adobe clay absorbs water fairly readily and is friable for a soil of such heavy texture when moisture conditions are favorable, but it will puddle if tilled while wet. Some difficulty is experienced in holding irrigation water on the slopes, owing to the porous character of the soil, which allows the water to run through the ridges along the furrows. The subsoil seems to absorb water readily, although few roots penetrate it very deeply, possibly because of the high lime content. It is practically free from injurious soluble salts. The organic-matter content is fairly low. This soil occupies alluvial slopes that are smooth but steep at the upper margins and more gently sloping in the lower parts. Surface drainage is well developed, but internal drainage is retarded by the heavy-textured subsoil.

Porterville adobe clay occurs as a narrow strip ranging from ⅛ to 1 mile in width in a few places along the foot slopes of the "lava hills" bordering the valley on the east. This strip is not continuous, as the granite hills extend out to the valley in a number of places, thereby breaking its continuity.

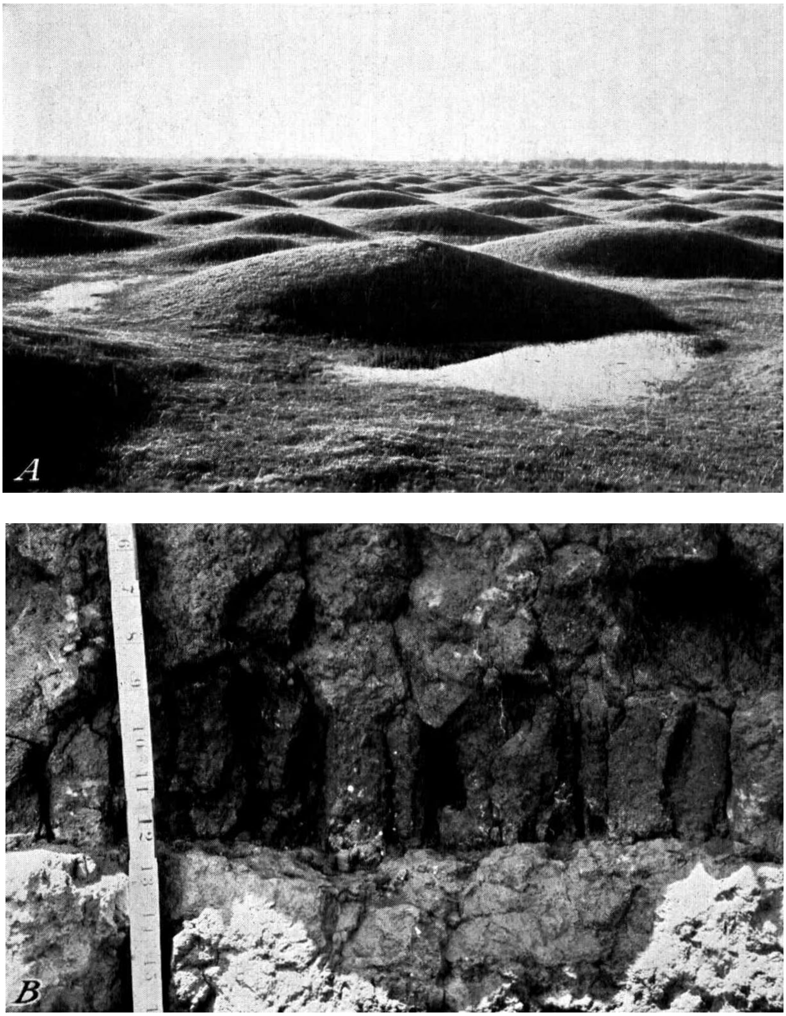
Because of its location in the thermal belt, considerable effort has been put forth in developing water on this soil and planting the land to citrus fruits and winter vegetables, but water is expensive, owing to the high pumping lift, and the available supply often is very deficient. Winter vegetables have given good results, and citrus fruits, olives, and figs are grown where water can be obtained for irrigation, but the heavy texture of this soil and its elevation above the source of available irrigation water, limits its use to a considerable extent. Under the low rainfall of this section, this is not a very good pasture soil.

Porterville adobe clay, stony phase.—The stony phase of Porterville adobe clay is similar to typical Porterville adobe clay, except that fine-textured basic igneous rock fragments, ranging from 2 to 10 inches in diameter, are numerous over the surface and throughout the soil mass. It occupies positions above areas of typical Porterville adobe clay, bordering the rough stony hills or steep alluvial slopes, and the land suffers considerable erosion, owing to run-off from the higher slopes. Bedrock is reached at a slight depth in places where this soil adjoins the hills.

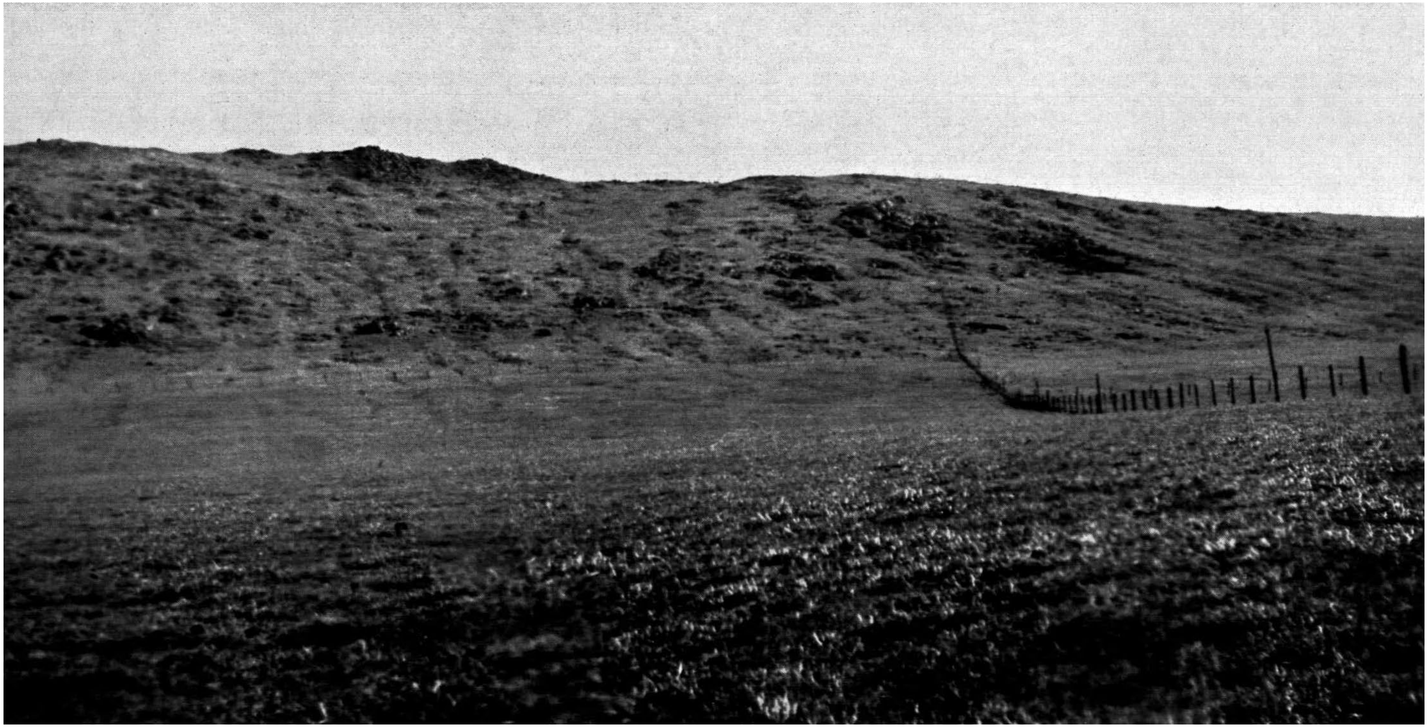
A few areas have been cleared of stones and protected from wash at considerable expense and are not planted to citrus fruits or used for the growing of vegetables, but most of the land is used for pasture. In seasons of high rainfall, the pasture is fairly good.

HOVEY SERIES

The 12- to 24-inch surface soils of members of the Hovey series are dark gray, becoming black when wet, are generally of heavy texture, and have a typical adobe structure. The adobe blocks are broken by secondary breakage into small angular fragments, to a depth ranging from 4 to 8 inches, or approximately to the average depth of the grass roots. This structural condition, which is unstable and gives way when the soil is walked on, is locally referred to as dry bog. These soils absorb water fairly readily, considering their heavy texture. If puddled by tillage when wet, the soils form dense hard blocks on drying, and these are broken with difficulty. The soils are basic in reaction, in some places being slightly calcar-



A, Characteristic hog-wallow microrelief of San Joaquin sandy loam: *B*, part of profile of San Joaquin sandy loam, showing claypan and hardpan layers.



Yokohl clay on hill slope in foreground, with area of rough stony land in distance.

eous, as shown by field tests with dilute acid. They have a moderate organic-matter content.

The upper part of the subsoils, extending to a depth ranging from 30 to 40 inches, is dark-gray clay, with many streaks and spots of lime, which has also accumulated in large nodules about the size of a pea. In places where the lime content is high, the subsoils break into small granules. In the lower part of the subsoils, the color, in general, is lighter gray than in the upper part, owing to the high content of fairly evenly distributed lime, which also masks the heavy texture, making it appear fairly light. The subsoils are permeable to roots and moisture, but roots do not penetrate to a great depth, probably because of the high concentration of lime. In a few places the lime content is lower and the material is of lighter texture at a depth ranging from 5 to 6 feet.

The members of the Hovey series consist of soils developed on transported alluvial materials that are derived primarily from basic igneous rocks. They occupy flat areas at the bases of alluvial or colluvial foot slopes, on which surface and subsurface drainage has been slow. The higher parts of the slopes are occupied by soils of the Porterville series. The excess of moisture in the past has favored the growth of water-loving grasses, and these soils support no shrubs or trees. Within recent years surface run-off has been so reduced that drainage conditions now are excellent. Only in years of excessive rainfall does water stand on these soils. Owing to the flat surface and the heavy texture of the soil, erosion is practically absent.

Hovey adobe clay is the only type of this series mapped in the Visalia area. In the earlier reconnaissance this soil was included with the Montezuma soils, from which it differs in parent materials, in relief, and in its more basic reaction in the surface soil. In this area, the Hovey soils are associated with the Porterville soils, from which they differ in their darker color and flatter surface.

Hovey adobe clay.—Hovey adobe clay conforms to the Hovey series as described in the foregoing pages. This heavy-textured soil is difficult to handle under irrigation. It is used for range pasture, grain, and grain hay, and for such use it rates fairly high, as it holds and retains a large amount of moisture and is fairly fertile. Its value for the crops grown is limited by the low rainfall of this section. The low flat position of this soil precludes its use for citrus fruits because of poor air drainage, and it probably contains too much lime to be favorable for growth of the trees.

Small bodies of Hovey adobe clay are north of Curtis Mountain, north of Stokes Mountain, and in Yokohl Valley; and a number of very small bodies are north of Woodlake.

Comparatively small areas included with Hovey adobe clay in the northern part of Round Valley, southeast of Lind Cove, and southwest of Lemoncove differ from the typical soil in having a clay loam surface soil. Had these areas been more extensive they would have been classed as Hovey clay loam. Owing to the lighter texture of the surface soil of these clay loam inclusions, they have higher agricultural value than the areas of typical adobe clay, and under irrigation they can be used for a fairly wide variety of crops;

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but, owing to their flatness, surface drainage is slow, and penetration of moisture and subdrainage are retarded by the heavy-textured subsoil.

DINUBA SERIES

The 12- to 30-inch surface soils of members of the Dinuba series are light brownish gray or light brown. The brown color is intensified when the soils are wet. The surface soils are highly micaceous, porous, contain many insect burrows, and break down to a granular structure. They are neutral to moderately basic in reaction but do not contain sufficient lime to produce effervescence when tested with dilute hydrochloric acid. They are low in organic matter. The subsoils are light gray or light brownish gray, and the lower parts are somewhat heavier in texture than the surface soils and contain sufficient colloidal material to make them somewhat compact. They show no definite structure except that they break into small lumps that can be crushed between the fingers. They are slightly to moderately calcareous, permeable to roots, and absorptive of moisture. In the lower part of the subsoils, at a depth ranging from 3 to 6 feet, lenses of light-gray silty material slightly cemented with lime occur in places. These lenses range from one-half inch to a few inches in thickness and can be broken easily in the fingers. They do not offer a great deal of resistance to the penetration of roots or moisture and lie at such a depth that they have very little effect on the agricultural value of the soil, except where they contain salts. The soil material between and below these silty lenses consists of light-gray micaceous variably textured loose sediments, and it is only slightly calcareous or even noncalcareous in places.

The Dinuba soils are developed on transported materials that have their source mainly in coarse-textured quartz-bearing igneous rocks. The surface run-off is fairly slow, therefore erosion is not active. Subdrainage is fair, but in a few places the soils contain some salts. The native cover consisted of grasses, a few shrubs, and a few oak trees, but all the land is now cleared and devoted to crops.

The Dinuba soils were mapped in the earlier reconnaissance as a brown phase of the Fresno series. They differ from the typical Fresno soils in that they have slightly browner less calcareous surface soils, and the silty hardpan lenses occur at a depth ranging from 4 to 6 feet below the surface, whereas in the Fresno soils they are much nearer the surface. The Dinuba soils have a much greater value for agriculture than have the Fresno soils.

Dinuba sandy loam is mapped in this area. It is associated with Tujunga sandy loam and Fresno fine sandy loam.

Dinuba sandy loam.—The surface soil of Dinuba sandy loam consists typically of light brownish-gray or light-gray noncalcareous sandy loam that is highly micaceous and contains considerable quartz or silica particles, which give the soil a sharp feel. The soil material appears light brown when moist but dries to a bleached gray color and is locally referred to as white-ash soil. The upper subsoil layer, beginning at a depth ranging from 18 to 24 inches, is in most places light brownish-gray slightly calcareous sandy loam or fine sandy loam, and it differs very little from the surface soil, except the material is calcareous and contains a slightly greater amount of colloidal clay, which causes the material in this layer to become harder when dry. Light-gray calcareous silty hardpan lenses, from ½ to 2 inches in thickness, occur at a depth ranging from 4 to 6 feet from the surface, and in general these alternate with light-gray fine sand or sandy loam layers containing much mica and quartz and less lime.

The surface soil of Dinuba sandy loam contains very little colloidal clay and can be tilled very easily. As mapped in this area the texture is somewhat variable, and small areas of loamy sand and fine sandy loam are included. The water-holding capacity of the surface soil ranges from 8 to 16 percent. The subsoil is permeable to roots and absorbs water well. The thin limy hardpan lenses occur at such depth that they do not offer much resistance to the penetration of roots or moisture. The content of organic matter is low, and for best results with most crops the nitrogen content should be built up, but mineral plant nutrients seem to be available.

With the exception of three small bodies indicated on the map as containing salts, this soil does not have soluble salts in sufficient quantity to be injurious to crops, although the lower part of the subsoil in places contains appreciable quantities, especially in areas that adjoin areas of the Traver or Fresno soils. The land in general is smooth and is easily tilled and irrigated. Where areas of this soil join areas of the Delhi soil, some shifting of soil material by the wind occasionally takes place.

Dinuba sandy loam occurs mainly in the district about 4 miles southwest of Dinuba. An area is just east of Kingsburg on the western side of the Kings River. A total of 10.2 square miles is mapped. With the exception of the small bodies containing salts, all this soil is in irrigated crops, including grapes, peaches, melons, alfalfa, cotton, and a number of other general field and truck crops. Probably more than 60 percent of the land is devoted to raisin grapes, and most of the remainder to peaches, alfalfa, and truck crops.

RAMONA SERIES

The surface soils of members of the Ramona series are brown or darker dull brown and richer brown in places. A richer brown color is apparent under moist field conditions. The subsoils are of similar or slightly richer or more reddish brown color and are moderately compact, with a moderate accumulation of clay materials, and in most places are noticeably heavier in texture than the surface soils. The organic-matter content generally is low, and the soil materials are characteristically somewhat gritty and include sharp angular particles of quartz and flat scales and particles of mica. The surface soils and subsoils are noncalcareous and of neutral to slightly basic reaction. They are developed on old alluvial-fan and valley-floor materials derived mainly from granitic rocks. Ramona loam is the only type of the Ramona series mapped in this area.

Ramona loam.—Ramona loam has a brown loam surface soil and a reddish-brown heavy loam or clay loam subsoil. The subsoil, beginning at a depth ranging from 15 to 28 inches, is fairly compact, but at a depth ranging from 36 to 48 inches the soil material becomes more friable and lighter textured. The material in all layers is noncalcareous but is neutral to slightly basic in reaction and contains a considerable quantity of mica and quartz particles. The soil is practically free from salts.

This soil is not quite so easy to till as Greenfield sandy loam, with which it is associated in places, and it has a tendency to puddle somewhat if tilled when too moist. It does not absorb water nearly so readily but has a higher water-holding capacity, compared with the Greenfield soil. The land is smooth and is irrigated easily.

The largest body of Ramona loam is about 1 mile southeast of Exeter, and smaller bodies are in the Dinuba district and east of Cutler. The same crops are grown as on Greenfield sandy loam. In the Exeter district most of the land is planted to citrus fruits and Emperor table grapes. Yields are as high as those obtained on the best soils of the area. For raisin grapes this soil probably is not quite so desirable as is Greenfield sandy loam, but for table grapes it gives better results.

HARDPAN SOILS DEVELOPED ON OLD ALLUVIAL FANS AND TERRACES

Occupying older and higher alluvial-fan and terrace remnants between the younger alluvial soils are a number of brown and reddish-brown soils underlain by cemented hardpan materials. These terraces slope gently toward the west, but most of them have a hog-wallow microrelief characterized by small mounds and depressions. These soils are developed on the older transported materials. Owing to their dominant red tinge, they are known locally as the red lands. They support a growth of short grasses and, along drainageways, a few scattered oak trees. Classed in this group are the soils of the San Joaquin, Exeter, Madera, Yokohl, and Seville series. All are characterized by a hardpan layer at a depth ranging from 1 to 4 feet below the surface. The San Joaquin soils are reddish brown and are derived from coarse-textured rocks, whereas the Yokohl soils are derived from fine-grained igneous rocks. The Madera soils have brown surface soils, calcareous subsoils, and a hardpan that is browner, softer, and more calcareous than that underlying the San Joaquin soils. The Exeter soils have brown surface soils, slightly heavier textured subsoils, and a hardpan similar to that underlying the San Joaquin soils. The Seville soils have chocolate-brown heavy-textured surface soils, calcareous subsoils, a soft calcareous hardpan, and are derived from fine-textured basic igneous rocks.

SAN JOAQUIN SERIES

The surface soils of members of the San Joaquin series are light reddish brown or dull reddish brown, the red shade being intensified when the soils are moist. These soils are, in general, somewhat micaceous, and angular quartz fragments are conspicuous throughout the soil mass. When pulverized the field-dry lighter textured types in many places appear to be somewhat yellow, and the heavier textured types are darker. These soils are friable when moist but bake fairly hard on drying, so that they absorb water slowly when it is first applied. Insect and worm casts are numerous, the organic-matter content is low, and the reaction is neutral or slightly basic (pH 7.0 to 7.5). The surface soils range in thickness from a few inches to as much as 30 inches.

Below the surface layer, the material is dull brownish-red compact clay or sandy clay, which breaks into blocks or hard clods coated with colloidal glazing and, when wet, is red and extremely sticky. The colloidal clay content of this layer is extremely high, and roots or moisture penetrate with difficulty. This layer ranges from 4 to 15 inches in thickness, and in some places it is very thin. The material is not calcareous but has a pH value of 7.2 to 8.0.

This layer is underlain by a red or reddish-brown cemented hardpan at various depths averaging about 30 inches. The material in the topmost 2 or 3 inches of the hardpan is noncalcareous and more firmly cemented than that in the lower part, which is lighter colored and contains lime infiltrations in seams and in cracks. The thickness of the hardpan ranges from about 6 to 18 inches and averages about 12 inches. The matrix of the hardpan consists of fine-grained soil particles of granitic origin cemented by silica and sesquioxides. The surface of the hardpan is slightly undulating but does not exactly conform to the surface of the land.

The soil material below the hardpan is composed of light-brown or grayish-brown micaceous sandy loam or loam, which is fairly compact but can be broken in the fingers when taken from an excavation.

The San Joaquin soils are developed on old transported material that has its origin mainly in coarse-textured granitic rocks. They represent old hardpan soils in which the younger stages in profile development might be the Hanford and Greenfield soils.

They occupy slightly elevated terraces, sloping gently toward the west, on the eastern side of the valley. They have a typical hog-wallow relief characterized by mounds ranging from 15 to 25 feet in diameter and from 18 to 48 inches in height. The soil on the crests of the mounds is lighter textured and thicker than the soil in the depressions, which in places is also darker.

Surface drainage is slow, and subdrainage is restricted by the heavy clay subsoil and the hardpan. Water stands in the depressions for long periods after a heavy rainfall. The subsoil generally becomes saturated after a 5- or 6-inch rainfall or when irrigated too copiously. The native cover is predominantly short grasses and herbaceous plants, such as alfileria. Salts are not present in injurious quantities in the soils of the San Joaquin series.

The San Joaquin soils are associated with the Madera soils, which have browner surface soils, calcareous subsoils, and hardpans containing more lime. The San Joaquin soils are of low value for general crops, but after the hardpan is broken up by blasting and the surface is leveled and irrigated, they are used for the production of citrus fruits (pl. 2), olives, and figs, and, to less extent, grapes.

The sandy loam, loam, and clay loam members of the San Joaquin series are mapped in this area.

San Joaquin sandy loam.—The surface soil of San Joaquin sandy loam is light reddish-brown noncalcareous micaceous sandy loam containing a large quantity of quartz particles. When wet the soil is rather red, but when pulverized in the dry state it is yellower or browner. This layer ranges in thickness from a few inches in the depressions to as much as 30 inches on the tops of the mounds.

The upper subsoil layer is brownish-red compact noncalcareous sandy clay loam or sandy clay, which breaks into distinct blocks showing a great deal of colloidal glazing on their surfaces. This material is very sticky and of pronounced red color when wet. It contains a high proportion of colloidal clay as well as sharp sand particles, which mask the heavy texture. The so-called red iron hardpan is reached at a depth ranging from 18 to 60 inches and averaging about 30 inches. The topmost 2- or 3-inch layer of material is extremely hard and does not contain lime, but the lower part of the subsoil is lighter brown, contains calcareous infiltrations in the seams, and is somewhat softer than the upper part. The thickness of the hardpan ranges from about 6 to 18 inches, with an average of about 10 inches (pl. 3, *B*). This hardpan does not soften to any degree when exposed to the air or water but has a rocklike character. The soil material below the hardpan is light-brown or light grayish-brown moderately compact micaceous sandy loam.

The surface soil of San Joaquin sandy loam holds a moderate amount of moisture. It bakes hard on drying and is very difficult to plow when dry. If worked when too wet it puddles very readily, which retards the absorption of water. After rains, water stands on the surface, owing to the slow rate of absorption or to a saturated condition of the surface layer overlying the heavy-textured subsoil and the impervious hardpan. Irrigation water and rains penetrate the subsoil very slowly. Grasses often dry up soon after the rains cease, owing to lack of moisture. Roots do not penetrate the hardpan layer. The soil is neutral or slightly basic in reaction, but it does not contain harmful quantities of salts. The content of organic matter is comparatively low, and plant nutrients are not so readily available as in the more recent alluvial soils, owing to the high degree of oxidation and leaching that the San Joaquin soil has undergone.

In the natural state, San Joaquin sandy loam has a hog-wallow microrelief, characterized by mounds ranging from 15 to 25 feet in diameter and from 18 to 48 inches in height, with intervening shallow depressions (pl. 3, *A*). When leveled for irrigation the land in general is fairly smooth. In some spots the surface soil is extremely shallow or the subsoil is exposed. These spots are unproductive and should be built up by the incorporation of organic fertilizers. Barnyard manure gives the best results. Where trees are planted the underlying hardpan should be broken by blasting. From ¼ to 1 pound of dynamite is used in each hole.

The largest bodies of San Joaquin sandy loam are in the section between Woodlake and Ivanhoe and northwestward toward Taurusa School and south of the Kaweah River in the vicinity of Lind Cove. Approximately 40.9 square miles are mapped. Less than 5 percent of the land is leveled and planted to irrigated crops, including oranges, olives, figs, and grapes. A few small plantings of deciduous fruits have been set out but have not proved successful. Alfalfa, cotton, or other field crops are not profitable, owing to the cost of leveling, the shallowness of the soil, and the difficulties of irrigation. This soil is utilized mainly for pasture and dry-farmed grain, grown under summer-fallow practice. Yields of grain range from four to six sacks [7] an acre.

[7] The capacity of grain sacks in the different markets of California ranges from 100 to 125 pounds, but the general average is about 2 bushels.

San Joaquin loam.—The 6- to 18-inch surface soil of San Joaquin loam consists of light brownish-red or reddish-brown noncalcareous loam, which contains considerable angular quartz sand particles. The soil is redder when wet and is friable, but it bakes fairly hard on drying, owing to a comparatively high colloidal clay content. Its chemical reaction is slightly basic. The subsoil is red or dark-red compact clay loam or clay, which is very sticky when wet but breaks on drying into hard blocks. These blocks have a considerable amount of colloidal glazing and generally dark manganese staining on their surfaces. Roots extend along the cracks between the blocks rather than through the blocks. This clay layer ranges in thickness from 4 to 12 inches, and the material has a basic reaction. The reddish-brown iron- and silica-cemented hardpan is reached at a depth ranging from 24 to 36 inches and is from 10 to 24 inches in thickness. This hardpan is very massive and hard and does not soften when exposed to the air or placed in water. The topmost 2- or 3-inch layer is harder and noncalcareous, whereas lime occurs in seams in the lower part. The soil material below the hardpan is brown, grayish-brown, or yellowish-brown micaceous sandy loam or gritty loam, which is very firm in places, and here and there is semicemented, but it can be crushed in the fingers. In general, it is noncalcareous but has a basic reaction. San Joaquin loam is locally known as a red-hardpan soil.

This soil holds considerable moisture in the surface layers, but penetration is limited by the heavy subsoil and the hardpan layer, so that crops exhaust the available moisture very soon after the rains have ceased. If worked when too wet the soil puddles readily. A plow sole develops in places if the soil is cultivated when too wet or is plowed to the same depth year after year. Irrigation water penetrates the subsoil very slowly. Neither roots nor moisture penetrate the hardpan layer.

Salts are not accumulated in injurious quantities, the organic-matter content is comparatively low, and plant nutrients are not so readily available as in the more recently deposited alluvial soils. Applications of organic and other nitrogenous fertilizers give good results.

San Joaquin loam occurs on slightly undulating terraces. Hog wallows are not so pronounced and the cost of leveling the land therefore is not so great as on San Joaquin sandy loam. Water occasionally stands on the surface between the mounds after heavy rains. Subdrainage is slow, owing to the heavy-textured subsoil and the hardpan layer.

San Joaquin loam is not quite so extensive as San Joaquin sandy loam, although it is fairly extensive. Large bodies are in the vicinities of Primero, Cutler, Seville, Woodlake, Lemoncove, and Strathmore. The total area is 33.9 square miles. Probably 50 percent of this land is leveled and planted to oranges, olives, figs, and grapes. The acreage of deciduous fruits is small. Field crops have not proved successful, owing to the cost of leveling, the shallowness of the soil, and difficulties of irrigation. Some grain is grown under dry farming, but the yields generally are low, owing to the low rainfall of this section. Before planting trees, the hardpan usually is blasted.

San Joaquin clay loam.—The surface soil of San Joaquin clay loam is reddish-brown or brownish-red noncalcareous clay loam that appears much redder when wet. At a depth ranging from 10 to 16 inches, this material grades into brownish-red compact noncalcareous clay that separates on drying into hard blocks. This material, in turn, contains a large proportion of colloidal clay and is extremely sticky when wet. Roots penetrate the surface soil but only follow the cracks in the heavy-textured subsoil. At a depth ranging from 2 to 3 feet, probably averaging about 2½ feet, the reddish-brown iron- and silica-cemented hardpan is present. The topmost 2 or 3 inches of the hardpan are extremely hard, whereas the lower part contains lime in seams and is somewhat softer. Roots and moisture cannot penetrate the hardpan, which averages about 12 inches thick. The soil material below the hardpan is light-brown compact micaceous sandy loam or gritty loam. The material in all soil horizons above the hardpan is noncalcareous but is basic in reaction.

The surface soil holds considerable moisture, but penetration of moisture is limited by the heavy subsoil and the hardpan. The soil bakes hard on drying, and it puddles readily if worked when too wet. A plow sole, which can be broken by deeper plowing, commonly develops throughout this soil. Irrigation water penetrates the subsoil very slowly. The soil does not contain salts in injurious quantities. The organic content is comparatively low but can be built up by the use of organic fertilizers.

This soil has an undulating terrace form of relief and includes a few hog wallows, but the surface is not so irregular as that of the unleveled areas of San Joaquin sandy loam. The land is somewhat difficult to level for irrigation, and, when it is leveled, spots occur in which the subsoil is exposed and the depth to hardpan is slight. Subdrainage is slow, owing to the heavy-textured subsoil and the hardpan, and water occasionally stands on the surface between the mounds after rains.

Areas of this soil occur in association with San Joaquin loam between Smith and Stokes Mountains, east of Orosi, and near Strathmore. Smaller bodies are near Woodlake and Lemoncove. The total area is 16.9 square miles. Probably 20 percent of this land is under irrigation and is planted to oranges, figs, olives, and grapes, and the rest is used for dry-farmed grain in seasons of sufficient rainfall. Irrigated field crops have not proved successful, owing to the cost of leveling and the difficulties of irrigating on a hardpan soil. Generally the hardpan is blasted when trees are planted, from ¼ to 1 pound of blasting powder being used for each hole. Table grapes of the Emperor, Flame Tokay, and Malaga varieties give the best results of the crops grown on this soil.

EXETER SERIES

The Exeter soils are brown noncalcareous soils developed on transported materials that rest on hardpan, similar to that of the San Joaquin soils, at a depth ranging from 2 to 5 feet.

The surface soils are brown or light brown, but they appear darker brown or reddish brown when wet. They range from 12 to 20 inches in thickness. Most of them contain conspicuous mica flakes and a large quantity of quartz. The soil material is readily penetrated by water but has a tendency to bake fairly hard on drying. The surface soils are noncalcareous but have a pH value between 7.0 and 7.6. The organic-matter content is low.

The upper layers of the subsoils, in most places, are slightly compact and possibly somewhat heavier textured than the surface soils. They have a slight yellow cast. They are not calcareous but have a pH value of 7.3 to 8.0. They are underlain by a hardpan layer at a depth ranging from 2 to 5 feet, in which the topmost 2 or 3 inches of material forms a hard reddish-brown noncalcareous sesquioxide-cemented layer that is dug through with extreme difficulty. Below this, the hardpan contains considerable calcium carbonate in the seams and cracks and is a little softer. The hardpan ranges from 3 to 12 inches in thickness, and grades into lighter brown compact sandy loam, which breaks into irregularly shaped blocks but can be crushed readily between the fingers. Alternating layers of similar soil and hardpan material extend to an undetermined depth.

These soils are developed largely from material derived from acid igneous rocks, although, in the vicinities of Lindsay and Strathmore, they contain some material from basic igneous rocks. They occupy gently sloping terracelike areas. In places where they join the San Joaquin soils, the surface has a microrelief characterized by small hog-wallow mounds and depressions, but this is not typical of these soils. Surface drainage is well developed, except in some spots at some distance from the streams or drainage channels.

The rainfall is carried away rather slowly, and erosion is not a serious problem. Subdrainage is retarded by the hardpan layers. In general these soils are better drained than the related San Joaquin or Madera soils. All areas have been cleared of their native vegetation and now are planted to grapes, but they probably originally supported a cover of small shrubs and native grasses.

These soils seem to be developed on overwash superimposed on older materials. The soil material above the hardpan is similar to that of the Greenfield or Ramona soils. Exeter loam, with a gravelly phase, and Exeter clay loam are mapped in this area. They occupy a position between the young alluvial soils and the hardpan soils of the San Joaquin and Madera series. In the earlier reconnaissance they were included with the Madera soils and to some extent with the San Joaquin soils. They are of better quality than the soils of either of those series.

Exeter loam.—The surface soil of Exeter loam is brown or light-brown, rich brown when wet, noncalcareous gritty loam containing many sharp quartz fragments. The subsoil differs from the surface soil mainly in that it is somewhat more yellowish brown or reddish brown in places, but the texture generally is about the same as that of the surface soil and the material is only slightly compact. This material is noncalcareous and rests on a reddish-brown iron- and silica-cemented hardpan at a depth ranging from 2 to 3 feet. The hardpan ranges from 3 to 12 inches in thickness. The topmost 2 inches are extremely hard without visible concentrations of lime, but the lower part contains seams of this material and is a little softer. The soil material below the hardpan is light-brown or light yellowish-brown compact sandy loam, which is fairly massive in place but can be broken in the fingers. This material contains considerable coarse granitic fragments and is highly micaceous. Other hardpan layers, alternating with similar soil material, occur below this.

Exeter loam is fairly easy to till but has a tendency to bake fairly hard on drying. The soil absorbs water readily and has a fairly good water-holding capacity, but deep penetration of moisture is retarded by the hardpan layer and, consequently, much water may be lost by run-off during excessive rainfall or heavy irrigation. In general, drainage is better than on the San Joaquin or Madera soils. Citrus fruits, figs, olives, and grapes do better than general field crops. This soil contains no injurious accumulations of salts. The organic-matter content is comparatively low, but available mineral plant nutrients are not lacking. The soil does not contain lime in sufficient quantities to produce effervescence when tested with dilute acid, but it is slightly basic in reaction.

Exeter loam occupies gently sloping alluvial terraces that can be irrigated and tilled with ease. In places where it joins the San Joaquin soils, it has a microrelief characterized by small mounds and depressions, or hog wallows. These areas require leveling before the land can be irrigated. About 27.1 square miles of Exeter loam are mapped in the area. The largest bodies are in the vicinity of Exeter and Lindsay, and smaller ones are near Cutler. Most of the areas occupy a position between the young alluvial soils of the Greenfield series and the hardpan soils of the San Joaquin series. North and southwest of Lindsay the color of the surface soil is somewhat duller than typical and contains more mixed material, owing to the influence of an admixture of the alluvial material giving rise to the Honcut soils, with which the Exeter soil is associated in that district.

All the land is cleared and under irrigation. Probably 80 percent is planted to grapes, raisin grapes predominating in the Cutler district and table grapes of the Emperor variety in the Exeter district. Acre yields ranging from 1 to 2 tons of raisins and from 6 to 8 tons of table grapes are obtained. Bodies of this soil close to the foothills produce good yields of citrus fruits, figs, and olives. Some plantings of deciduous fruits occupy the bodies where the hardpan lies below a depth of 3 feet.

Exeter loam, gravelly phase.—The gravelly phase of Exeter loam has a surface soil of light reddish-brown loam containing considerable gravel of basic igneous rocks similar to the rocks giving rise to the Honcut soils. The subsoil is of about the same color and texture but, in places, is slightly more compact than the surface soil, and it also contains considerable gravel. The silica- and iron-cemented hardpan is present at a depth ranging from 3 to 6 feet and averaging about 4 feet. The soil material is noncalcareous above the hardpan, but the lower part of the hardpan contains calcium carbonate segregated in cracks and seams. This soil is developed on outwash from Lewis Creek, deposited over the top of a hardpan soil, from which the surface material had been eroded. The land slopes gently toward the west. This soil is mapped 3 miles southeast of Lindsay.

Although the gravel interferes to some extent with tillage, it does not materially lower the water-holding capacity or agricultural value of this soil. All the land is used for the production of citrus fruits, with good results. It is adapted to a fairly wide range of crops under irrigation, and it is more productive than the associated San Joaquin soils.

Exeter clay loam.—Exeter clay loam is similar in all respects to Exeter loam, except the surface soil consists of clay loam. The subsoil consists of brown noncalcareous clay loam, which rests on the silica- and iron-cemented hardpan at a depth ranging from 2 to 3 feet. The hardpan ranges from 3 to 12 inches in thickness, with calcium carbonate occurring below the topmost 2 inches. It is underlain by sandy loam or loam. This soil probably owes its heavier texture to the influence of the heavier textured adjoining soils, which are developed on outwash from fine-textured rocks.

The total area of this soil is small. Bodies of it are 1½ miles southeast of Cutler, 3 miles west of the Venice Hills and 2 miles west of Strathmore. The soil is used for essentially the same crops as is Exeter loam. The heavier texture of the surface soil makes the land a little more difficult to handle.

MADERA SERIES

The members of the Madera series are brown mineral soils developed on old transported alluvium that has its source in a variety of rocks. The coarser textured types contain considerable mica and quartz, but the finer textured types do not contain so much. These soils occur on the broad valley floor, and they slope gently toward the west. They are characterized by small mounds and depressions, locally known as hog wallows. Water stands in the depressions between the mounds after heavy rains, and surface run-off and subdrainage are slow. Erosion is not active, owing to the flat surface. The native vegetation consists of wild grasses and herbaceous plants, which spring up after the winter rains. Some saltgrasses and other salt-tolerant vegetation grow in places where these soils join the soils of the Lewis and Fresno series. The normal profile has a well-developed sesquioxide-cemented hardpan having a high content of lime in seams and crevices.

The 8- to 18-inch surface soils of members of the Madera series are light brown or brown, are friable, and are well filled with root and worm holes. They granulate well at the optimum moisture content but are sticky when wet and bake fairly hard on drying. Care must be used in tilling them while wet, otherwise they will puddle and on drying will form hard blocks. They have a low organic content and a basic reaction, with a pH value between 7.0 and 8.0.

The subsoils are light brown or brown, moderately compact, and somewhat heavier textured than the surface soils. They are moderately calcareous. The lime is segregated in nodules and seams in the upper part of the subsoils, and in many places the quantity increases in the lower part just above the hardpan, with a resultant grayer color. In the heavier textured types the subsoils break into cubical blocks having considerable colloidal glazing on the surfaces of the soil aggregates.

A grayish-brown hardpan layer, ranging from 8 to 15 inches in thickness, occurs at a depth ranging from 2 to 4 feet below the surface. To a considerable degree it is transitional in character between the silica- and sesquioxide-cemented hardpan of the San Joaquin soils, which occur farther north in the valley, and the lime hardpan of the lower lying Lewis soils. In most places the material in the topmost 1 inch of the hardpan layer is harder, but it becomes softer with depth. Nearly everywhere the hardpan can be dug out with a sharp bar, but it does not soften appreciably when pieces are placed in water. In most places grayish-brown sandy loam or loam lies below the hardpan. This material is fairly loose in some places, yet much of it is rather massive and compact. After it is dug out, it can be pulverized readily in the fingers. This material in general is calcareous, and a number of calcareous hardpan layers, with alternate layers of soil material, were observed in wells, extending to a great depth.

Madera sandy loam, Madera loam, and Madera clay loam are mapped. The Madera soils occupy a place intermediate between the San Joaquin soils and the Lewis soils, both in profile characteristics and in location in the area. The appearance of their surface, aside from being browner, is similar to that of the San Joaquin soils, but the soils of the two series differ in that the Madera soils have calcareous grayer subsoils and softer and more calcareous hardpans. In this area the Madera soils contain more lime and have a softer hardpan than the Madera soils farther north in the San Joaquin Valley.

Madera sandy loam.—The surface soil of Madera sandy loam is light-brown or rather dull-brown friable noncalcareous sandy loam. The subsoil is light-brown or light grayish-brown slightly compact fine sandy loam or loam, which ranges from slightly to moderately calcareous. In places this layer is reddish-brown clay loam. This layer begins at a depth ranging from 14 to 20 inches and extends to a grayish-brown hardpan containing considerable calcium carbonate in seams. The hardpan layer occurs at a depth ranging from 3 to 6 feet and ranges in thickness from 4 to 10 inches. This hardpan is not so hard nor so thick as the hardpan underlying the San Joaquin soils. The soil material below the hardpan is light yellowish-brown or grayish-brown moderately compact calcareous sandy loam. It is massive in place but when removed can be pulverized readily in the fingers. The soil material is high in mica and angular quartz particles.

Madera sandy loam is easy to till, absorbs water readily, and has a fairly good water-holding capacity. The hardpan lies at sufficient depth that it does not retard the penetration of roots, except those of the deeper rooting crops. Some care must be used in the irrigation of alfalfa not to apply too much water. The soil shows no evidence of injurious quantities of salts. The organic-matter and nitrogen content are comparatively low, and the use of organic fertilizers is recommended. The soil occupies smooth alluvial areas, and very little leveling is needed to put it in condition for irrigation. Drainage is better developed in Madera sandy loam than in the heavier textured Madera soils. although an excess of water would cause a perched water table over the hardpan.

Several square miles of this soil are mapped, chiefly south of Dinuba in the Monson district, where it is associated with Greenfield sandy loam. The land originally had a native cover of grasses and oaks, but it has been cleared and is utilized for the growing of grapes, chiefly of the Sultanina and muscat varieties, which are used primarily for raisins. Yields are somewhat better than average. Peaches also yield well.

Madera loam.—The surface soil of Madera loam is brown or light-brown loam, which typically is noncalcareous to a depth ranging from 10 to 18 inches, where it grades into brown, dark-brown, or dark grayish-brown moderately compact calcareous clay loam containing lime segregated in soft nodules. At a depth of about 30 inches, this material rests on light grayish-brown highly calcareous clay loam, in which the lime is distributed uniformly, giving it a lighter color. A light brownish-gray hardpan, ranging from 6 to 10 inches in thickness, occurs at an average depth of about 3 feet, has a high content of lime in seams, and rests on light brownish-gray slightly calcareous sandy loam or gritty loam. This material is fairly hard in place but can be broken between the fingers. Other hardpan layers, similar to the one described, are present in places at lower depths. All layers of Madera loam contain considerable mica and angular quartz particles. The soil is known locally as brown-hardpan soil.

This is a medium-textured soil and is not difficult to till. It holds a moderate quantity of moisture, but the heavy-textured subsoil and the hardpan retard the penetration of roots and moisture. Care must be used in irrigation not to apply large quantities of water to saturate the soil above the hardpan and cause drainage difficulties. The salt conditions are variable. Most of the higher lying areas are free of salts, but most of the bodies joining the Fresno or Lewis salty soils have a spotted condition or contain moderate quantities of salts. The surface soil normally is practically free of salts, but the subsoil may contain salts in moderate quantities. The salts are mainly the chlorides and sulfates of sodium, although sodium carbonate, or so-called black alkali, is present in some places. Owing to the drainage difficulties caused by the heavy-textured subsoil and the hardpan, it is doubtful whether reclamation of these spots by leaching is feasible. The organic-matter content of the soil is fairly low, but it can be improved materially by the incorporation of manures or other sources of organic matter and nitrogen.

Madera loam occupies fairly smooth alluvial terraces having a hog-wallow microrelief, with the mounds ranging from 1 to 2 feet in height. Water often stands in the depressions between the mounds after rains, thereby causing a saturated condition of the soil above the hardpan. When leveled, the land is smooth and easy to irrigate, although the soil material is shallow in spots where considerable surface soil has been moved in order to fill the depressions.

Fairly large areas of Madera loam are midway between Visalia and Monson and southwest of Lindsay between the San Joaquin soils and the soils of the Lewis or Fresno series. Scattered bodies are in the vicinity of Ivanhoe, south of Dinuba, near Sultana, southeast of Woodlake, and north and west of Lindsay. The total area is 36.7 square miles.

In places where Madera loam joins the Fresno or Lewis soils, the surface soil is intermittently calcareous and lighter colored. These areas are of very low value except for the pasture they afford.

Only a small proportion of Madera loam is tilled, the greater part of it being used for grazing. Most of the land supports a fair growth of alfileria and other native plants and grasses. Small areas adjoining the Exeter or San Joaquin soils are used to some extent for citrus fruits, figs, olives, and grapes. Where the soil is free of salts and sufficiently deep over the hardpan, fairly good yields are obtained. Some areas are used for the production of grain under dry farming.

Madera clay loam.—Madera clay loam has a surface soil of brown noncalcareous clay loam, which, at a depth ranging from 8 to 14 inches, rests on brown or grayish-brown fairly compact clay loam or clay that contains considerable lime in seams and in the form of soft white nodules. The lower part of the subsoil, just above the hardpan, is lighter colored and softer than the upper part and contains an abundance of calcium carbonate. At a depth of about 3 feet is a 6- to 10-inch grayish-brown calcareous hardpan layer which seems to be cemented with silica and iron but has a high content of calcium carbonate. It is soft enough to be picked out fairly readily with a heavy bar, although it does not soften in water. The soil material below the hardpan consists of grayish-brown compact gritty loam or sandy loam that contains some calcium carbonate. The entire soil material is somewhat micaceous, although there is less mica than in Madera sandy loam or Madera loam.

The surface soil contains sufficient colloidal clay to make it hard on drying. The soil absorbs water fairly readily, although the heavy textured subsoil and hardpan layer restrict penetration. Normally it is practically free of injurious salts.

This soil occupies a smooth sloping plain with low hog-wallow configuration, and the land can be leveled at moderate expense. Both surface and internal drainage are slow. Madera clay loam is associated with Madera loam in the Monson, Cutler, Ivanhoe, and Lindsay districts, and small bodies are mapped in other places. Its total extent is not large. Because of its comparatively smooth surface and freedom from salts, most of the land is in orchards and vineyards. Figs, olives, and table grapes are the principal crops, and some of the land is dry-farmed to grain. Yields of grain are good in years of sufficient rainfall. General field crops, such as alfalfa, sorghums, and cotton, do not do so well as on the deeper alluvial soils of the Kaweah delta. Citrus fruits do fairly well in places where the air drainage is good and frosts are not likely to occur.

YOKOHL SERIES

The surface soils of members of the Yokohl series range from 8 to 12 inches in thickness. They are typically reddish brown, though some areas are dark chocolate brown. Many small stones derived from fine-grained igneous rocks are embedded throughout the soil mass. Like many of the mature surface soils, the surface soils bake fairly hard on drying but may be reduced to a fragmental structure by drying and shrinking and under cultivation. When wet the color is distinctly redder. Grass roots are abundant throughout, although the organic-matter content is low. These soils are noncalcareous, having a pH value of 7.0 to 7.5.

The subsoils consist of dull-red or dark reddish-brown compact clay that is extremely high in colloidal clay and breaks into angular or somewhat prismatic fragments having considerable colloidal glazing on the surfaces. The material in the subsoils is not penetrated to any extent by roots or worms. It is noncalcareous, with a pH value of 7.0 to 7.5. The subsoils range in thickness from 6 to 16 inches. At a depth ranging from 16 to 24 inches the red clay rests on a cemented layer, in which the topmost 2 to 4 inches of material consists of a red silica- and iron-cemented noncalcareous hardpan. The matrix contains approximately 50 percent of small rounded pebbles of basic igneous character, ranging from ¼ to 1 inch in diameter. Below this the hardpan is lighter brown and somewhat softer, and it contains considerable lime in large seams. The hardpan layer ranges from 6 to 12 inches in thickness and averages about 9 inches. The soil material below the hardpan is brown or grayish brown, moderately compact, and of variable texture. It contains many angular fragments of fine-grained igneous rocks.

The Yokohl soils are developed on old transported materials derived from fine-grained basic igneous rocks. They occupy high sloping alluvial fans or alluvial terraces, in which erosion has cut a number of deep channels, but at present erosion is not active except on the edges of the gullies, as the soils are untilled and support a grass cover, which holds the surface soils in place between the natural drainage channels. The microrelief is characterized by small hog-wallow mounds and depressions, the mounds ranging from 6 inches to 1 foot in height, but this type of microrelief is not so pronounced as that of the San Joaquin soils. Surface run-off is fairly rapid, although a little water stands in the small depressions, but subdrainage is restricted by the heavy-textured subsoil and the hardpan layer. The soils of this series do not contain injurious quantities of salts. The native cover consists of short grasses that spring up after the winter rains but dry soon after the warm weather starts. These soils support no trees or large shrubs.

The Yokohl soils seem to be normally developed mature hardpan soils developed on old basic igneous alluvial material, in which the younger alluvium might be represented by the Honcut soils.

Yokohl clay loam and Yokohl clay are mapped in the Visalia area along the edges of the hills, in association with the more recent soils of the Honcut series and the residual soils of the Las Posas and Lassen series. They were not recognized in the earlier reconnaissance. Their utilization is limited by their shallowness. A few of the deeper areas are planted to citrus fruits, where water for irrigation is available, but in general these soils are used for pasture.

The Yokohl soils differ from the San Joaquin soils in that their parent material is outwash from fine-grained basic igneous rocks, whereas the parent material of the San Joaquin soils is derived from coarse-textured granitic rocks, and a much larger proportion of coarser sharp quartz particles is present in the soil mass.

Yokohl clay loam.—The surface soil of Yokohl clay loam is pronounced reddish-brown or dark dull-red noncalcareous clay loam containing a few basic igneous stones. The subsoil, beginning at a depth ranging from 6 to 15 inches, is dull-red compact noncalcareous clay with a high content of colloidal clay. At a depth ranging from 16 to 24 inches, this red clay rests on a silica- and iron-cemented hardpan layer, the topmost 2 to 4 inches of which is extremely hard and is noncalcareous, whereas the lower part is a little softer and contains lime in seams. The hardpan has a high content of water-worn gravel and stones of basic igneous origin. It is variable in thickness, in some places being as much as 3 feet thick. The soil material below the hardpan is brown moderately consolidated gravelly sandy loam or gravelly loam, in which rock fragments of schistlike character predominate. Yokohl clay loam is developed on old transported material, which was derived from fine-grained igneous or metamorphosed rocks and in which a hardpan substratum has formed.

The stone content of the surface soil is sufficient to interfere with cultivation, and in most places the soil material is too shallow for the successful cultivation of crops. The soil occupies high sloping alluvial fans or alluvial terraces, in which erosion has cut a number of deep channels, although at present erosion is not active. The relief is characterized by small hog-wallow mounds and depressions. Both surface drainage and subdrainage are slow, on account of the heavy-textured subsoil and the hardpan, and water stands on the surface after rains.

Yokohl clay loam occurs along the edges of the hills east of Woodlake, in Frazier Valley east of Strathmore, and in Yokohl Valley east of Exeter. A small total acreage is mapped, of which less than 10 percent is tilled. The use of this soil is limited by its shallowness mainly to pasture, but the native grasses dry rather early in the summer.

Yokohl clay.—The 6- to 12-inch surface soil of Yokohl clay consists of dark chocolate-brown noncalcareous clay. This rests on dark reddish-brown compact noncalcareous clay, which, when dry, forms hard adobe blocks. A red silica-and-iron-cemented hardpan, ranging from 10 to 20 inches in thickness, lies about 2 feet below the surface. The topmost 2 to 4 inches of the hardpan layer is noncalcareous, and the lower part contains considerable lime. A large quantity of rounded gravel of schistose character is embedded in the hardpan. The soil material below the hardpan is variable in texture, calcareous, light grayish-brown, softly consolidated, and contains water-worn fragments of schist, amphibolite, or serpentinelike rocks.

The heavy texture of the surface soil renders it hard to till. The soil material is sticky when wet and dries to a fairly hard mass, although it breaks on drying into finer aggregates about the size of a walnut. It does not absorb water very readily, owing to the heavy subsoil and the hardpan.

Yokohl clay occupies fairly smooth sloping terraces (pl. 4). Surface drainage is good, but subdrainage is slow, owing to the presence of the hardpan layer. Small areas of this soil are in Yokohl Valley east of Exeter and in Round Valley northeast of Lindsay. One citrus orchard occupies about 80 acres of this soil, and the rest of the land is not cultivated. The land supports fairly good pasture of burclover in years of normal rainfall. This soil is not recommended for most crops, owing to its shallowness and heavy texture.

SEVILLE SERIES

The 6- to 18-inch surface soils of members of the Seville series are dark chocolate brown and, as occurring in this area, are of heavy clay texture. On drying, these soils develop large adobe blocks about 21 inches in diameter, which, with progressive drying and shrinking, break down to smaller angular aggregates. This secondary breakage develops a loose structure which gives the soil its local name of dry bog, because the feet sink into the soil when a person walks over it. These soils become very sticky and plastic when wet but develop a loose fragmental or granular structure if tilled at the proper moisture content. The surface soils are basic in reaction (pH 7.5 to 8.2) but in general do not contain sufficient lime to effervesce with dilute hydrochloric acid, except in a few included spots. Although the surface soils contain many plant roots, the organic content is low.

The subsoils are dark chocolate brown grading to somewhat more gray or pinkish gray in the lower part. They are compact and break into hard adobe blocks in the upper part. Lime occurs in large soft nodules from one-eighth to one-half inch in diameter, and when the material is crushed it appears of lighter color owing to the included lime. The lime content increases with depth. In the lower part of the subsoils the structure becomes cubical. The subsoil material includes considerable colloidal clay, and the surfaces of the aggregates have a colloidal glazing. The lower part of this horizon is not penetrated to any extent by roots. At a depth ranging from 24 to 36 inches, the subsoil material rests on a light brownish-gray or light-gray highly calcareous platy hardpan, which seems to be sesquioxide-cemented but has a high content of calcium carbonate in the seams and is not penetrated by roots or moisture. It varies in density and thickness; in some places it occurs as a crust only a few inches thick, and in other places it is more than 3 feet thick.

The soil material below the hardpan is light grayish brown, moderately compact, and of variable texture. It is decidedly basic in reaction and may be calcareous. Mineralogically it is made up mainly of fragments from fine-grained igneous rocks. This horizon is considerably softer than the hardpan layer, although it appears fairly massive in places.

In surface color, texture, and structure the Seville soils are similar to the Porterville soils, but they differ from those soils in that they have a calcareous hardpan and occupy smooth flat terraces at lower elevations, whereas the Porterville soils occupy sloping alluvial fans, many of which are fairly steep. Erosion is not a problem on the Seville soils, because they are flat and heavy textured. Surface runoff may be somewhat slow, but the slope to the west in most places is sufficient to remove the excess water. These soils are treeless, but they support a native cover of short grasses.

In the earlier reconnaissance they were included with the Madera and the Porterville soils. Seville adobe clay is mapped in this area.

Seville adobe clay.—The surface soil of Seville adobe clay consists of dark chocolate-brown clay, with a typical adobe structure. When dry it breaks into large blocks about 12 inches in diameter, which, in turn, break into smaller loose aggregates, giving the soil its local name of dry bog. The surface soil, in places, is calcareous. At a depth ranging from 6 to 14 inches, the surface soil grades into dark chocolate-brown clay that has an adobe structure and contains lime segregated in large soft nodules. The lime content increases with depth, so that just above the hardpan the soil is lighter colored and much softer than at the top of the layer. The light brownish-gray hardpan, occurring at a depth ranging from 24 to 36 inches, ranges in thickness from 6 inches to 4 feet. An abundance of lime in seams and lenses gives it a more or less platy structure. In general, it is not so hard as the hardpan underlying the Madera soils, but in places it is extremely thick and calichelike. The soil material below the hardpan is light grayish-brown moderately compact calcareous loam or clay loam, which is softer than the hardpan yet is fairly massive.

The soil becomes very sticky when wet, but it develops a structural condition that breaks down readily if tilled under favorable moisture conditions. Water is readily absorbed, but the application of irrigation water is sometimes difficult to control, as the water tends to follow lateral cracks in the dry soil. Roots penetrate the surface soil and upper part of the subsoil readily, but they do not reach very far into the deeper limy layer. Thus, the effective root zone ranges from only about 12 to 20 inches in thickness. The soil does not contain salts in injurious quantities.

The surface is smooth, and surface run-off may be somewhat slow, but most of the land has sufficient slope to remove excess surface water.

About 8.1 square miles of Seville adobe clay are mapped in the Visalia area. The largest two bodies are in the vicinities of Yettem and Seville, and areas are along Lewis Creek east of Lindsay and in Frazier Valley east of Strathmore. A few figs and olives are grown on this soil in the Yettem district, but in general the soil is used for pasture or for grain in seasons of sufficient rainfall. Under irrigation it may be used for the production of citrus fruits in frost-free locations, but it is not considered a good general farming soil, owing to its heavy texture, shallowness in places, and excessive lime content of the subsoil. In seasons of normal or above-normal rainfall the growth of grass is excellent, but in seasons of low rainfall the growth is considerably less than on the lighter textured soils in this section.

SALINE AND ALKALI SOILS DEVELOPED UNDER POOR DRAINAGE

In the western part of the area and occupying flat areas between the alluvial fans is a belt of light-colored saline and alkali soils. These have slow surface drainage and poor subdrainage. Soluble mineral salts are present in these soils in moderate to large quantities and include both the saline and alkali salts. The vegetation consists of saltgrass, inkweed, and associated salt-tolerant plants. After rains, short grasses and weeds spring up, but they soon wither and die when the days become warm in late spring. These soils have developed under poor drainage with the resultant accumulation of alkaline and saline salts. The Traver, Waukena, Lewis, and Fresno soils are included in this group. The Traver soils are light-gray soils with fairly compact subsoils of the same or only slightly heavier texture, the Waukena soils have tough dense columnar subsoils, the Fresno soils have silty lime-and-silica-cemented hardpan lenses, and the Lewis soils are very similar to the Fresno soils but have heavy-textured darker colored subsoils of columnar structure. The parent material of the Lewis soils is of somewhat mixed mineralogical composition, whereas the parent materials of the Traver, Waukena, and Fresno soils are derived from granitic sources. All these soils have very little value for agriculture because of their high salt content.

TRAVER SERIES

The dry surface soils of members of the Traver series are of a light-gray color, which appears light brown when the soils are wet. The surface soils pulverize easily, contain considerable mica, and have a vesicular structure in the topmost 2 inches. They bake fairly hard on drying, are highly calcareous, and have a low organic content. At a depth ranging from 15 to 24 inches, the subsoils become moderately compact but very little heavier in texture. The material in this horizon is the same color as the surface soils. Below a depth of about 50 inches, the material consists of light yellowish-gray or light-gray fairly friable silty sandy loam that is mottled with red and yellow in places. The entire soil mass is calcareous, but the mottled layer generally contains the least lime.

The Traver soils occur on a broad alluvial plain and are developed on old alluvial materials of granitic origin. They have a saltgrass cover, together with a few other native grasses. The salt content is variable, but soluble salts nearly everywhere are present in moderate quantities. The surface appearance of the Traver soils is very similar to that of the Fresno soils, but the soil profile lacks the silty calcareous cemented seams characteristic of the Fresno soils. In a few places there are low mounds, or hog wallows, such as those characteristic of the Fresno soils.

In the stage of profile development and characteristics, the Traver soils are between the Cajon and Fresno soils, and geographically they occur between these soils in the Visalia area. The Traver soils in the earlier reconnaissance are included with the Fresno soils.

Traver fine sandy loam and Traver loam are mapped in this area.

Traver fine sandy loam.—The surface soil of Traver fine sandy loam consists of a 10- to 24-inch layer of light-gray calcareous fine sandy loam, which appears grayish brown when moist. In barren flat areas the material of the topmost 2 inches is extremely vesicular and pulverizes to a fine powder with slight pressure. Fairly large particles of quartz are present throughout the entire soil mass. The upper part of the subsoil is light-gray moderately compact sandy loam, has a high silt content, contains considerably more colloidal material than the surface soil, and is very hard when dry. The lower part of the subsoil in most places is light yellowish-gray silty fine sandy loam, in many places mottled with brown and yellow, which is considerably more friable than the overlying material, and generally contains less lime. Owing to its light color, this soil is referred to as white-ash land by residents.

Nearly all of this soil contains salts in moderate to strong concentrations, and practically none of the land is farmed. Black alkali is present in most areas, and it is doubtful whether any of the soil can be reclaimed economically for crops. Small mounds and depressions are common over the surface. Saltgrass grows on the mounds, and the depressions are bare of plant growth. Because of its puddled condition and compact subsoil, Traver fine sandy loam absorbs water very slowly. Only the margins of areas bordering other soils and areas containing less salts are tilled, and these with very poor results. Some pasture is provided by the short grasses, which spring up after the winter rains. During the summer the soil is hard, dry, and devoid of vegetation, except saltgrass. In order to produce pasture grasses, some areas have been flooded in the spring and early summer with water obtained by gravity from the Kings or Kaweah Rivers.

Traver loam.—Traver loam differs from Traver fine sandy loam in that it has a surface soil of light-gray calcareous loam. The subsoil is light-gray moderately compact calcareous loam or clay loam, which rests, at a depth ranging from 4 to 5 feet, on the parent material of light-gray or light yellowish-gray fairly loose and friable fine sandy loam.

The agricultural value of this soil is governed by the salt content. As most of it contains a moderate quantity of salts, including the highly injurious black alkali, tilled crops generally cannot be produced. The soil absorbs water very slowly and puddles easily. The organic-matter content is very low.

This soil is inextensive. Small bodies lie between Tulare and Farmersville. Only the areas containing a very small quantity of salts are in general use, in association with better soils, for the production of grain, cotton, or general farm crops, but the more extensive bodies containing the larger quantities of salts are used for pasture.

WAUKENA SERIES

The Waukena soils have light-gray or light grayish-brown surface soils, which are calcareous only here and there and are, for the most part, leached of salts and lime. The organic-matter content is low. The immediate surface layer has a vesicular crust and mulch structure. The surface soils are underlain abruptly, at a depth ranging from 6 to 10 inches, by brownish-gray tough exceedingly compact sandy clay of columnar structure, the tops of the columns being rounded and thinly coated with light-gray siliceous material. This layer is comparatively free of salts and lime but is only about 4 or 6 inches thick. It is underlain by brownish-gray compact clay loam containing nodules of lime. When disturbed this material breaks to a blocky or cubical structure. Below this is light brownish-gray massive but rather soft and permeable material with a high content of disseminated lime.

These soils are developed on flat valley plains where surface drainage and subdrainage are poorly developed. The land has a slightly hummocky or rather irregular microrelief, and slick spots are numerous. Loss of water by percolation is arrested by the compact subsoil, and grasses and salt-tolerant weeds cover the areas in the early spring but soon disappear with the advance of the dry summer season. The soils of this series are associated with the Traver soils, from which they are distinguished by the compact solonetzlike subsoil and surface materials partly leached of salts and lime.

Waukena fine sandy loam.—The surface soil of Waukena fine sandy loam is light-gray, darker when wet, vesicular fine sandy loam, which does not contain sufficient lime to effervesce with acid. Grass roots occur throughout this layer, which is comparatively free of soluble salts. At a depth ranging from 6 to 10 inches, this material rests abruptly on dark brownish-gray very compact sandy clay that is distinctly columnar when dry. The columns, which are about 2 inches in diameter and 4 inches in length, have rounded tops with a thin gray siliceous layer on their upper surfaces. Saltgrass roots follow down along the faces of these columns rather than penetrate them. At a depth ranging from about 14 to 18 inches the material changes to brownish-gray compact clay loam, with a blocky or cubical structure. Lime is present in large nodules. The parent material below this is light brownish-gray sandy loam, which is fairly massive in place but readily breaks down to a single-grain mass and contains more or less lime uniformly disseminated.

This soil occurs at a slightly lower elevation than the associated Traver fine sandy loam, in the southwestern part of the area north of Waukena. Slick spots are common over the surface. The subsoil contains a fairly high concentration of salts, especially black alkali, which renders the soil valueless for any agricultural purpose except pasture. Water stands on the surface following rains, but the soil absorbs very little moisture, so that the grasses, which spring up after the winter rains, soon dry in the early summer. It is doubtful whether this soil could ever be reclaimed economically, owing to the heavy-textured subsoil and the high content of sodium carbonate.

LEWIS SERIES

The members of the Lewis series have light-gray calcareous surface soils that are somewhat micaceous and very low in organic matter. To a depth ranging from 1 to 6 inches they are vesicular when dry and contain many sharp silica particles. Below this is dark grayish-brown very compact clay of columnar structure. The color is darker on top of the layer, and the columns are well defined. At a depth ranging from 4 to 8 inches, within this clay horizon, calcium carbonate is accumulated in soft nodules from one-eighth to one-fourth inch in diameter. The lime content increases with depth, and the soil material becomes browner and breaks into cubes when dry. It grades into a lighter brown or pinkish-brown and softer material containing an abundance of lime. This is underlain by a light brownish-gray or yellowish-gray lime-cemented hardpan at a depth ranging from 2 to 5 feet. This hardpan is softer than that underlying the Madera soils but harder and thicker than that underlying the typical Fresno soils. The hardpan ranges from 2 to 12 inches in thickness and rests on light brownish-gray calcareous fairly massive but not consolidated loam or clay loam.

The Lewis soils are developed on old transported parent material of somewhat mixed mineralogical origin. They occupy flat plains and have a microrelief characterized by low mounds and shallow basinlike depressions or hog wallows. Owing to the flat surface, erosion is not active. Surface drainage is slow, and water stands on these soils after heavy rains. Subdrainage is restricted by the heavy clay subsoils and hardpan. The native vegetation consists of saltgrass and other salt-tolerant plants but includes no trees or large shrubs.

The soil profile is very definitely solonetzlike. The light-gray vesicular surface layers contain very little salts, but the subsoils have a high content, especially of sodium carbonate. The surface is characterized by slick spots, common to many of the solonetzlike soils, which are barren of any type of vegetation. In general, the salt content of the Lewis soils renders them valueless for any agricultural use except saltgrass pasture.

On the basis of textural differences in their surface soils, two types of the Lewis soils are mapped—Lewis fine sandy loam and Lewis clay loam. They are transitional between areas of the Madera and Fresno soils, both in geographical position as well as in general characteristics. They were included with the Fresno and the Madera soils in the earlier reconnaissance.

Lewis fine sandy loam.—The surface soil of Lewis fine sandy loam consists of a 2- to 5-inch layer of light-gray vesicular fine sandy loam. It contains many sharp silica particles. Below this is a layer, ranging in thickness from 4 to 16 inches, of dark brownish-gray very compact clay loam with a columnar structure. The material in this layer is calcareous but has a lower lime content than the underlying material, which is brown compact loam or clay loam that breaks up into small blocks or cubes containing soft nodules of lime ranging from one-eighth to one-fourth inch in diameter. Just above the hardpan the soil is yellowish-brown highly calcareous loam or clay loam, which is less dense than the overlying material. The yellow hardpan layer occurs at a depth ranging from 2 to 5 feet and consists of clay cemented with lime. It ranges from 2 to 12 inches in thickness, and is considerably softer than the hardpans underlying the Madera or the San Joaquin soils. The material below the hardpan is light-brown or light brownish-gray calcareous fairly compact loam or clay loam. The soil contains some mica and quartz particles but seems to be of somewhat mixed mineralogical composition.

Because of its high salt content, Lewis fine sandy loam is of little value for agriculture. The thin surface soil is comparatively free of soluble salts, but the subsoil layers contain a large quantity, especially of sodium carbonate. Owing to this condition, roots do not penetrate the subsoil.

This soil occupies level plains that have a microrelief characterized by low mounds and intervening flat spots or depressions. Surface drainage is restricted, and water stands on the surface for a long time after rains. Many barren slick spots occur within the areas supporting a growth of inkweed and other salt-tolerant plants.

A total area of 16 square miles is mapped, mainly in one large body west of Lindsay and Strathmore. This soil lies below areas of Madera loam and just above areas of Fresno fine sandy loam, and it is used only for pasture.

Along Lewis Creek east of Lindsay, in Round Valley, and in Frazier Valley, are several very small bodies of Lewis fine sandy loam that differ from the typical soil in having a thicker surface layer, ranging from 6 to 15 inches in thickness, of calcareous fine sandy loam or loam, overlying a light brownish-gray calcareous loam or clay loam subsoil. A calichelike hardpan of cemented basic igneous cobbles lies from 2 to 5 feet below the surface and ranges from 1 to 3 feet in thickness. It is underlain by a substratum of gravel and cobbles of basic igneous rocks. These areas are better drained and contain less salts than does typical Lewis fine sandy loam. A few orchards of citrus fruits and olives have been planted, but they show injury from alkali.

Lewis clay loam.—The surface soil of Lewis clay loam consists of light-gray or dull-gray calcareous clay loam to a depth ranging from 6 to 12 inches. It is underlain by dark brownish-gray compact calcareous somewhat prismatic clay that contains more calcium carbonate in soft nodules and seams and is darker colored in the upper part than in the lower part. At a depth of approximately 20 inches is light pinkish-brown or salmon-colored clay loam which has a very high lime content and is softer than the material in the layer above. The light brownish-gray highly calcareous hardpan layer, occurring from 2 to 5 feet below the surface, normally ranges from 4 to 10 inches in thickness and is softer than the hardpan underlying the Madera soils but harder than that underlying the Fresno soils. The soil material below the hardpan is light brownish-gray calcareous loam or clay loam. This material is fairly massive in place but breaks readily in the fingers. Some granitic mica and quartz particles and a considerable quantity of mixed basic igneous materials are present throughout.

This soil occupies flat, more or less basinlike areas, including a few low hog-wallow mounds and depressions. Surface drainage is poor, and water stands on the surface after rains. Subdrainage is very slow because of the compact heavy-textured subsoil.

This soil occupies a total area of 20.8 square miles. It occurs chiefly in a large area extending from the Kings County line, a few miles south of Traver, in a northeasterly direction to Seville. The extreme eastern part, extending from the Visalia-Cutler highway to Seville, has a surface soil of clay texture.

This soil is extremely high in soluble salts, and black alkali is very abundant. The land has no value for farming, except for the pasturage afforded by the vegetation, which is chiefly saltgrass. The flat position, heavy-textured subsoil, underlying hardpan, and content of black alkali make the possibility of reclamation of this land very questionable.

FRESNO SERIES

The members of the Fresno series have light-gray surface soils that are very low in organic matter, calcareous, and contain many fine sharp particles of silica. At a depth ranging from 6 to 12 inches the soil material becomes more compact, highly calcareous, in many places is mottled with brown and yellow stains, and, although it is not much heavier in texture than the surface soils, breaks out in small blocks, which pulverize fairly readily to a floury mass. This material is underlain by light-gray very compact silty calcareous hardpan plates or lenses at a depth ranging from 18 to 48 inches, which continue to a depth of several feet. Most of the lenses range from only ½ to 2 inches in thickness and are separated by mottled uncemented sandy loam and fine sandy loam. They probably represent silty layers that were deposited in the small depressions during the process of building up the soil material by deposition and were cemented by lime and possibly other cementing materials. They are very irregular in depth, thickness, and hardness.

The Fresno soils are developed on alluvial outwash, which has its source mainly in granitic rocks. These soils occupy the broad level valley floor midway between the alluvial fans of the Kings, Kaweah, and Tule Rivers. The land slopes gently toward the west. The microrelief is characterized by small mounds and depressions, locally known as hog wallows. After rains, the water stands in the depressions until evaporated. Subdrainage is very much restricted by the hardpan layers and the puddled structure of the soils. The presence of black alkali has deflocculated the soil material, causing it to absorb water very slowly, and renders the reclamation of these soils very difficult.

The Fresno soils have developed under poor drainage and a high content of soluble salts, of which sodium chloride, sodium sulfate, and sodium carbonate are present in large quantities, but they do not have the solonetzlike structure of the related Lewis soils. The related Traver soils lack the hardpan lenses but otherwise are very similar to the Fresno soils. Fresno fine sandy loam is the only type mapped in this area. Owing to its high content of salts, which limits any agricultural development, no attempt is made in mapping to differentiate included areas of sandy loam or loamy sand.

Fresno fine sandy loam.—The surface soil of Fresno fine sandy loam is light-gray highly calcareous fine sandy loam, with included variations of very fine sandy loam or, in places, sandy loam. At a depth ranging from 8 to 12 inches, the soil becomes more compact and is slightly heavier textured in places. The silty calcareous hardpan lenses are reached from 18 to 48 inches below the surface. The hardpan layers range in thickness from less than 1 to 3 inches and alternate with layers of light-gray or dull-gray sandy loam or silty loam. The material is highly micaceous throughout.

Fresno fine sandy loam occupies the broad level valley floor midway between the alluvial fans of the Kings, Kaweah, and Tule Rivers and extends to some distance out on the floor of the valley. The microrelief is characterized by small hog-wallow mounds and depressions. Surface drainage is poor, as water stands in the depressions after rains; and subdrainage is very much restricted by the hardpan layer and the puddled condition of the soil. Sodium carbonate is present in sufficient quantity to puddle the soil and render reclamation very questionable. About 20 percent of the land is bare of vegetation, but the rest supports a growth of saltgrass and other alkali-tolerant plants. A growth of short grasses may spring up on the crests of the mounds after the winter rains but soon dries when the rains cease. The organic-matter content is extremely low. With the exception of some use for pasture, Fresno fine sandy loam has no agricultural value.

MISCELLANEOUS LAND TYPES

In addition to soils that fall into a natural classification of soil series, types, and phases, described in the preceding pages, two miscellaneous land types—rough stony land and riverwash—are mapped.

Rough stony land.—Rough stony land consists of rugged stony and steep areas, in which the slope is too steep and the soils too shallow and stony for cultivation. A large proportion of rock outcrop and much loose stone are characteristic of this land. Included in this material is a small area of steep land without stones, which would be separated as rough broken land if it were more extensive. The steep slopes have a shallow layer of soil material, which continually moves downward, thereby exposing the bedrock in places. Areas are included of both coarse-textured and fine-textured igneous rocks, such as those that give rise to the residual soils of the Vista, Lassen, and Las Posas series. Some areas having a thin covering of soil similar to the Vista soils support a cover of oak trees and some grasses, but the areas of soil developed from the finer textured rocks support only grasses. Both afford some grazing. Run-off is excessive.

Rough stony land occurs in the mountainous section east of the valley land and in the isolated stony hills along the eastern edge of the area. The total area is 63.7 square miles. It is classed as nonagricultural land.

Riverwash.—Riverwash includes alluvial deposits of coarse sand and gravel occupying the present channel of the Kaweah River. The material is light gray and is composed chiefly of granitic fragments similar to those in the coarser textured Tujunga soils. Riverwash is subject to overflow when the river channel contains water. It is barren of any vegetation except some brush and cottonwood trees along the edges of the areas. It has no agricultural value.

SALTS AND ALKALI

The term "alkali" as commonly used in the West refers to all the more soluble mineral salts, though such a use is not technically correct. These salts accumulate in the soil in places, because of poor drainage and excessive surface evaporation, in concentrations harmful to the growth of plants. The salts are formed or released directly or indirectly through the natural weathering to which rocks are subjected. The most common salts are sodium chloride (table salt), sodium sulfate (Glauber's salt), sodium bicarbonate (baking soda), calcium chloride, and magnesium sulfate. These are not distinctly alkaline in reaction and not true alkalies and are popularly referred to as "white alkali" because of the white crust formed on the soil when they accumulate on the surface. Sodium carbonate, a true alkali, acts on the organic matter in the soil, giving rise to dark stains and a hard black crust and is popularly termed "black alkali." White alkali, comprising the saline salts, is less harmful than black alkali, which not only is extremely toxic to plants but also deflocculates, or puddles, the soil.

Soils containing black alkali are difficult to reclaim, particularly if they have heavy-textured surface soils, heavy-textured subsoils, or hardpan layers, which restrict the penetration or free movement of water. The saline, or white alkali, salts are more readily removed from the soil by leaching. The feasibility of such a procedure depends on the texture and structure of the soil, the underdrainage, and the relative proportions of replaceable calcium and sodium. Soils in which the content of calcium is low in proportion to the content of sodium are very difficult to leach because of sodium saturation, which results in puddling of the soil and a hard, tight, impervious condition. When present in comparatively large quantities, calcium replaces sodium in the absorption complex, and the soil is more permeable and in better physical condition. Soils with heavy-textured subsoils of solonetzlike structure, with a high sodium content, are exceedingly difficult to reclaim.

It has been shown that the application of sulfur or gypsum, which improves the chemical and physical condition, aids in reclaiming soils containing black alkali. In following such a procedure, applications of the chemical should be comparatively heavy. Many farmers apply a small quantity of these chemicals hoping to improve their soils and are disappointed by practically negative results.

Another factor which influences the toxic effects of salts is their localization in the soil profile. A concentration of toxic salts near the surface prohibits the growth of most cultivated crops, whereas if the salts are localized at a depth ranging from 4 to 5 feet they may not have much effect on shallow-rooted crops. This feature is made use of by farmers who plan to keep the salts at sufficient depth below the surface by careful management in irrigation.

According to Kelley and Brown (9), the following points should be carefully considered before attempting to reclaim an area of alkali soil: (1) Drainage conditions, (2) composition of the soluble salts, (3) content of replaceable (absorbed) sodium in the soil, (4) nature and content of the calcium minerals of the soil, and (5) composition of the available irrigation water. Another important item is the physical character of the subsoils, that is, whether or not they are pervious to the movement of water.

Saline and alkaline salts are present in many of the lighter colored lower lying soils of this area in sufficient quantities to harm or prohibit the growth of crops, and approximately 23 percent of the total area is affected to some degree. Salt-affected areas are enclosed on the soil map by broken or solid red lines. Three conditions, or grades, of salt accumulation are differentiated and shown by symbols. These are determined by the total salt content in field samples, the kind of salts, and the degree to which they affect or prohibit crop growth as reflected in native vegetation or field crops. The symbol A within solid outlines designates areas having a high concentration of salts; the symbol M within broken outlines, areas having a moderate concentration of salts; and the symbol S within broken outlines, areas that are slightly affected or of spotted character. The symbol F is used to designate the comparatively salt-free areas. The location of field samples is indicated on the map by red dots. The percentage of salts present, as determined by the Wheatstone electrolytic bridge, is indicated in the form of a fraction, thus $\frac{0.25}{0.60}$ B. The number above the line indicates the percentage of total salts in air-dry soil to a depth of 1 foot; and the number below the line shows the average percentage of salts to the depth sampled. The letter B indicates the presence of black alkali.

In the strongly affected areas the growth of crops is prohibited by a high concentration of salts. Such areas are for the most part barren of vegetation or support a growth of salt-tolerant plants, such as inkweed and saltgrass. Many barren spots have a white efflorescence or crust of the soluble salts. In places where the content of sulfates is high, the surface crust is fluffy and soft, whereas the black alkali salts deflocculate the soils, giving them a hard slick surface that does not absorb water readily. Water stands on the surface of such areas after rains. Approximately 10 percent of the total area surveyed, including nearly all of Lewis fine sandy loam, Lewis clay loam, and Fresno fine sandy loam, and approximately 25 percent of Traver fine sandy loam is in this strongly alkali affected grade. Salt determinations generally show a concentration of 0.6 to 3 percent of total salts in the surface soils as well as a similar content in the subsoils. Included spots might show a smaller amount, with high averages a few feet away. Sodium carbonate, or black alkali, was found to be present in more than 75 percent of the determinations. The soils containing a high concentration of salts would be very difficult to reclaim under any circumstances. Drainage is poor in both surface soil and subsoil, and the amount of replaceable sodium is high in the colloidal complex. Even if heavy applications of sulfur or gypsum were made, the drainage problem for the removal of soluble salts from the soil would still remain.

In areas having a moderate concentration of salts, the amount is sufficiently high in most places to prevent the successful growth of crops but not to prohibit the growth of all grasses. The concentration of salts in the surface soils is lower than that in the strongly affected areas. In some places where the subsoils are permeable, reclamation has proved successful by leaching out the soluble salts. No definite concentration limits were used in drawing boundaries for this grade of salt concentration, but generally the content of total salts is between 0.3 and 0.8 percent. In many places the surface soils are comparatively free of salts, but the subsoils contain from 0.6 to 0.8 percent. In general value and ease of reclamation, areas designated by M are more favorable than those designated by A; although at present very little use or attempt at reclamation is being made. Approximately 75 percent of Traver fine sandy loam, 20 percent of Cajon sandy loam, 12 percent of Madera loam, and 7 percent of Cajon fine sandy loam contain a moderate amount of salts.

Slightly affected, or alkali-spotted, areas occur in a number of soils including Cajon sandy loam, Cajon fine sandy loam, Madera loam, Chino clay loam, shallow phase (over Fresno soil material), Foster fine sandy loam and its shallow phase (over Fresno soil material), and a few spots in Chino silty clay loam and Chino fine sandy loam. The salt content in these areas ranges from 0.1 to 0.4 percent, but the salts are so distributed throughout the soil profile that they can be kept more or less under control and have but slight effect on crop growth. It must be borne in mind, however, that the occurrence of salts in small amounts is indicative of potential danger. Some of these areas can be improved materially or reclaimed by leaching, together with drainage, and careful irrigation must be practiced in order to keep the salts below the root zone. Included in this grade are spotted areas in which spots have a moderate concentration of salts with probably from 70 to 80 percent of the land being comparatively free. Where the spots are small and distinct this condition is shown on the map by a red plus (+) symbol rather than the symbol S.

Results of salt determinations, made in the laboratories of the University of California, in selected soil samples are given in table 8.

TABLE 8.—*Soluble salts in soils as determined [1] from water extracts, in the Visalia area, Calif.*

Soil type	Location	Depth	Vegetation and character of land	Various ions calculated as—						
				CO_3	HCO_3	Cl	SO_4	Na	Ca	Mg
		Inches		*Parts per million*	*Parts per million*	*Parts per million*	*Parts per million*	*Parts per million*	*Parts per million*	*Parts per million*
Chino silty clay loam	½ mile north of Buena Vista School.	0-12	Cotton; poor		1,098	70	109	400	40	15
Chino silty clay loam	⅝ mile north of Buena Vista School.	0-12	Cotton; good	30	335	50	31	(2)	50	13
Waukena fine sandy loam	3 miles southwest of Buena Vista School.	0- 5			122	60	94	125	10	17
		12-16	Columnar horizon		426	80	78	200	30	14
		30-36			183	30	37	125	30	9
Traver fine sandy loam	⅝ mile east of Liberty School	0- 2	Salty mulch	12,420	12,250	2,280	7,370	10,200	20	34
Traver fine sandy loam	1 mile northeast of Paige	0-12	No vegetation	9,300	6,527	1,090	5,330	9,000	33	61
		12-24		300	1,280	260	3,568	250	20	41
		24-54		60	610	60	159	200	20	35
Waukena fine sandy loam	3 miles north of Waukena	0-12		120	670	20	82	250	20	46
		12-24	Columnar horizon	120	976	40	101	250	30	35
		24-48		120	610	40	115	250	20	53
Traver fine sandy loam	1 mile north of Goshen	0-12	Bare	6,300	4,515	3,220	3,968	8,000	20	61
		12-24		420	1,400	800	568	450	30	36
		24-48			244	420	135	300	20	34
Waukena fine sandy loam	3 miles west of Walnut Grove School.	0- 8		60	610	120	324	250	30	23
		8-14	Columnar horizon	180	693	100	205	350	20	60
		14-24		120	1,098	100	215	350	30	48
		24-50		120	1,037	80	203	350	10	72
Chino fine sandy loam	2¼ miles north of Tulare	0-12	Saltgrass		122	790	450	350	140	117
		12-24		60	426	30	55	200	30	25
		24-60		30	275	40	54	150	20	25
Porterville adobe clay	¾ mile north of Seville	0-10	No evidence of salts	60	305	20	76		70	48

[1] Determinations made in the laboratories of the University of California, by using Hibbard's approximate method. CO_3, HCO_3, and Cl were determined by titration, and SO_4 by precipitation with $BaCl_2$.
[2] Trace.

IRRIGATION AND WATER SUPPLY

Owing to the low annual rainfall of this section and the high evaporation during the growing season, irrigation is necessary for the production of most crops. In many years the annual rainfall is not sufficient for the maturing of dry-farmed grain or grain hay. In the early agricultural history of the county the underground water table stood close to the surface over most of the Kaweah delta and the moisture supply was ample to cause the continual growth of forage crops during the summer. Following the settlement of these lands, the flow of the river and its tributaries was controlled by the farmers and pumps were installed for the purpose of withdrawing the underground water for irrigation. Eventually the ground water receded to a point where it became necessary to irrigate the native forage grasses, in order to keep them growing during the summer. The 1930 census reports a total of 6,239 irrigated farms in Tulare County, having a total irrigated area of 410,683 acres, more than 65 percent of which lies within the area covered by this survey.

Tulare County receives its supply of water (*2*, *7*) from three major streams—the Kings, Kaweah, and Tule Rivers. The Kaweah and Tule Rivers supply water for lands entirely within the county, and Kings River supplies water, both surface and underground, for lands in the northern part of the county. The Alta irrigation district serves lands on the south side of Kings River in Fresno, Tulare, and Kings Counties, and uses gravity water from canals during the period of high flow in the river, supplemented by pumping from wells. In general, the ground-water level has been lowered to some extent in this district, due to pumping, especially near the hills. The acre demand for water is less than in other parts of the county, owing to the large acreage devoted to grapes which use less water than do alfalfa or general crops. The Foothill irrigation district extends along the foothills east of Dinuba and Seville, where scattered citrus-fruit orchards obtain water from wells. Replenishment of ground water in this section is so small that the water table is dropping very rapidly, thereby making pumping more and more costly.

Records available on the Kaweah River show a mean annual discharge of 451,000 acre-feet. The combined mean annual discharge of Sand, Storey, Yokohl, and Lewis Creeks is 15,500 acre-feet. The Tule River discharges only a small amount of underground water into the area west of Strathmore. According to records of the State Division of Water Resources, the average run-off of the Kaweah River from 1921 to 1929 was 297,500 acre-feet, and a number of mutual water companies divert water from this river. An exception is the Tulare irrigation district. During the period of low water a supplemental supply must be obtained by pumping from wells. Records show that it requires a run-off of approximately 450,000 acre-feet to balance the amount used. For the 8-year period the water table dropped an average of 2.25 feet annually. Near the river the drop was small, but farther away it increased very rapidly. West of Tulare the water table has been lowered from 3 to 5 feet a year. The district between the deltas of the Kaweah and Tule Rivers receives a very small run-off from Yokohl and Lewis Creeks. Early pumping for citrus fruits resulted in a very rapid lowering of the ground water in the Lindsay-Strathmore district, and the present Lindsay-Strathmore irrigation district brings in water from the outside to augment the underground supply. About 7,800 acres were irrigated in 1929. Between 1921 and 1929 the ground water in this district was lowered an average of 6.85 feet.

In general a continuance of the present use of water will result in such a lowering of the ground water level that pumping no longer will be profitable on some of the land. Some reduction in acreage of irrigated land already has been made but not sufficient materially to relieve the situation as a whole. In many districts the present draft exceeds the replenishment.

The cost of irrigation water differs considerably. In the foothill district on citrus orchards it ranges from $20 to $60 an acre a year, and in the alfalfa- and cotton-growing district the yearly acre cost ranges from $5 to $15 (*1*).

Citrus fruits are irrigated from March to October, the usual practice being to give an irrigation each month for 6 to 8 months, although more frequent irrigations are given on the shallower soils. The quantity of water used ranges from about 1.5 acre-feet in places where water is scarce and expensive to as much as 3 acre-feet in some places, with a probable average of about 2.5 acre-feet. The furrow method of applying water is in common use. Deciduous fruits also are usually irrigated by means of furrows, but on a few farms the basin system of irrigation is followed. The quantity of water used is less than for citrus fruits, owing to the shorter irrigating season, but generally a larger quantity is applied at each irrigation. The average duty of water for the area as a whole is probably about 2 acre-feet, applied in about four irrigations, except on the areas of hardpan soils where the number of irrigations is increased and a smaller quantity of water given at each irrigation. Grapes are irrigated in about the same manner as deciduous fruits, but the quantity of water at each irrigation is less.

Alfalfa is irrigated by means of border checks, ranging from 40 to 80 feet in width and from 250 to 1,320 feet in length, the larger checks being used on the heavier textured soils and the smaller checks on the sandier soils. The irrigation season extends from March to September, inclusive, about 6 acre-inches are used a month, applied in one or two irrigations. On the soils that do not absorb water so readily, two irrigations a month are made, and on the deep medium-textured alluvial soils, one irrigation of 6 inches generally is applied. From 3 to 4 acre-feet are used annually on alfalfa, the average under all conditions probably being 3.5 acre-feet, but with careful practice, without wastage, 3 acre-feet probably would be ample. The total quantity used depends to considerable extent on the cost of water, as where water is cheap a larger quantity is used.

Cotton is irrigated by means of furrows. A heavy irrigation of 6 to 10 acre-inches generally is applied before the cotton is planted, followed by two or three irrigations of 4 to 6 acre-inches each, after the first of July.

Summer crops, such as Egyptian corn and milo, are given one to four irrigations, the total use of water probably ranging from 0.8 to 1.5 acre-feet. The acreage devoted to irrigated grain crops varies from year to year, and the quantity of irrigation water applied depends on the amount and distribution of the rainfall. Two irrigations may be necessary in a season of low rainfall, whereas one heavy application of water may be ample in a year of normal rainfall. Where water is not too expensive, an irrigation for grain more than repays the cost in the increased yield.

CLASSIFICATION OF SOIL TYPES ACCORDING TO CHARACTERISTICS AFFECTING PRODUCTIVITY

In Table 9 the soils of the Visalia area are evaluated by means of the Storie index (*11*) on the basis of such soil characteristics as depth, texture, density of the surface soil and subsoil, reaction, content of salts, and drainage conditions. This index rating is based solely on soil characteristics in which local climatic conditions or availability of irrigation water are not considered and is a comparison of the soils in this area with other soils of California, irrespective of location.

TABLE 9.—*Classification of the soils of the Visalia area, Calif., arranged in descending order of their index rating*

Grade	Soil type	Index
		Percent
1	Cajon fine sandy loam	100
1	Foster fine sandy loam	100
1	Foster loam	100
1	Foster sandy loam	95
1	Hanford sandy loam	95
1	Honcut sandy loam	95
1	Greenfield sandy loam	95
1	Visalia sandy loam	91
1	Ramona loam	90
1	Chino fine sandy loam	86
1	Chino silty clay loam	86
1	Tujunga sandy loam	86
1	Honcut loam	80
1	Foster fine sandy loam (spotted salt concentration)	80
1	Cajon fine sandy loam (slight salt concentration)	80
2	Chino silty clay loam (spotted salt concentration)	76
2	Chino clay loam	73
2	Chino sandy loam	73
2	Cajon sandy loam	72
2	Dinuba sandy loam	72
2	Farwell fine sandy loam	70
2	Honcut silty clay loam	68
2	Chino fine sandy loam (slight or spotted salt concentration)	68
2	Traver fine sandy loam (slight or spotted salt concentration)	68
2	Greenfield sandy loam, shallow phase	67
2	Visalia sandy loam, shallow phase (over Fresno soil material)	65
2	Cajon sandy loam (slight alkali)	65
2	Exeter loam, gravelly phase	63
2	Exeter loam	60
3	Visalia sandy loam, shallow phase (over San Joaquin soil material)	57
3	Dinuba sandy loam (slight salt concentration)	57
3	Tujunga sand	56
3	Delhi loamy sand	53
3	Exeter clay loam	51
3	Porterville adobe clay	51
3	Foster fine sandy loam, shallow phase (over Fresno soil material)	50
3	Chino clay loam, shallow phase (over Fresno soil material)	48
3	Madera sandy loam	48
3	Hovey adobe clay	46
3	Vista sandy loam	43
3	Cajon fine sandy loam (moderate salt concentration)	40
3	Madera loam	40
4	Lewis fine sandy loam (nontypical material)	38
4	Traver loam (moderate salt concentration)	36
4	Cajon sandy loam (moderate salt concentration)	36
4	Madera clay loam	34
4	Madera loam (slight salt concentration)	32
4	Dinuba sandy loam (moderate salt concentration)	29
4	Traver fine sandy loam (moderate salt concentration)	26
4	San Joaquin loam	25
4	San Joaquin sandy loam	24
4	Seville adobe clay	24
4	San Joaquin clay loam	21
4	Madera loam (moderate salt concentration)	20
4	Foster fine sandy loam, shallow phase (over Fresno soil material) (considerable salt concentration)	20
5	Las Posas stony clay loam	19
5	Honcut sandy loam, gravelly phase	19
5	Yokohl clay loam	18
5	Yokohl clay	18
5	Porterville adobe clay, stony phase (steep, erodible)	17
5	Vista sandy loam, rock-outcrop phase	14
5	Tujunga sand, gravelly phase	12
5	Lassen stony adobe clay	11
6	Traver fine sandy loam (strong salt concentration)	8
6	Waukena fine sandy loam (strong salt concentration)	6
6	Lewis fine sandy loam (strong salt concentration)	4
6	Lewis clay loam (strong salt concentration)	4
6	Fresno fine sandy loam (strong salt concentration)	3
6	Rough stony land (nonarable)	2
6	Riverwash (nonagricultural)	2

On the basis of the index rating the soils are placed in six grades. Soils having an index rating ranging from 80 to 100 percent are placed in grade 1. They are considered to be of excellent quality and suitable to a wide range of crops. Grade 2 soils (index rating from 60 to 79 percent) are of good quality and suitable for most crops. Grade 3 soils (index rating from 40 to 59 percent) are somewhat limited in their use by extremes of texture, by drainage, by heavy-textured subsoils, or by other soil factors. Grade 4 soils (index rating from 20 to 39 percent) are suitable for few crops except grasses and shallow-rooted crops, or, possibly, salt-tolerant plants. Some soils in grade 4 may be raised to grade 3 by reducing their content of salts, drainage, leveling, or breaking of the hardpan by blasting. Grade 5 soils (index rating from 10 to 19 percent) generally are of very poor quality for any cultivated crop, owing to such conditions as shallowness or stoniness. Grade 6 soils (index rating of less than 10 percent) are nonarable or nonagricultural.

MORPHOLOGY AND GENESIS OF SOILS

The Visalia area lies along the southeastern margin of that part of the great interior valley of California drained by the San Joaquin River. The soils have formed under a climatic environment characteristic of the drier parts of the Pacific coast region. For further information on soil formation and classification see United States Department of Agriculture Yearbook for 1938 (*3*, *6*). The summers are very dry and warm and the winters mild and moist. Daily temperatures of 100° F. to 110° are not uncommon in June, July, and August, during which months no rain falls. The temperatures of the winter months are moderate, and on only a few days does the temperature drop below 32°. The winter rains in general are gentle. In the valley, the annual precipitation ranges from 6 to 13 inches, with an average of about 9 inches. It is a few inches more in the eastern foothill belt. The climate is distinctly semiarid.

Under this prevailing climate, the native vegetation consists mainly of short grasses on the lower foothills, well-drained plains, and alluvial fans; oaks and brush on the higher hills and mountains; moisture-loving plants on the more poorly drained salt-free land; and salt-tolerant grasses and plants on the salt-affected soils. Oaks cover the valley lands where the moisture supply is sufficient and the soils do not contain too much salts. On the grass-covered soils, a good growth of alfileria, bur-clover, and other herbaceous plants spring up following the winter rains, but with the coming of the warm dry summer they dry up. The organic matter formed by their decomposition is, for the most part, oxidized and destroyed during the summer and fall. As a result, most of the well-drained soils are light brown, brown, or reddish brown. On the lower more poorly drained soils the growth and decomposition of grasses, sedges, and other moist-land plants have caused a greater accumulation of organic matter, with the result that the soils are dark grayish brown, dark brownish gray, or dark gray. Many of the soils on the Kaweah delta are dark-colored, owing to an ample supply of water for the growth of grasses. The salt-affected soils are generally light gray or light brownish gray, with included black alkali spots of darker color.

All the soils range from neutral to alkaline in reaction. Many contain lime throughout the entire soil mass, and others have accumulated lime in the subsoils. A large acreage of soils contains an excess of soluble salts, and these soils are commonly known as alkali soils. These characteristics are the result of the low rainfall.

The texture of the surface soils depends to a great extent on the kind of parent material and the processes of accumulation of that material. The coarse-textured rocks, such as granite, give rise to coarse-textured soils, and the fine-textured rocks form fine-textured soils. Soils developed at the heads of the alluvial fans are of coarser texture than those at the bases of the fans.

The soils of the Visalia area are identified with four physiographic divisions, namely: (1) Soils of the foothills, (2) soils of the alluvial fans and plains, (3) hardpan soils of the terraces, and (4) saline and alkali soils of the basins. The soils are further classified on the bases of differences in color and profile.

Some of the soil series and types recognized in the Visalia area present apparent conflicts in mapping and classification with those of the earlier reconnaissance of the middle San Joaquin Valley (*8*). These conflicts and discrepancies are the result, in part, of differences in the scope, character, and purpose of the two kinds of surveys. The purpose of the earlier survey was to obtain information of a general character, within a short space of time, covering a large area. The maps were drawn on a small linear scale, and for practical purposes the soils were classified into inclusive related or closely associated soil series and groups. In the present survey a smaller area is mapped in much greater detail, and the classification is the result of much more intensive field observation and technical study, and progressive development in the science of soils and their classification since the date of the earlier survey. This has resulted in the recognition of new soil series and types and the dividing of former inclusive categories into two or more individual soil series or types, defined on the basis of more detailed and more accurate scientific study.

The soils of the foothill section are developed on consolidated parent bedrock, and, because they occupy slopes, erosion is more or less active and keeps pace with weathering agencies, resulting in immature soil development. The surface soils, except in the heavier textured soils, are of soft or medium-granular structure and are fairly friable. The subsoils in general are slightly heavier textured than the surface soils, and when dry they break into slightly compact blocks. The subsoils grade into the disintegrating bedrock, and fragments of the parent bedrock occur in most places in the lower parts of the subsoils. The surface soils range from neutral to slightly basic in reaction. This section of the area includes soils of the Vista, Las Posas, and Lassen series.

A typical profile of the soils of the foothill group is represented by Vista sandy loam. Under virgin conditions the A_1 horizon, to a depth of about 2 inches, consists of light grayish-brown granular sandy loam that is permeated with grass roots. The A_2 horizon, which extends to an average depth of 14 inches, is brown sandy loam, which is fairly soft when moist and has a faintly developed granular structure. The soil does not contain sufficient carbonate of lime to effervesce when tested with dilute hydrochloric acid but has a pH value of 7.0 or above. At a depth ranging from 12 to 16 inches, the subsoil consists of light reddish-brown slightly compact gritty loam, which breaks out somewhat blocky when dry and includes some pieces of granite bedrock. The material in this horizon is slightly basic in reaction but does not effervesce when tested with dilute hydrochloric acid. It shows some slight accumulation of colloidal clay. The disintegrating granitic bedrock occurs at a variable depth below the surface. Particles of quartz, mica, and feldspar are prominent throughout the soils of the Vista series. Vista soils occur under a fairly low rainfall. In the earlier reconnaissance they were included with the soils of the Holland series, which are now recognized as having developed under higher rainfall, with resulting differences in reaction.

The soils of the Las Posas series are developed on fine-textured igneous parent rocks, such as amphibolites. The surface soils are reddish brown or light brownish red, and the subsoils are slightly redder and slightly compact. Both surface soils and subsoils are of basic reaction but do not effervesce when tested for lime with dilute acid. The Las Posas is a comparatively new soil series. The earlier reconnaissance classed these soils with the Olympic or Sierra series. The Olympic series is now restricted to residual soils developed under higher rainfall and having somewhat different physical and chemical characteristics, and the Sierra soils are derived from granitic parent material under higher rainfall.

The Lassen soils are of chocolate-brown color and rest on fine-textured basic igneous bedrock. Both the surface soils and subsoils are of heavy texture and break to a typical adobe block structure. The surface soils normally are noncalcareous, but the lower part of the subsoils and top of the bedrock generally contain lime in visible form. The Lassen soils were classed with the Olympic series in the earlier reconnaissance.

The soils of the recent or young alluvial fans and flood plains are represented by soils of various colors, mineralogical composition, lime content, drainage, and stage in profile development, depending on general drainage conditions, parent material, and the time the soils have remained in place. The brown well-drained recent or young alluvial soils are classed in the Hanford, Honcut, Farwell, and Greenfield series.

The Hanford soils are brown or light brown throughout the entire profile, with the exception of the topmost part which appears a little more grayish brown. These soils are friable, highly micaceous, and contain considerable quartz fragments. They break down to a single-grain structure when dry but are somewhat granular when moist. The subsoils and parent material are made up of stratified alluvial materials having their source in coarse-textured igneous rocks. The soils are slightly basic in reaction, but they do not effervesce when tested with dilute hydrochloric acid.

The Honcut soils appear similar to the Hanford soils but are of richer brown or more reddish brown color and contain less conspicuous mica or quartz particles. They are derived from outwash material, mainly from basic igneous rocks, and are slightly basic in reaction. These soils were included with the Hanford soils in the earlier reconnaissance. Table 10 gives the results of mechanical analyses of samples of the surface soil and subsurface soil of Honcut sandy loam.

TABLE 10.—*Mechanical analysis of Honcut sandy loam in the Visalia area, Calif.*

Sample No.	Description	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay
		Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
578594	Surface soil, 0 to 16 inches	2.8	9.5	9.7	22.5	14.6	28.4	12.5
578595	Subsurface soil, 16 to 72 inches	5.2	8.5	6.5	21.4	14.6	30.6	13.2

The Greenfield soils are similar to the Hanford soils in color and mica and quartz content, but the subsoils are slightly more compact and slightly heavier textured than the surface soils. They represent a very youthful stage in soil development in granitic alluvial material slightly older than the Hanford material but not so far advanced as the Ramona soils. The subsoils contain a slight accumulation of colloidal clay, and when broken out the material takes the form of soft irregular-shaped clods, which can be pulverized readily. The reaction of the soil mass is neutral to slightly basic.

The darker colored recent and young alluvial soils are grouped in the Visalia, Foster, and Chino series. These soils contain more organic matter than any other soils of the area.

The members of the Visalia series have dull brownish-gray micaceous surface soils and light grayish-brown micaceous subsoils. They are developed where considerable moisture has resulted in a good growth of grasses and herbaceous vegetation. They are like the Hanford soils in that they are formed by recent deposition of granitic alluvial material but are darker than those soils. They differ from the Foster soils in having a lower content of lime and in not effervescing when tested with acid. They were included with the Foster and Hanford soils in the reconnaissance.

The members of the Foster series have surface soils that are typically dull brownish gray or dark brownish gray, highly micaceous, of fine-granular structure, calcareous, and friable. The subsoils are light grayish brown and in general contain less lime than the surface soils. The subsoils are stratified and rest on micaceous stratified soil material mainly of sandy texture. The lime content ranges from 1 to 6 percent in these soils.

The Chino soils are associated for the most part with the Foster soils, but they occupy a lower position and have heavier textured and more compact subsoils. They appear to represent advanced development in Foster soil materials. Following is a description of a profile of Chino fine sandy loam which is representative of soils of the Chino series.

A. 0 to 12 inches, dark brownish-gray calcareous fine sandy loam, which is dull gray or dark gray when wet.

B_1. 12 to 26 inches, dark brownish-gray calcareous silty clay loam, which is slightly compact and breaks to irregular-shaped blocks. Lime occurs in soft nodules in seams and old root channels.

B_2. 26 to 42 inches, light brownish-gray uniformly calcareous slightly compact loam, which breaks to irregular-shaped blocks.

C. 42 to 72 inches, light-brown friable sandy loam, slightly calcareous.

The light-colored soils having recent or young profiles are grouped in the Tujunga and Cajon series.

The Tujunga soils consist of very recent alluvial deposits of granitic material, are very low in organic matter, and are light gray or light brownish gray. The subsoils are of about the same color and generally are coarser in texture than the surface soils. These soils are related to the Hanford soils but are of lighter color and lower organic-matter content. They differ from the Cajon soils in that they are not calcareous.

As mapped in this area the Cajon soils are similar to the Tujunga soils, but they effervesce when tested with acid, indicating the presence of considerable lime. They are associated with the Foster soils on the delta of Kaweah River but are lighter in color. They are probably a little darker and show more mottling in the subsoil than do the Cajon soils mapped on the Mojave Desert.

The members of the Delhi series are developed on wind-modified alluvial deposits and have light grayish-brown surface soils. The subsoils are light brown, slightly compact, and of about the same texture as the surface soils, with, in most places, some slight staining and discoloration in the lower part. The entire soil mass is noncalcareous, the reaction being about neutral or slightly basic. These soils are sandy throughout, the total sands comprising about 80 percent of the soil material. These soils were included with the Oakley soils in the earlier reconnaissance.

The Porterville and Hovey soils have about the same general sequence of soil horizons. They are derived from the same general kind of parent material and have moderately developed profiles with nodular accumulations of lime in the subsoils.

The members of the Porterville series have dark chocolate-brown heavy-textured surface soils with a high colloidal content. They have a typical adobe structure, forming blocks ranging from 12 to 16 inches in diameter when dry. At a depth ranging from 12 to 16 inches nodular accumulations of lime begin. This material also breaks with an adobe structure. It is underlain, at a depth ranging from 30 to 50 inches, by reddish- or yellowish-brown calcareous clay. The Porterville soils occupy sloping alluvial fans adjacent to hills that are underlain by fine-textured igneous rocks. This is an old established series.

The surface soils of the Hovey soils are dark gray, heavy textured, and slightly or moderately calcareous. The subsoils have a high content of lime. These soils occupy flat areas below the Porterville soils and are derived from the same kind of basic igneous material. The organic content is high.

The Ramona soils represent a somewhat more advanced stage in development of the Greenfield soils, and they have more compact subsoils.

The Dinuba soils occupy a position on the alluvial plains between the recent alluvial soils and the lime hardpan soils of the Fresno series.

They have light brownish-gray surface soils which appear light brown when moist. They are highly micaceous, porous, and of basic reaction, although they do not contain lime carbonate in sufficient quantities to produce effervescence when tested with dilute acid. The subsoils, beginning at a depth ranging from 12 to 30 inches, are light gray or light brownish gray, somewhat heavier textured than the surface soils, contain some colloidal accumulation, and are slightly to moderately calcareous. Lenses of light-gray silty material, softly cemented with lime, occur at a depth ranging from 3 to 6 feet below the surface. The soil material between and below these layers is light-gray sandy loam or fine sandy loam, high in mica. The Dinuba is a new soil series recognized for the first time in this area. Similar soils were classed as brown phases of the Fresno soils in the earlier reconnaissance.

The members of five soil series are included in the group of hardpan soils of the terraces. The locations of these soils are shown in figure 2. They are members of the Exeter, San Joaquin, Yokohl, Seville, and Madera series.

The members of the Exeter series have brown micaceous surface soils that rest on light reddish-brown or yellowish-brown slightly compact subsoils of somewhat heavier texture, at a depth ranging from 16 to 20 inches. These layers are noncalcareous and about neutral in reaction. A silica-and-iron-cemented hardpan occurs at a depth of about 30 inches below the surface and ranges from 3 to 12 inches in thickness. The material below the hardpan is light grayish-brown compact sandy loam. The Exeter soils have their source, to a considerable extent, in materials of granitic origin. They occupy gently sloping terraces. In stage of development they are immature but are developed on a hardpan. The soil material above the hardpan is very similar to the Greenfield or Ramona soils. The Exeter soils were differentiated in the old soil survey of the Porterville area but have not been mapped since. They were included with the Madera soils in the reconnaissance of the middle San Joaquin Valley.

The San Joaquin soils are the most extensive soils of this group. The following description of a profile of San Joaquin loam is representative of the characteristics of these soils. The land is undulating, with a hog-wallow relief. The soil appears red as viewed across a field.

- A. 0 to 10 inches, light reddish-brown noncalcareous loam, which bakes fairly hard on drying but is somewhat granular when moist.
- B. 10 to 20 inches, red compact noncalcareous clay, which breaks to a prismatic structure when dry; roots extend along cracks rather than penetrate the blocks, which have slick shining faces, due to a high accumulation of colloidal clay.
- B_2. 20 to 38 inches, reddish-brown iron-and-silica-cemented hardpan, which is very massive and hard. The lower part of the hardpan contains a little lime, in seams, and embedded quartz particles. The hardpan does not soften when placed in water.
- C. 38 to 72 inches, brown or drab-brown compact micaceous loam, which is fairly massive in place but can be broken between the fingers.

The San Joaquin soils are developed on old transported material, which has its origin mainly in coarse-textured igneous rocks. They represent the more extremely developed hardpan soils, developed from materials similar to those of the young soils of the Hanford and Greenfield series. Processes of weathering and soil development, probably operating under rather abnormal or impeded drainage conditions for a long period of time, have produced the hardpan and the claypan above it. The San Joaquin is an old established series.

The Yokohl soils are very similar to the San Joaquin soils in general position, relief, color, and sequence of horizons, but they are derived from fine-grained basic igneous rocks, and the conspicuous mica and quartz minerals present in the San Joaquin soils are lacking. Schistose rock fragments are present in the hardpan and to some extent throughout the rest of the soil material. The Yokohl soils represent a new series of soils recognized for the first time in this area.

The Seville soils are of heavy texture and are associated with the Porterville soils on flat terracelike relief. These soils are derived from basic igneous material. The dark chocolate-brown surface soils break into large adobe blocks on drying. The 4- to 6-inch surface layer, in most places, does not effervesce when tested for lime, but the subsoils have a high content of lime in nodular form. The color of the subsoils is about the same as that of the surface soils, but it becomes somewhat pinker just above the hardpan. A somewhat brown platy lime-cemented hardpan is at a depth ranging from 24 to 48 inches below the surface. The soil material below the hardpan is light grayish-brown moderately compact clay loam containing lime in seams. This is a new series of soils mapped for the first time in this area. These soils were classed with the Porterville or the Madera soils in the earlier reconnaissance.

The Madera soils are related to the San Joaquin soils but are browner, have lime in the subsoil, and have a hardpan that contains considerable lime in seams and cracks. The Madera soils occupy a place intermediate between the San Joaquin soils and the Lewis soils, both in general characteristics and geographic location. In the Visalia area they contain more lime in the subsoils and have a softer hardpan than in places where they occur farther north in the San Joaquin Valley.

The light-colored saline and alkali soils of the valley flats and basins are represented by the Traver, Lewis, Waukena, and Fresno soils. All occupy areas where both surface drainage and subdrainage are restricted and where the vegetation, except that resistant or tolerant of salts, is sparse. These soils contain both the white, or saline, and black alkali salts.

The members of the Traver series have light-gray calcareous surface soils and light-gray moderately compact subsoils of the same or of slightly heavier texture than the surface soils. The substrata consist of light-gray or light yellowish-gray micaceous sandy alluvial materials. The Traver soils are associated with the related Fresno soils, but they lack the cemented silty hardpan layers that underlie the Fresno soils.

The Waukena soils have light-gray surface soils with very compact impervious solonetzlike subsoils.

The Lewis soils are characterized by very thin light-gray surface soils, which are vesicular when dry. At a depth ranging from 2 to 4 inches, the material is dark brownish-gray very compact clay of columnar structure. The upper 3 or 4 inches of this horizon has very dark colloidal staining. Roots do not penetrate the columns. The layer below this is browner and breaks to hard angular blocks. At a depth ranging from 24 to 30 inches, this material rests on yellowish-brown loam that is high in lime, and this, in turn, rests on yellowish-gray calcareous hardpan lenses, ranging from 1 to 6 inches in thickness, composed of heavy-textured lime-cemented material. The soil material below the hardpan is light grayish-brown calcareous loam or clay loam. In many respects the Lewis soils seem to represent a solonetzlike development of the Fresno soils.

The Fresno soils are light gray, and the subsoils are only slightly heavier textured than the surface soils. The most characteristic feature is the presence of the light-gray silty hardpan lenses, which occur at a depth ranging from 2 to 3 feet below the surface, are from 1 to 3 inches thick, and alternate with layers of friable soil material. The Fresno soils have developed under poor drainage, with a heavy accumulation of soluble salts of sodium and calcium. The silty lenses probably were deposited in the small depressions when the soil material was accumulating, and, following deposition, were cemented by calcium carbonate and other cementing materials. These soils are low in organic matter and contain many sharp particles of silica. They are developed on alluvial outwash, which probably had its source in coarse-grained igneous rocks. The presence of black alkali has deflocculated these soils, but they do not have the solontezlike morphology of the related Lewis soils.

LABORATORY STUDIES[8]

The results of mechanical analyses and other laboratory studies are shown in tables 11, 12, and 13.

TABLE 11.—*Mechanical analyses of several soils from the Visalia area, Calif.*[1]

Soil type and sample No.	Depth	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay (5μ-2μ)	Colloid (<2μ)
Dinuba sandy loam:	*Inches*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
578507	0–20	1.31	9.42	5.34	19 29	20.74	34.02	3.44	4.55
578508	20–50	.49	7.12	4.57	23 37	20 70	37.02	3.24	3.62
578509	50–56	3.66	3.93	2 38	13 36	14.51	38.63	13.66	9.60
578510	56–75	.04	1.12	1.23	18.95	31.55	42.48	2.67	1.17
San Joaquin loam									
578533	0–10	1.58	7.45	6.65	21.21	13.66	30.92	3.61	15.63
578534	10–20	1.00	4.54	3.78	11.84	5.92	13.09	2.12	58 36
578535	[2] 20–38	-------	-------	-------	-------	-------	-------	-------	-------
578536	38–72	-------	-------	-------	-------	-------	-------	-------	-------
Greenfield sandy loam:									
578552	0–24	2 85	9.72	6.06	22.33	15.62	28 38	3 17	13.08
578553	24–42	3.51	9.27	9 01	24.05	13 36	23 44	2 56	14.66
578554	42–65	5.60	11.24	9 07	24.66	12.75	20.60	2.91	12.41
Traver fine sandy loam:									
578562	0–20	1.06	9.78	5 62	20 87	16 49	37.83	4.13	3.87
578563	20–50	.60	7.73	4.51	12 84	15.81	41 54	9.61	6.61
578564	50–72	1 09	12.12	7.01	18 17	8.38	45.47	4.28	2.74
Fresno fine sandy loam:									
578565	0–9	.06	2.97	4.93	17.66	18 26	45.30	5.68	4.26
578566	9–20	.22	3.12	2 58	13 87	14.37	48 47	8.20	8.68
578567	20–30	31	2 26	2.37	10.36	12 40	55.31	10.28	7.09
578568	30–38	4.15	10.03	4.54	12.93	14.93	35.50	11.20	7.48
578569	38–48	.06	.53	.76	15.18	14.44	32.74	19.78	17.18
Yokohl clay loam:									
578581	0–12	1.35	2.12	1.94	7.22	10.11	42 74	5 41	29.02
578582	12–20	.92	2.46	1.64	6.35	8.63	36.32	3.40	41.27
578583	[2] 20–24	-------	-------	-------	-------	-------	-------	-------	-------
578584	24–28	-------	-------	-------	-------	-------	-------	-------	-------
578585	28–40	-------	-------	-------	-------	-------	-------	-------	-------

[1] Analyses by the modern international method.
[2] Hardpan.

[8] This discussion is a contribution from C. F. Shaw, division of soil technology, University of California.

TABLE 11.—*Mechanical analyses of several soils from the Visalia area, Calif.*—Continued

Soil type and sample No.	Depth	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay (5μ-2μ)	Colloid (<2μ)
Chino silty clay loam:	*Inches*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
5785115	0–16	.37	1.47	1 24	6 31	10 75	53 98	9.34	17.33
5785116	16–30	.14	1.10	.76	5.43	13.79	54 63	8.33	17.44
5785117	30–48	.55	2.46	1 74	13.35	13.73	44.36	6 81	17 66
5785118	48–60	1 08	7.99	5 90	29 47	17.27	18.66	3 99	15.67
Lewis fine sandy loam:									
5785125	0–3	2 53	4.84	4.35	17 79	15 61	42 23	4.82	7 86
5785126	3–12	2 27	6.56	5 17	15 37	14.67	30.37	6.71	18.85
5785127	12–28	1.47	5.18	4 63	16 93	18 85	36.13	7.55	10 29
5785128	28–46	1 36	4.13	4.76	20.04	19.56	38.10	6.36	5.15
5785129	[2] 46–54								
5785130	[2] 54–72								
Madera loam:									
5785136	0–14	1 41	5 90	3.60	14.17	15 96	39.18	6 45	13.45
5785137	14–30	.88	4.98	4.29	14 34	14.35	37 84	5 89	18.13
5785138	30–42	1.05	4 83	4.12	22.73	22 40	32 97	4.79	7.12
5785139	[2] 42–48								
5785140	48–72								

[2] Hardpan.

TABLE 12.—*Moisture and carbonate relations of soils from the Visalia area, Calif.*

Soil type and sample No.	Depth	Moisture equivalent	Carbonate	Alkalinity
Porterville adobe clay:	*Inches*	*Percent*	*Percent*	
578501	0–12	41.14	0.72	
578502	12–40	42 66	4 28	+
578503	40–80	42 93	5.32	+
Delhi loamy sand:				
578504	0–16	5 92	.25	
578505	16–40	5 34	.23	
578506	40–80	5 94	.25	
Dinuba sandy loam:				
578507	0–20	10 84	3 20	
578508	20–50	11.79	2.38	+
578509	[1] 50–56		24 46	+
578510	56–75	11.39	1.90	+
Tujunga sandy loam:				
578511	0–12	11 82	.33	
578512	12–72	11.81	.28	
Madera clay loam:				
578513	0– 9	19 96	.72	
578514	9–16	22 71	.74	
578515	16–28	21.96	2.38	+
578516	[1] 28–35		15.34	+
578517	35–48	10.95	.45	
San Joaquin clay loam:				
578518	0– 9	15 64	.46	
578519	9–19	15.53	.46	
578520	19–27	23 23	.63	
578521	[1] 27–30		43	
578522	[1] 30–40		3.23	+
578523	40–80	14.69	40	
San Joaquin sandy loam:				
578524	0–20	12 44	.30	
578525	20–30	13 96	.48	
578526	[1] 30–33		.58	
578527	[1] 33–40		.38	
578528	40–55	8 74	.57	
Seville adobe clay:				
578529	0– 8	29.79	1.18	
578530	8–28	32.23	7.41	+
578531	[1] 28–64		30 00	+
578532	64–100	29 73	5.70	+
San Joaquin loam:				
578533	0–10	14.55	.35	
578534	10–20	31.77	.65	
578535	[1] 20–38		.65	
578536	38–72	18.47	.46	
Hovey adobe clay:				
578537	0– 6	42 19	1 64	
578538	6–18	42.43	2.26	
578539	18–40	42.28	12.11	+
578540	40–72	38.73	11.68	+

[1] Hardpan.

TABLE 12.—*Moisture and carbonate relations of soils from the Visalia area, Calif.*—Continued

Soil type and sample No.	Depth	Moisture equivalent	Carbonate	Alkalinity
Visalia sandy loam:	*Inches*	*Percent*	*Percent*	
578541	0-15	14 61	.42	----------
578542	15-72	15.10	.42	----------
Lewis clay loam:				
578543	0- 8	29 05	9.74	+
578544	8-17	37 20	14 68	+
578545	17-28	38.63	12 35	+
578546	[1] 28-34	----------	21 17	+
578547	34-50	21 55	7.83	+
Madera sandy loam:				
578548	0-16	11.81	.42	----------
578549	16-40	12.65	.69	+
578550	[1] 40-48	----------	7.88	+
578551	48-60	13.53	12.21	+
Greenfield sandy loam:				
578552	0-24	13 91	.36	----------
578553	24-42	13 91	.79	----------
578554	42-65	13.01	.32	----------
Vista sandy loam:				
578555	0-14	10 51	.24	----------
578556	14-24	16.73	.56	----------
578557	24-28	21.62	.73	----------
Hanford sandy loam:				
578558	0-12	14 16	.40	----------
578559	12-60	13.84	.40	----------
Tujunga sand				
578560	0- 8	5.62	.25	----------
578561	8-72	2.50	.19	----------
Traver fine sandy loam:				
578562	0-20	11 34	.38	+
578563	20-50	18.32	6 18	+
578564	50-72	11.66	.61	+
Fresno fine sandy loam:				
578565	0- 9	14 44	2.85	+
578566	9-20	21.17	3 23	+
578567	[1] 20-30	----------	1.68	+
578568	[1] 30-38	----------	10.21	+
578569	38-48	24 92	3.94	+
Cajon sandy loam:				
578570	0-18	10 04	.38	----------
578571	18-72	12.46	2.14	+
Chino fine sandy loam:				
578572	0-18	22 09	1.33	----------
578573	18-40	18 23	2.05	+
578574	40-72	15 85	.61	----------
Las Posas stony clay loam:				
578575	0-12	17.31	.46	----------
578576	12-24	17.33	.48	----------
Honcut loam				
578577	0-24	14.93	.50	----------
578578	24-72	15.93	.51	----------
Honcut silty clay loam:				
578579	0-20	24.01	.81	----------
578580	20-72	26.77	1 52	----------
Yokohl clay loam:				
578581	0-12	22 55	1.40	----------
578582	12-20	30 13	.79	----------
578583	[1] 20-24	----------	.78	----------
578584	[1] 24-28	----------	31.10	+
578585	28-40	26.85	12.11	+
Yokohl clay:				
578586	0- 8	39.67	1.04	----------
578587	8-24	36.99	1 08	----------
578588	[1] 24-28	----------	.37	----------
578589	[1] 28-34	----------	3 40	+
578590	34-58	35.22	20.80	+
Lassen stony adobe clay				
578591	0- 8	26.14	1.00	----------
578592	8-20	26.82	1.10	----------
578593	20+	26.77	32.10	+
Honcut sandy loam:				
578594	0-16	12.77	.41	----------
578595	16-72	14.53	.46	----------
Farwell fine sandy loam:				
578596	0-16	13.42	.58	----------
578597	16-72	17.28	3.23	+
Cajon fine sandy loam:				
5785102	0-12	11.35	.65	----------
5785103	12-72	28.99	1.27	----------

[1] Hardpan.

TABLE 12.—*Moisture and carbonate relations of soils from the Visalia area, Calif.*—Continued

Soil type and sample No.	Depth	Moisture equivalent	Carbonate	Alkalinity
Foster fine sandy loam:	*Inches*	*Percent*	*Percent*	
5785104	0-10	26.71	5.70	----------
5785105	10-72	20 17	5.23	----------
Chino clay loam:				
5785106	0-16	23 73	1.26	----------
5785107	16-30	14 73	1.06	----------
5785108	30-72	11.57	.85	----------
Foster loam:				
5785109	0-14	22.78	1.30	----------
5785110	14-60	20.38	.95	----------
Waukena fine sandy loam:				
5785111	0- 8	15 31	.52	----------
5785112	8-14	26 44	1.04	----------
5785113	14-28	20 30	1.64	+
5785114	28-48	14.53	1.19	+
Chino silty clay loam				
5785115	0-16	31 36	8.30	+
5785116	16-30	29 28	8.22	+
5785117	30-48	25.18	2.47	+
5785118	48-60	18.26	1.99	----------
Foster sandy loam:				
5785119	0-16	16.19	.72	----------
5785120	16-72	9.94	.96	----------
Chino fine sandy loam				
5785121	0-12	16.02	.88	----------
5785122	12-26	23.42	----------	+
5785123	26-42	20.73	1.30	+
5785124	42-72	13.23	.94	----------
Lewis fine sandy loam:				
5785125	0- 3	17.34	.48	----------
5785126	3-12	43 31	2.32	+
5785127	12-28	34.65	1.36	+
5785128	28-46	24 18	1.59	+
5785129	[1] 46-54	----------	25.50	+
5785130	54-72	24.11	----------	+
Exeter loam:				
5785131	0-16	14.47	.51	----------
5785132	16-30	13.26	.55	----------
5785133	[1] 30-32	----------	.64	----------
5785134	[1] 32-39	----------	.52	----------
5785135	39-50	12 06	.61	----------
Madera loam:				
5785136	0-14	15.39	.59	----------
5785137	14-30	29 08	1 35	+
5785138	30-42	27.87	5.22	+
5785139	[1] 42-48	----------	26 20	+
5785140	48-72	28.70	11.61	+

[1] Hardpan.

TABLE 13.—*Determinations of pH values of samples of typical soil profiles from the Visalia area, Calif.*[1]

Soil type and sample No.	Depth	pH	Soil type and sample No.	Depth	pH
Porterville adobe clay:	*Inches*		San Joaquin clay loam—Contd.	*Inches*	
578501	0-12	8 0	578520	19-27	6 5
Delhi loamy sand:			578521	27-30	7.6
578504	0-16	7 5	578522	30-40	7.9
578505	16-40	7 5	578523	40-80	7.6
578506	40-80	7.5	San Joaquin sandy loam:		
Dinuba sandy loam:			578524	0-20	7.1
578507	0-20	8.0	578525	20-30	7.1
Tujunga sandy loam			578526	30-33	7 3
578511	0-12	7.6	578527	33-40	7.9
Madera clay loam			578528	40-55	8.1
578513	0- 9	7 2	San Joaquin loam		
578514	9-16	7 6	578533	0-10	6 9
San Joaquin clay loam:			578534	10-20	6.7
578518	0- 9	6 7	578535	20-38	7.8
578519	9-19	6.8	578536	38-72	7.5

[1] Determinations made by the glass-electrode method, using a 1:3 suspension.

TABLE 13.—*Determinations of pH values of samples of typical soil profiles from the Visalia area, Calif.*—Continued

Soil type and sample No.	Depth	pH	Soil type and sample No.	Depth	pH
	Inches			*Inches*	
Greenfield sandy loam:			Honcut sandy loam:		
578552	0-24	8 1	578594	0-16	7.4
578553	24-42	7.6	578595	16-72	7.7
578554	42-65	7 7	Waukena fine sandy loam:		
Vista sandy loam:			5785111	0- 8	7 6
578555	0-14	7.4	5785112	8-14	9 0
578556	14-24	7.1	5785113	14-28	9 5
578557	24-28	7 0	5785114	28-48	9.5
Las Posas stony clay loam			Lewis fine sandy loam:		
578575	0-12	6.9	5785125	0- 3	6.9
578576	12-24	7.0	Exeter loam		
Yokohl clay:			5785131	0-16	6.9
578581	0-12	7 8	5785132	16-30	7.5
578582	12-20	7.5	5785133	30-32	7.9
578583	20-24	7.6	Madera loam:		
578584	24-28	8 2	5785136	0-14	7.0
578585	28-40	8.1	5785137	14-30	9.2
Lassen stony adobe clay			5785138	30-42	9.4
578591	0- 8	7.3	5785139	42-48	9.5
578592	8-20	7.5	5785140	48-72	9.4
578593	20+	8.1			

Mechanical analyses of all the samples of surface soils were made by a proximate method in which the air-dried soils were screened through a 2-millimeter sieve, the lumps being brushed and the particles coarser than 2 millimeters rubbed comparatively clean. The screened soil was shaken in distilled water with ammonia as a dispersant, then washed through a 300-mesh sieve to remove the sands, which are reported as total sands. The silt and clay suspension, which passed through the sieve, was made up to volume, allowed to stand, and sampled by the pipette at the proper time intervals to give effective maximum diameters of silt at 50 microns, clay at 2 microns, and colloid at 1 micron. The results of these unpublished analyses were used only to check the field textural classification.

The samples from nine representative soil profiles were analyzed by the more complete dispersal method, whereby the soil was pretreated with hydrogen peroxide and hydrochloric acid, to remove organic matter and carbonates, and dispersed with sodium oxalate, the subsequent manipulation being essentially the same as that just described. The results of these analyses are given in table 11.

A comparison of the results obtained by this complete dispersion method and the proximate method showed very minor differences, and in few instances would it change the textural classification of the soil. In most of the soil analyzed, the content of clay was from 1 to 3 percent lower by the proximate method, whereas the content of silt varied, in some samples being slightly lower and in others slightly higher. In Dinuba sandy loam, the complete analysis showed 10 percent more silt and about 1 percent more clay but did not change the classification as a sandy loam. Yokohl clay loam showed an increase of 3 percent of silt and 8 percent of clay. The complete analysis showed an exceptionally high proportion of clay under 2 microns effective diameter (more than 29 percent) with only 5 percent of clay and 42.74 percent of silt. Chino silty clay loam likewise showed a rather high proportion of colloid (more than 17 percent) with about 9 percent of clay. Lewis fine sandy loam which, by the proximate method, analyzed very heavy fine sandy loam, by the complete analysis is shown to be of light loam texture, and to contain an increase of 1½ percent of silt and 3½ percent of clay as compared to the proximate analysis. In distinction from these soils, all which increased in the content of both silt and clay, Madera loam showed a decrease of 5½ percent of silt and an increase of 7 percent of clay when analyzed by the complete method as compared to the proximate method. Evidently the change in this soil was almost wholly due to the breaking down of aggregates that had shown as silt by the proximate method. The content of colloid (nearly 13½ percent) is relatively very high, there being only about 5½ percent of coarse clay. It was rather surprising to find the proximate method, in which ammonia is used as a deflocculant, giving results so nearly concordant with the analyses made by the more drastic complete method, especially because many of the soils analyzed were alkaline and some contained considerable quantities of lime.

The results of the complete analyses as shown in table 11 show some rather striking features with reference to the texture and structure of the soil materials in the various horizons of the profiles of the several soils studied. The San Joaquin soils are considered to be maturely developed and have a thoroughly cemented hardpan horizon. Above this horizon is, in most places, a layer of high clay content and in the samples analyzed, of San Joaquin loam, the content of clay is very low, both in the surface soil and the upper subsoil horizon, being 3.61 percent and 2.12 percent, respectively, but the content of colloid under 2 microns, which is 15.63 percent in the surface horizon, increases to 58.36 percent in the upper subsoil horizon. The hardpan horizons were not analyzed, as they are cemented to a rocklike condition and could not be broken down by shaking with any deflocculant. Greenfield sandy loam, which in other profile characteristics closely resembles the typical Greenfield soils, does not show any material increase in colloid in the subsoil. Lewis fine sandy loam, which in its second horizon has a very compact calcareous material of columnar structure, generally described as a clay, actually showed only 6.71 percent of clay and 18.85 percent of colloid. Evidently the density of this horizon and its characteristic structure are due to other features than the total content of colloid—probably to the composition of the colloid and to the content of sodium carbonate.

Moisture equivalents were determined by the standard method, by which 30 grams of saturated soil are subjected to a force of 1,000 times gravity in a centrifuge. The moisture equivalents are reported in percentage of moisture calculated on the basis of oven-dry soil. They represent approximately the normal field-moisture capacity, or the amount of water that is held in a soil after a heavy rain or an irrigation where drainage downward is free and uninterrupted. The results, given in table 12, do not show any unusual variations in texture among the soils examined.

The percentage of carbonates (table 12) was determined by the McMiller method, in which the soil is treated with hydrochloric acid until effervescence ceases and then titrated back with sodium hydroxide to determine the amount of acid that is consumed in the reaction, calculating the amount as calcium carbonate. It is recognized that this method involves certain errors, particularly when sodium carbonate is present, but it gives an approximate measure of the carbonate content of the soil and, generally, of the calcium carbonate, or lime, present. The high amount of carbonate present in the hardpan of Madera loam (26.2 percent), in the hardpan of Madera sandy loam (7.88 percent), and in the horizon immediately below it (12.21 percent) are in striking distinction to the low amounts in the San Joaquin soils, all which are below 1 percent in all horizons except the lower horizon of San Joaquin clay loam (3.23 percent). The Madera and the San Joaquin soils are considered to be in approximately the same stage of development, both having dense cemented hardpans, but the Madera soil is brown and the San Joaquin soil reddish brown, and in most places the former contains lime in the hardpan, although rarely in quantities as high as those shown in this section. The subsoil of Porterville adobe clay generally is referred to as being highly calcareous, but it shows only about 5 percent of carbonate. The hardpan of Seville adobe clay contains 30 percent of carbonate, Yokohl clay loam contains from 20 to 30 percent in the lower part of the hardpan or in the substratum immediately below it, and Lassen stony adobe clay contains 32 percent. Nearly all of the soils in this area are either almost neutral or basic in reaction. None are definitely acid.

Colorimetric determinations of the pH value of these soils were made both in the field and in the laboratory, and they are given throughout the report. Determinations were made also on 54 samples of soil by means of the glass-electrode method, using a 1:2 suspension. The surface soils of the San Joaquin soils generally are considered the most acid, but these proved to be close to neutrality, all being above pH 6.5. The results of these studies are shown in table 13.

A number of the soils in this area contain considerable quantities of saline as well as true alkali salts. The presence of sodium carbonate was determined colorimetrically by the use of phenolphthalein and is indicated in table 12 by a plus sign wherever a positive reaction was obtained. Very slight reaction was obtained from Porterville adobe clay and from the soils of the Madera series, although ordinarily these contain very little salt and particularly are not expected to contain sodium carbonate. The Dinuba subsoils contained very small amounts, whereas their more distant relatives, the Traver and Fresno soils, showed large amounts. The Lewis soils likewise showed large quantities of sodium carbonate in the subsoil horizons. As indicated above, these soils have the characteristic columnar structure that is considered characteristic of the Solonetz. In the content of sodium carbonate they conform to the chemical as well as to the morphological requirements of Solonetz characteristics. The Waukena soils likewise have profiles with the columnar structure characteristic of the Solonetz morphology and in the deeper parts of the subsoils show the presence of sodium carbonate. These soils of the Lewis and Waukena series are the first that have been discovered in the great interior valley that show both the morphology and chemistry of the Solonetz.

SUMMARY

The Visalia area is in the northwestern part of Tulare County, Calif. It comprises a total area of 850 square miles, or 544,000 acres. Nearly all of the area is in the San Joaquin Valley. A narrow margin on the east is in the Sierra Nevada foothills. In general the area includes four broad physiographic belts—(1) Foothills and mountains, (2) the old alluvial fans and terraces, (3) the smooth gently sloping recent or younger alluvial fans, and (4) the flat basin-like areas of the valley plains.

Main and branch lines of the Southern Pacific system and of the Atchison, Topeka & Santa Fe Railway serve the area, and many paved highways reach all sections.

The climate is semiarid. The summers are warm and dry, and the winters are moist and mild. The mean annual temperature at Visalia is 62.3° F., and the mean annual rainfall is 9.06 inches.

The first settlement in this section was made in 1850. Tulare County was organized in 1852 and included a much larger area than at present. With the development of irrigation, the population increased very rapidly. The larger towns of the area are Visalia (the county seat), Tulare, Dinuba, and Exeter.

Many different crops are grown, including citrus fruits, alfalfa, cotton, table and raisin grapes, peaches, prunes, olives, figs, walnuts, and several other crops. Dairy products, cattle, poultry, and eggs also are important products.

Soils of the Vista, Lassen, and Las Posas series have been developed in place on consolidated bedrock. In general most of these soils are stony and are used for pasture.

Soils developed on the recent or young alluvial fans and flood plains are those of the Hanford, Honcut, Tujunga, Cajon, Visalia, Foster, Chino, Greenfield, and Farwell series.

The Hanford and Honcut soils are brown recent alluvial soils, the Tujunga and Cajon are light-gray or light brownish-gray recent alluvial soils, and the Visalia and Foster are dark brownish-gray recent alluvial soils that have a greater organic-matter content than the other soils mentioned. These soils, under irrigation, are used for a wide range of orchard fruits, grapes, and general field crops.

The Farwell soil has a brown surface soil and light-brown calcareous subsoil. This soil is used mainly for citrus fruits.

The members of the Chino series have dark brownish-gray surface soils and slightly heavier textured and more compact subsoils. They are used chiefly for general field crops, such as alfalfa, cotton, and corn.

The members of the Greenfield series have light-brown micaceous surface soils and slightly compact subsoils. These soils generally are used for a wide range of crops but chiefly for grapes in this area.

Soils developed on wind-modified alluvial-fan materials are represented by Delhi loamy sand. This is a light-brown soil of loose, open character and is somewhat wind-blown.

Soils developed on the older alluvial-fan materials include the Ramona, Porterville, Dinuba, and Hovey soils. The Ramona are brown soils with moderately compact noncalcareous subsoils. They are utilized for the production of citrus and deciduous fruits, grapes, and a wide variety of other crops.

The Porterville soils are chocolate-brown soils of heavy adobe clay texture. They have highly calcareous subsoils and are developed on basic igneous outwash. They are used chiefly for the growing of citrus fruits.

The Hovey soils have dark-gray clay surface soils of adobe structure, with subsoils high in lime and of heavy texture. Their use is limited by their heavy texture throughout.

The Dinuba soils have light-gray or light brownish-gray surface soils with moderately compact calcareous subsoils underlain by softly cemented calcareous hardpan lenses at a depth ranging from 3 to 6 feet. Under irrigation, they are used for field crops, such as cotton and alfalfa.

The red or brown hardpan soils of the terraces and older alluvial fans are included in the Exeter, San Joaquin, Yokohl, Seville, and Madera series.

The members of the Exeter series have brown surface soils resting on an iron- and silica-cemented hardpan at a depth ranging from 2 to 4 feet below the surface. These soils are used for grapes, citrus fruits, and olives.

The San Joaquin soils have reddish-brown surface soils and red clay subsoils resting on an iron- and silica-cemented hardpan. They are of granitic origin. They are of irregular microrelief and are costly to level and prepare for crops. Citrus fruits are grown to some extent on areas where the hardpan can be broken up by blasting.

The Yokohl soils are similar to the San Joaquin soils but are developed on materials of basic igneous origin. They are used to a small extent for citrus fruits.

The Seville soils have chocolate-brown adobe clay surface soils resting on a calcareous hardpan. They are of basic igneous origin. Their use is limited by their heavy texture.

The Madera soils have brown surface soils, brown heavier textured calcareous subsoils, and a silica- and iron-cemented hardpan that contains considerable lime. These soils are used chiefly for grapes.

The light-colored saline and alkali soils developed in the western part of the area under restricted drainage include the Traver, Waukena, Lewis, and Fresno soils. All are light gray. The Traver soils have slightly heavy textured and more compact subsoils; and the Fresno soils have light-gray silty lime-cemented hardpan lenses at a depth ranging from 2 to 4 feet. The Lewis soils have heavy-textured subsoils of columnar structure and solonetzlike morphology, resting on a calcareous hardpan, and the Waukena soils have similar profiles without the hardpan. All these soils contain salts in sufficient quantities to render them useless for crop growth.

The nonagricultural land types are rough stony land and riverwash.

Excessive and injurious concentration of soluble salts is prevalent in the Traver, Fresno, Waukena, and Lewis soils, and locally such spots may occur in the Cajon, Foster, Chino, and Madera soils. Where the drainage is good and the subsoil is pervious, and where the salts are chiefly sodium chloride or sodium sulfate, they can be washed down or out of the soil. An excess of lime must be present in order to obtain good results in reclaiming these soils. Soils containing black alkali are more difficult to reclaim. Small areas have been benefited by applying sulfur in large quantities.

The Visalia area receives its water supply from the Kaweah and the Kings Rivers, and a large acreage is irrigated both by water obtained by gravity and by pumping. Pumping of underground water is extensively practiced.

Grain crops are grown without irrigation, but other crops of the area are irrigated.

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