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GROUND WATER IN AVRA-ALTAR VALLEY, ARIZONA

BY

DAVID A. ANDREWS

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GROUND WATER IN AVRA-ALTAR VALLEY, ARIZONA

By David A. Andrews

Abstract

Avra-Altar Valley is in Pima County, southeastern Arizona, about 30 miles west of Tucson and tributary to the Santa Cruz Valley, in which Tucson is situated. It heads about 70 miles farther south, near the international boundary, and is 8 to 15 miles wide. The valley is sparsely inhabited, chiefly by cattle ranchers. Within recent years several settlers have entered land in its northern portion under the Grazing Homestead Act.

The valley is bordered by several partly detached mountain masses, consisting of several kinds of rock. From the mountain bases a gently sloping bedrock surface partly covered by a thin layer of gravel forms a mountain pediment. The pediment surface merges into lower slopes underlain by deep gravelly wash, and these extend to flat lowlands along the central part of the valley.

The area is drained by intermittent streams that carry water only during and shortly after rainy periods. The average yearly rainfall is about 10 inches in the lower part of the valley, increasing to nearly 18 inches along its upper border. In the lower lands the vegetation is sparse and consists chiefly of small mesquite and other thorny bushes. Creosote bush and several kinds of cacti grow on the gravelly upper slopes. The sahuaro cactus and palo verde and palo fierro trees cover part of the pediment zone. In the southern part of the valley, which has somewhat more rainfall than the northern part because of its higher altitude, are large areas of grassland.

The demands for water are almost wholly for domestic needs and stock, but a few acres of wheat has been irrigated with water lifted 160 feet. Other irrigation has been confined to a few fields of Johnson grass, irrigated when flood water is available, and to some lawns that are irrigated with pumped water.

Water in moderate amounts is obtained from wells in the lower alluvial lands at depths of about 150 to 350 feet. A few wells on the higher alluvial slopes have been drilled to the water table at 550 to 800 feet. In some parts of the pediment zone small amounts of water are obtained at depths of about 20 to 100 feet in disintegrated rock. In most places the ground water is of good quality, but in a few places in the pediment zone where sandstone and shale of Cretaceous age are penetrated the water is hard and contains undesirable quantities of soluble salts.

INTRODUCTION

Location and extent

Avra-Altar Valley is in Pima County, southeastern Arizona, and is tributary to the Santa Cruz River, in whose valley is the city of Tucson. It extends northward from a point near the international boundary nearly parallel with the Santa Cruz Valley and 20 to 30 miles west of it. Its main drainage channel joins the Santa Cruz River about 30 miles northwest of Tucson. The location of Avra-Altar Valley and of

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other areas that have been described in water-supply papers of the United States Geological Survey is shown in figure 28.

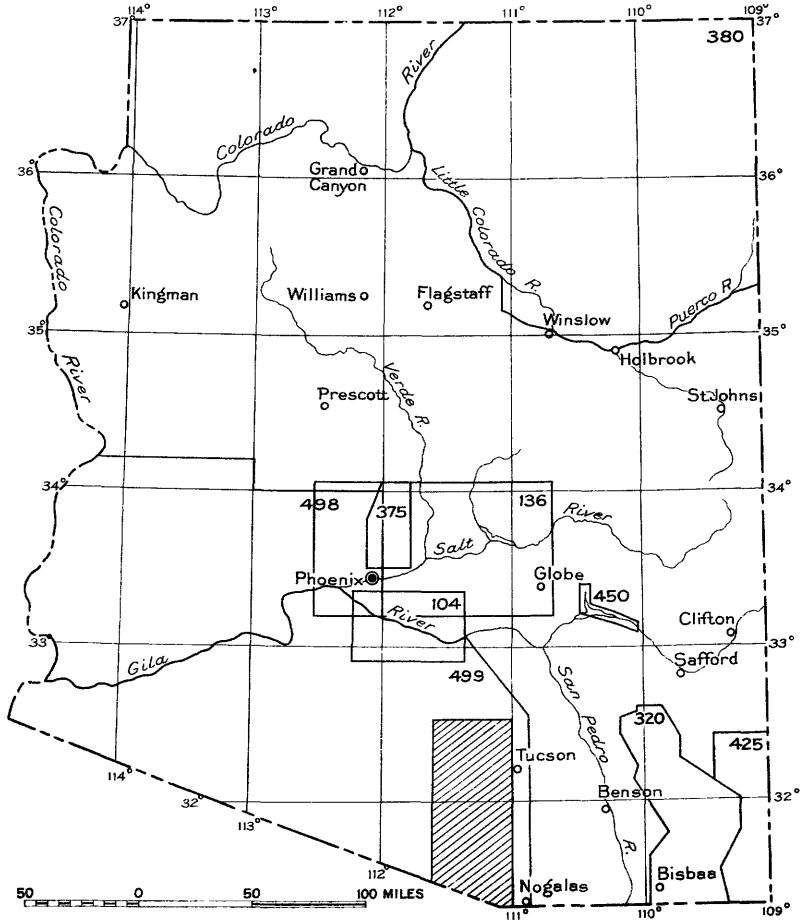
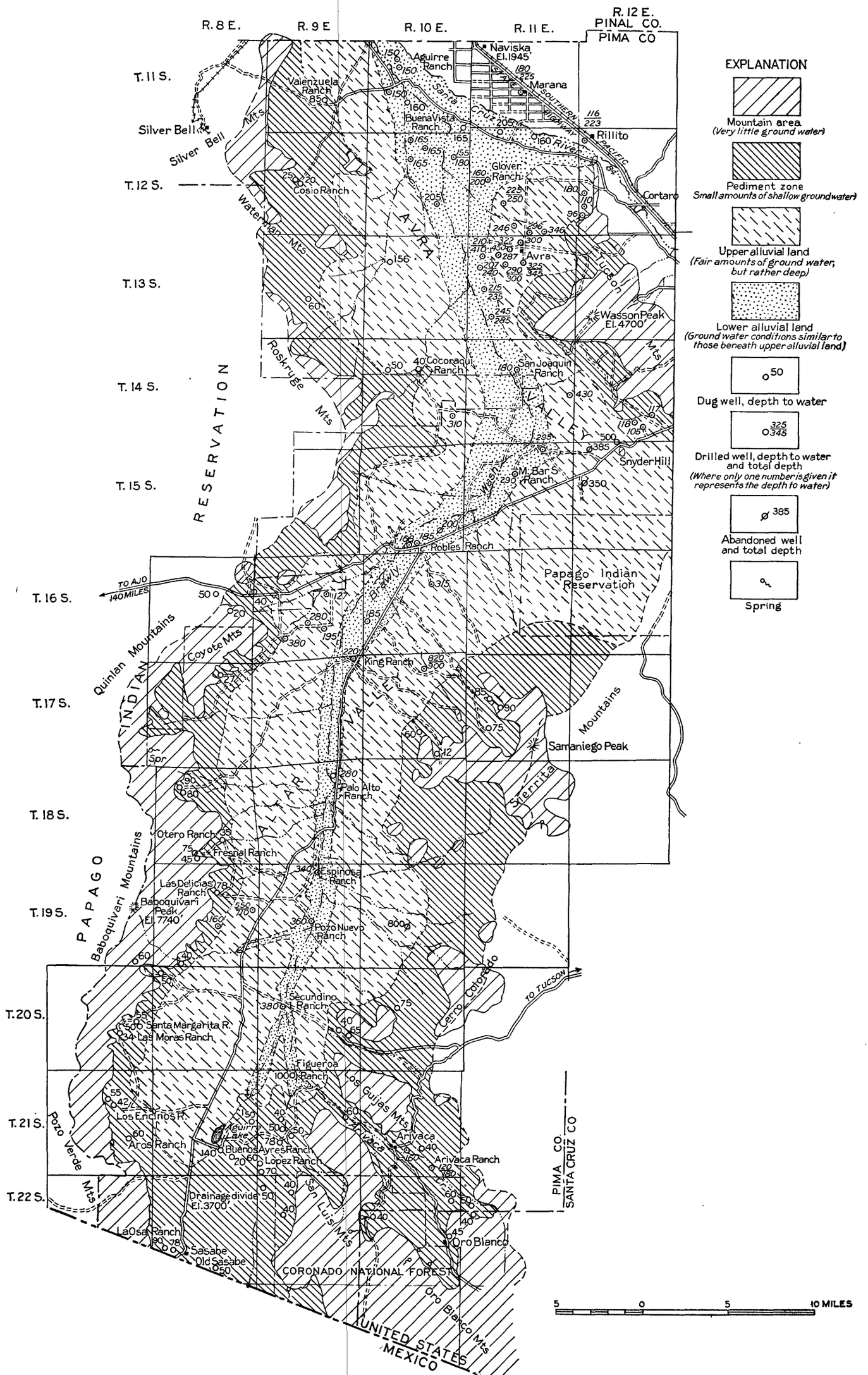


Figure 28.--Index map of Arizona showing area covered by the present report and by other water-supply papers of the U. S. Geological Survey.

The southern portion of the area described in this report is a part of Altar Valley, which extends southward into Mexico; a broad though definite drainage divide about 3 miles north of the international boundary separates the two valleys, as shown on plate 41.

In its northern portion Avra Valley expands to a wide flat area that extends to open land along the Santa Cruz River. Avra-Altar Valley is about 70 miles long and about 8 to 15 miles wide between the bases of the bordering mountains. The total area within its drainage basin is nearly 1,400 square miles. The valley land ranges in altitude from



MAP OF AVRA-ALTAR VALLEY, ARIZ., SHOWING WELLS AND GROUND-WATER CONDITIONS.

about 1,900 feet above sea level near the Santa Cruz River to about 3,700 feet on the broad divide separating Avra Valley from Altar Valley.

Previous investigation

The geology, geography, and ground-water conditions in Avra-Altar Valley have been briefly described by Bryan in a report on a large area in southern Arizona.[1/] Little else that treats specifically of the valley has been published, for it is sparsely settled and has been of slight economic interest except for grazing, although for many years there have been sporadic prospecting and small gold-mining operations in the bordering mountains.

Present report

The present report is the result of field work done in January and February 1934. The work was carried on under the supervision of G. A. Waring, geologist, of the U. S. Geological Survey, and the general direction of O. E. Meinzer, geologist in charge of the division of ground water, with funds allotted by the Public Works Administration to the Geological Survey for such studies.

GEOGRAPHY

Mountains

The mountains that border Avra-Altar Valley consist of several partly detached masses. On the northeast side the Tucson Mountains constitute a rugged area about 20 miles long and 3 to 6 miles wide. In the northern part the slopes are in some places precipitous. They culminate in Amole Peak (Wasson Peak), 4,700 feet above sea level, or about 1,500 feet above the valley land. The southern part of the mountains has lower and smoother slopes and terminates in an outlier known as the Black Hills. A few miles farther south the Sierrita Mountains constitute a group of peaks of which Samaniego Peak rises to an altitude of 5,300 feet. The Cerro Colorado is a smoothly rounded mountain mass, as shown in plate 42, A. It is separated from the Sierrita Mountains to

1/ Bryan, Kirk, The Papago country, Ariz., a geographic, geologic, and hydrologic reconnaissance with a guide to desert watering places: U. S. Geol. Survey Water-Supply Paper 499, pp. 109-110, 169-172, 184-188, 243-248, 287-293, 374-377, 1925.

the north and from the small mass of the Guijas Mountains to the south by passes 3 or 4 miles wide. At the southeast end of the valley the San Luis and Oro Blanco Mountains form an upland area extending southward into Mexico and rising southeastward to the higher mass of the Tumacacori Mountains.

On the west side of the valley the Pozo Verde, Baboquivari, and Coyote Mountains form a continuous range with steep slopes rising to prominent crests and culminating in Baboquivari Peak, shown on plate 42, B, at an altitude of 7,740 feet. The Roskruge Mountains are a lower range, of which the Waterman Mountains form a northern extension. On the northwest the valley is bordered by the Silverbell Mountains, whose summits reach altitudes of about 4,000 feet.

Pediments

From the steep mountains gentler slopes extend down to lower lands at gradients of 50 to 200 feet to the mile. These slopes are in most places covered with only a thin layer of gravel and rock debris and form essentially a bedrock surface. This bedrock slope, from which the steep mountains rise abruptly, has been termed a mountain pediment by Bryan, who defined it as follows:[2/]

> In general the mountains of the Papago country rise from plains which are similar in form to the alluvial plains that commonly front mountains of an arid region, but large parts of the plains are without alluvial cover and are composed of solid rock. These plains constitute a land form that is distinct and requires a name. "Mountain pediment" has been chosen as the name for such a plain of combined erosion and transportation at the foot of a desert mountain range.

The character of the pediment surface rising gently to the Cerro Colorado on the east side of the valley is shown in plate 42, A, and the pediment at the base of the Baboquivari Mountains, on the west side of the valley, is shown in plate 42, B. A few hills rise above the pediment surface, but in general it has been eroded to a nearly even plain.

Valley land

From the lower border of the pediment zone the slope continues downward toward the axis of the valley at a gradually lessening gradient. Although topographically the boundary between the mountain pediments and the valley land is not very definite, the character of the surface

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2/ Bryan, Kirk, op. cit. (Water-Supply Paper 499), p. 93.

changes within a short distance from one in which the bedrock is occasionally exposed to land which is deeply underlain by gravelly wash. The lower border of the gentle gravelly slope merges into nearly flat loamy land along the axis of the valley except where the streams have developed inner valleys, as explained in the following paragraph.

Drainage

The main drainage channel of Avra-Altar Valley is Brawly Wash, named from the old Brawly ranch, in the central part of the valley. Its principal tributary is Arivaca Creek, which drains a mountainous area in the southeastern part of the basin. Arivaca Creek flows throughout most of the year in its upper portion, but the other streams carry water only a small part of the year, during and shortly after rainy periods. Numerous washes carry flood water from the mountains and valley sides to the main drainage channels. The lower portion of Arivaca Creek and the upper portion of Brawly Wash and adjacent parts of several tributaries are in a flat-bottomed inner valley a quarter of a mile to 1½ miles in width, bordered by bluffs of sand and gravel from a few feet in height to a maximum of about 70 feet near the mouth of Arivaca Creek. Within this narrow valley the main stream channels are entrenched 5 to 15 feet between nearly vertical banks of alluvium. Some of this trenching has taken place within comparatively recent years. Arivaca Creek is entrenched near the village of Arivaca in a channel 15 feet deep and 200 yards wide. The bluffs bordering the inner valley gradually decrease in height downstream, being about 20 feet high near the road bridge across Brawly Wash, as shown on plate 43, A, and disappearing northward within a distance of about 10 miles. Some of the tributary washes are entrenched 10 to 30 feet deep in the disintegrated rock of the pediment zone, but as they approach the lowlands they become less and less distinct, and many of them disappear as definite channels before reaching Brawly Wash.

Climate

Avra-Altar Valley, like other parts of southern Arizona, has an arid climate, with long periods of slight precipitation. Rain falls chiefly during July, August, and September, with a secondary rainy season during the winter. In January and February there are occasional falls of snow on the higher mountain slopes. The mean annual

temperature is about 65° F.; the maximum is about 115° during July and August, and the minimum about 20° in January and February.

The following statistics of precipitation at Redrock, a few miles beyond the north end of the valley, at Silverbell, near its northwest border, and at the Santa Margarita ranch, on its southwest border, are taken from the records of the United States Weather Bureau.

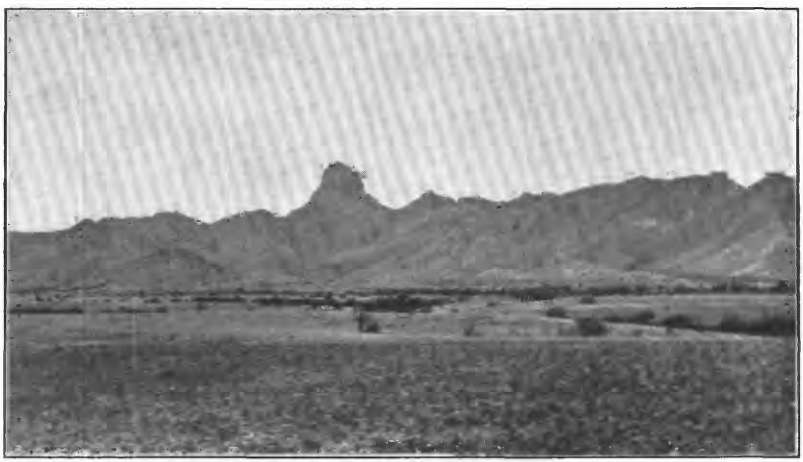
Rainfall, in inches, at stations in or near Avra-Altar Valley, Arizona
(From records of the United States Weather Bureau)

Year	Redrock (altitude 1,885 feet)	Silverbell (altitude 2,500 feet)	Santa Margarita ranch (altitude 4,000 feet)
1907	....	11.43	.....
1908	(a)	13.83	.....
1909	9.68	(a)	.....
1910	8.00	(a)	.....
1911	10.88	14.84	.....
1913	(a)	11.42	.....
1914	(a)	13.76	.....
1915	11.55	(a)	.....
1917	8.22	(a)	.....
1918	(a)	15.01	.....
1919	15.16	(a)	25.51
1920	(a)	13.79	15.55
1921	(a)	.....	22.78
1922	11.27	.....	(a)
1923	12.36	.....	17.02
1924	6.29	.....	9.19
1925	(a)	.....	18.79
1926	14.88	.....	25.63
1927	6.96	.....	18.83
1928	3.29	.....	8.99
1929	8.61	.....	15.19
1930	9.29	.....	17.14
1931	12.78	.....	30.34
1932	8.10	.....	17.14
1933	5.93	.....	12.82
Average	9.60	13.44	18.22

a Record incomplete.

These figures show the irregularity of the yearly rainfall during the periods covered by the records and indicate that the average is about 10 inches in the lower part of the valley and 13 to 18 inches in the higher parts.

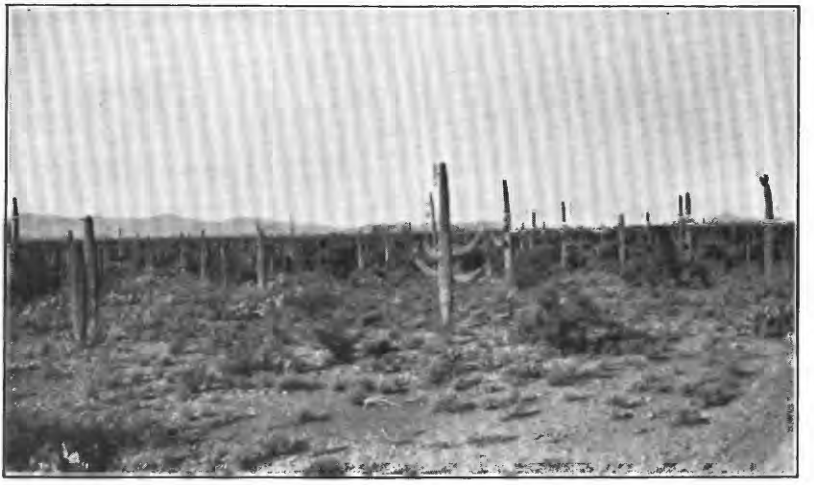
A. CERRO COLORADO, ON EAST SIDE OF ALTAR VALLEY.



B. BABOQUIVARI MOUNTAINS, ON WEST SIDE OF ALTAR VALLEY.

A. LOWLAND NEAR BRAWLY WASH AND BLUFFS RISING TO TERRACE LAND, LOOKING EAST TO SIERRITA MOUNTAINS.

B. SPARSE VEGETATION IN ALTAR VALLEY WEST OF SIERRITA MOUNTAINS.



A. SAHUARO CACTUS ON UPPER SLOPE OF AVRA VALLEY WEST OF TUCSON MOUNTAINS.

B. VEGETATION ON UPPER SLOPE OF ALTAR VALLEY, LOOKING SOUTHEAST TO SIERRITA MOUNTAINS.

Vegetation[3/]

In these lower parts of the valley, where the soil is loamy or clayey, the native vegetation is sparse and consists almost exclusively of small mesquite bushes and catclaw, as shown in plate 43, B. On the somewhat higher slopes of coarse wash several other bushes, chiefly creosote and ocotillo are common. In these areas several varieties of cactus, including the bisnaga or barrel cactus and the giant sahuaro, abound, as shown in plate 44, A. On these slopes the palo verde and Olneya tesota (ironwood) trees are plentiful in some places, and along Arivaca Creek and upper Brawly Wash there are a few cottonwood and hackberry trees. The mountain pediments of thin soil support a scanty growth of stunted shrubs consisting chiefly of burro weed and bursage, with occasional bushes of mesquite and catclaw, as shown in plate 44, B. On the pediment slopes of the southern part of the valley these low shrubs give way to grasses, which form large areas of good grazing land where the precipitation due to higher altitude is greater than in the main valleys.

On the mountain slopes bordering the southern part of the valley the mesquite and palo verde are replaced by live oaks above an altitude of 4,000 feet. In the southeast, parts of the San Luis and Oro Blanco Mountains support a thin forest of oaks, and this area has been included within the Coronado National Forest. The trees are of little value for timber, but under their protecting shade there is a thick growth of grasses, and the lands are leased for grazing.

Roads and settlements

Avra-Altar Valley is crossed about midway of its length by an improved road that extends from Tucson to the copper-mining town of Ajo, 180 miles to the west. State Highway 84 extends northwestward from Tucson parallel with the Southern Pacific Railroad. From this highway a road branches westward at Cortaro and leads across the north end of Avra Valley to the mining camp of Silverbell. Secondary roads extend northward to the irrigated district near Marana and southward, up the valley, to join the Tucson-Ajo road at the Robles ranch. Thence a main road leads southward along the east border of the inner valley for about 17

3/ Most of this information was supplied by G. M. Kerr, of the United States Geological Survey.

miles, then crosses Brawly Wash and continues southward along the west side of the valley to and beyond Sasabe at the international boundary.

On the east side of the valley near its north end a settlement of several homesteaders was established in 1925 near Avra, where there was a school and nearly a dozen families in 1934. In the fall of 1933 this settlement was augmented by a camp of the Civilian Conservation Corps, established three-quarters of a mile to the south. Farther north in the valley were several other homesteaders and also older ranchers. A small area in the east-central part of the valley and another in the west-central part are within the Papago Indian Reservation and are used as grazing lands by the Indians, some of whom reside farther west and others to the east in Santa Cruz Valley.

Near the southwest base of the Tucson Mountains several settlers have filed claims on homesteads near the main road. The upper part of the valley has long been occupied by several cattle ranches. The Palo Alto, La Osa, Las Moras, and Las Delicias are important centers of this ranching.

On the southwest border of the valley the Santa Margarita ranch has been headquarters for the Carlos Ronstadt cattle interests, which also have a large area under lease for grazing.

Arivaca, in the southeast, a village of about 50 people in 1934, is connected with Tucson by a road extending northeastward across the drainage divide and into Santa Cruz Valley. Oro Blanco in the 1880's was an active mining camp near the base of the mountains of the same name. After declining it had a revival of prosperity about 1911, but since then it has been nearly deserted.

Sasabe, half a mile north of the international boundary, was in 1934 a village of about 75 people, with stores, post office, school, and a United States customs office. The Mexican customs office was about 2 miles farther south.

Industries

By far the largest industry in the valley is that of cattle raising, which has long been carried on by several companies. Within recent years many horses have also been raised, especially on the Palo Alto ranch.

Although the homesteaders in the northern part of the valley made entry under the Grazing Homestead Act, most of them took up land

primarily in order to obtain a place to reside for reasons of health; for the region around Tucson as well as the city itself has come to be recognized as having a climate favorable to people suffering from throat and lung diseases. Little attempt has been made by these settlers either to graze or to cultivate the land. On several of the older ranches, however, some Johnson grass is grown as stock feed, by irrigation with flood water from Brawly Wash and its main tributaries. Flood water collected in Aguirre Lake, at the head of the valley, is used to irrigate Johnson grass for cattle feed, and several acres of beans have also been grown by irrigation from this lake. On the Glover dairy ranch, 4 miles northwest of Avra, about 20 acres of wheat was under irrigation in 1934, with well water pumped from a depth of 160 feet.

Gold placer mining and prospecting for lodes have been carried on in the Guijas Mountains near Arivaca since about 1870, but little ore has been taken out. Prospects farther north, in the Sierrita Mountains, have been described by Ransome,[4] who discussed the nature of the ore deposits. In the mountains along the west side of the valley there has also been much prospecting, one small mine having been opened at the base of the Baboquivari Mountains. In the northwest, Silverbell was from 1904 to 1910 a copper-mining camp of some importance; it has been described by Stewart.[5]

GEOLOGY AND GROUND-WATER CONDITIONS

Mountain areas

Like most of the other mountains in southern Arizona, the detached mountains that border the Avra-Altar Valley are composed of various kinds of rocks. These rocks are not differentiated on plate 41, as they have no especial significance with regard to ground water, but they may be briefly described as follows:

On the east side of the valley granite of presumably pre-Cambrian age forms the northern part of the Sierrita Mountains and is also exposed in their southwest parts. On the opposite side of the valley granite constitutes the Coyote and Quinlan Mountains. At the south end of the valley ancient granite forms a large part of the San Luis and

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4/ Ransome, F. L., Ore deposits of the Sierrita Mountains, Pima County, Ariz.; U. S. Geol. Survey Bull. 725, pp. 407-440, 1922.

5/ Stewart, C. A., The geology and ore deposits of the Silverbell mining district, Ariz.: Am. Inst. Min. Eng. Trans., vol. 43, pp. 240, 290, 1913.

Oro Blanco Mountains, on the east, and the Pozo Verde Mountains, on the west. At the northwest border of the valley granite forms the central part of the Silverbell Mountains. Small areas of limestone of Paleozoic age are exposed in the Waterman Mountains and the southern part of the Silverbell Mountains; and on the opposite side of the valley in the Tucson Mountains. At Snyder Hill, an outlier at the south end of these mountains, an outlier of an overthrust fault of the limestone has been quarried and burned for lime. On the southwest side of the valley sandstone and shale of Cretaceous age cover an area of several square miles on the flank of the Baboquivari Mountains. To the southeast these sedimentary rocks form a large part of the slopes near Arivaca between the San Luis and Guijas Mountains. Farther north considerable areas of Cretaceous rock are also present on the west sides of the Sierrita and Tucson Mountains. In both of these mountain masses there are also considerable areas of intrusive granite and porphyry, which are considered to be of Cretaceous age. Some of these intrusive rocks are mineralized, and in them most of the prospecting of the region has been done. On the east side of the valley the Cerro Colorado (pl. 42, A) is a rounded mountain mass composed of lavas of Tertiary age. In the southwest the Baboquivari Mountains are composed chiefly of lavas of Tertiary age, which form rugged slopes culminating in the pluglike Baboquivari Peak (pl. 42, B). Most of the mountain areas farther north on this side of the valley are also composed of lavas, of Tertiary and Quaternary age.

In the mountains there are a few small perennial springs and several minor wet-weather springs. In a few places short tunnels have been driven to develop stock water, but available ground water beneath the upper slopes is scanty.

Pediment zone

The rocks underlying the pediment zone, which borders the mountains as shown on plate 41, are the same as those of the adjacent mountain slopes; but as granite and the harder lavas are the most resistant rocks, they constitute practically all the gravel that forms the thin cover of the pediments. In most places these bedrock slopes merge so gradually into the lower alluvial slopes that the boundary between the two is indefinite. It has therefore been indicated on the map by a broken line. Within the pediment zone several dug wells have found shallow water in small quantities in washes where the rock is sufficiently fractured and

disintegrated to serve as a storage reservoir for rain or run-off water that penetrates below the surface.

Alluvial land

The alluvial land consists of outwash slopes that lie between the pediment zone and the flat valley land. It is nearly everywhere underlain by sand, gravel, and cobbles, mainly of granitic and basaltic origin, with a few boulders 1 or 2 feet in diameter. Wells generally find fairly large supplies of water in this valley fill, but in some places the material is cemented with lime and yields little or no water.

The depth to the water table is determined largely by the altitude above the axis of the valley, although the water table seems to slope from the upper parts of the alluvial lands gently downward toward the valley. In the upper part of the alluvial slopes several wells have been drilled to depths of 600 to 800 feet before reaching water. In addition to showing the great depth to water beneath these upper slopes, these wells indicate that the coarse alluvial fill of the valley is deep and of fairly uniform character. The bench lands on each side of the inner valley along the upper course of Brawly Wash are essentially the same in character as the upper parts of the alluvial land in the northern part of the valley. They are really parts of the upper alluvial slopes in which narrow valleys have been cut.

The axial part of Avra-Altar Valley, as shown on plate 41, is an area of lower alluvial land. This area is nearly flat, as distinguished from the sloping upper alluvial lands, and its soil is largely sandy or loamy, in contrast to the coarse materials of the higher slopes. The decline in the upper part of the valley from the Secundino ranch northward to the Robles ranch is about 800 feet, or 30 feet to the mile. From the Robles ranch downstream to the valley of the Santa Cruz River the gradient gradually flattens, the average for this lower part being about 22 feet to the mile. Until Brawly Wash reaches several miles below the Robles ranch it has a channel trenched 5 to 10 feet deep in the dark, fine-grained alluvium of its inner valley. The channel then becomes shallow and divides into several branches, which distribute the flood water over the flat lands. Such water is used, whenever available, for the irrigation of fields of Johnson grass, which is cut as cattle feed.

There seem to be no perched water tables in the gravelly fill of Avra-Altar Valley, and wells must be sunk to the deep water level in the valley fill. In the northern part of the valley the depth to water is somewhat less than in the southern part. The depth ranges from about 150 feet near the mouth of Brawly Wash to 200 feet in the central part of the valley and about 380 feet at the Secundino ranch, in the southern part. Apparently some artesian head is locally developed when the gravel of the valley fill becomes fully saturated. The only well that was reported to have encountered water under pressure was that of H. Alexander, near Brawly Wash, 5 miles northwest of Avra. In this well the water was said to have risen temporarily about 15 feet above the level at which it was struck.

GROUND-WATER DEVELOPMENTS

Explanation of map showing wells

On plate 41 are shown all the wells which were visited or concerning which information was obtained in 1934. They are believed to constitute nearly all the wells in use in the valley at that time. Most of the figures of depth to water and total depth were obtained from the owners or drillers of the wells. Measurements of several wells were kindly furnished by Mr. McCash, assistant county agricultural agent of Pima County. The data on the various wells show the approximate depth to water in most parts of the valley.

Wells in the pediment zone

In the pediment zone on the northwest side of Avra-Altar Valley a dug well on the Valenzuela ranch reached water at 85 feet in disintegrated granite. By means of a windmill and small gasoline engine this well has furnished water for 500 head of cattle at one time. At the Cosio ranch, 6 miles to the south, two shallow wells in decomposed andesite have supplied water for 200 cattle. Near the base of an eastern outlier of the Roskruge Mountains, J. Burrell obtained water at 40 feet in disintegrated lava.

In the pass through which the Tucson-Ajo road extends westward a few wells were dug several years ago by gold prospectors. At Alamo mining camp water was obtained at about 40 feet in disintegrated lava.

The Dobbs well, 2 miles farther west, reached water at 50 feet in the lava of a small wash and has long been a watering place for travelers and prospectors in the region.

In the pediment zone along the southwest side of the valley two wells at the Redondo ranch found fair supplies of water at about 90 feet in disintegrated granite. Farther south water has been obtained along the base of the Baboquivari Mountains in disintegrated lava on the Otero, Fresnal, and Ronstadt ranches, at depths of 35 to 160 feet. Along the base of the Pozo Verde Mountains water is found at about 50 feet on the Santa Margarita ranch and in several other wells. Water is also found at comparatively shallow depths on the pediment slopes of the opposite side of the valley. In a reentrant of the Sierrita Mountains H. C. Keeney obtained a small domestic supply at a depth of 12 feet. Several wells near Arivaca obtained small supplies of water from sandstone of Cretaceous age at depths of about 40 to 100 feet. Near the town the Boice well was drilled to 160 feet to obtain an ample supply.

A short distance beyond the south limit of Avra Valley two wells in disintegrated granite near Sasabe reached water at 78 and 90 feet and have supplied most of the needs of the village.

On the southwest flank of the Tucson Mountains several wells have been put down by homesteaders for domestic supply. The well of J. C. Fraps reached water at 117 feet and that of P. Merriman at 105 feet. Farther east O. F. Virch obtained a small supply of water of poor quality at 165 feet.

Wells in alluvium

In sinking wells in the valley alluvium little attempt has been made by the drillers or diggers to keep records of the materials penetrated. The material consists almost entirely of gravel, with minor layers of sand and silt at irregular intervals, and the water table is fairly uniform.

In the north end of the valley two wells drilled on the Aguirre ranch struck water at a depth of 150 feet and were equipped with small engines and storage tanks to supply water for stock. To the south a dug well on the Buena Vista ranch obtained water at 160 feet and was pumped by horsepower for domestic use and stock. In much of the northern part of the valley the gravel fill is sufficiently cemented by lime so that wells can be dug or drilled without curbing or casing,

although in the course of several years they may cave in. This happened to the well on the Maish ranch, dug 165 feet to water, but about 2 miles to the east J. A. Wash had dug a well 205 feet deep to water without encountering caving ground. On the Glover dairy ranch a large supply of water was struck in coarse sand at 160 feet. To the southwest, near Brawly Wash, H. Alexander's well had water at 205 feet. Other wells to the southeast toward Avra found water at somewhat greater depths, due to the rise of the surface. E. Johanson's well struck water at 225 feet, and others near Avra at about 250 to 300 feet, depending on the surface altitude. The well of D. H. Newcomer, 5 miles northeast of Avra, although started in alluvium, is said to have struck water at 180 feet at the base of a layer of andesite lava resting on hard blue limestone. On the ranches of Chico, Luis, and Frank Garcia, near Brawly Wash, southwest of Avra, water was found in dug wells at a little more than 200 feet. The north well was dug to 240 feet, or about 30 feet below the ground-water level, and was drilled to 410 feet, in an unsuccessful attempt to obtain a larger supply. Each well was reported to have a capacity of about 10 gallons a minute and was pumped by a windmill for domestic and cattle supply.

The Manvel Jones well, near Avra School, struck water at 322 feet and was drilled to bedrock at 450 feet. During the winter of 1933-34 it furnished 8,000 gallons a day for a camp of the Civilian Conservation Corps three-quarters of a mile to the south.

On the San Joaquin ranch, farther up the valley, water was pumped by windmill from a depth of 180 feet, and the supply was sufficient for about 100 head of cattle. On the Cocoraque ranch, on the higher slopes to the southwest, water was found at 310 feet, and on the Phillip ranch, 3 miles farther south, water was struck at 365 feet. At the Robles ranch water for cattle was obtained from two wells at 185 and 168 feet. Farther south along the axis of the valley water was obtained at somewhat greater depths. The water table is about 220 feet below the surface at the King ranch, 280 feet at the Palo Alto ranch, 340 feet at the Espinosa ranch, 360 feet at the Pozo Nuevo ranch, and 380 feet at the Secundino ranch. So far as could be learned, water was found in each well in coarse gravel. Some of these wells have yielded 200 gallons a minute during the summer. On the upper alluvial slope on the west side of the valley two wells on the Gill ranch had water at 195 and 280 feet.

The well on the Coleman ranch, on higher slopes, reached water at 380 feet. On the opposite side of the valley the Blacklidge well was drilled to 820 feet before encountering water and was continued to bedrock at 900 feet without greatly increasing the supply. About 15 miles farther south an unsuccessful well was drilled by the West Coast Cattle Co. to bedrock at 800 feet. This was reported to have found only a very small supply of water below 600 feet. On the opposite side of the valley the Manning well reached water at 550 feet and was continued to 710 feet without obtaining a much larger supply than was yielded by the upper 50 feet of water-bearing material. The alluvium below the water table may in some places be cemented by lime so as to be a poor water bearer.

QUALITY OF GROUND WATER

During the course of the field examination samples of water were collected from 11 wells in the valley. These were later analyzed by E. W. Lohr, of the United States Geological Survey. The analyses of water from 5 other wells in the valley, collected by Kirk Bryan in 1917, are also available.[6/] Analyses of samples from 10 other wells, made by Robert A. Green, of the University of Arizona, were kindly furnished by him. The results of these analyses are given in the table on page 179 arranged in two groups--15 samples from wells in the valley alluvium and 11 samples from wells in bedrock of the pediment zone.

All the waters analyzed from the valley alluvium except that of the Blacklidge well (sample 10) are satisfactory for domestic use. They contain only 150 to 270 parts per million of total dissolved solids; the principal constituents are sodium and bicarbonate, with secondary amounts of chloride, and only minor amounts of calcium and magnesium. They are therefore fairly soft waters. The unusually small quantities of sulphate present are noteworthy. The very small amount of fluoride in all the waters is of interest, because in several other valleys of southern Arizona, notably the San Pedro and San Simon Valleys, to the east, some well waters contain several parts per million of fluoride; and this is recognized as the cause of mottled teeth among a considerable portion of the residents who use these waters for domestic supplies.

6/ Bryan, Kirk, The Papago country, Ariz., a geographic, geologic, and hydrologic reconnaissance with a guide to desert watering places: U. S. Geol. Survey Water-Supply Paper 499, pp. 172, 184, 188, 1925.

The content of about 2 parts per million of iron reported in samples 10 and 12, which are from the deepest two wells, may be derived from the well tubing and is of little significance. Sample 10, from the deepest well, contains about twice as much total solids as most of the other alluvial waters. Its chief constituents are sodium, bicarbonate, and chloride. In its comparatively high content of chloride, 168 parts per million, this water differs markedly from the other alluvial waters. The chloride may be derived from sandstone and shale of Cretaceous age, for these rocks form part of the adjacent mountain slopes and may have been reached in the well, which was drilled to bedrock.

Of the 11 samples of water from wells in the pediment zone, the first 5 (samples 16-20) are comparatively high in total solids. Sample 16 is from disintegrated lava, and although its chief dissolved solids are sodium and bicarbonate, it contains sufficient calcium and magnesium to make it noticeably hard. The high content of nitrate indicates that this shallow dug well receives drainage water which carries the products of oxidation of organic matter. Samples 17, 18, and 19 contain the highest amounts of dissolved solids. In addition to sodium and bicarbonate, they contain comparatively large amounts of calcium, magnesium, and sulphate and are hard waters. Their mineral matter is very probably derived from the Cretaceous sandstone and shale in which the wells are sunk. The water of the Virch ranch (sample 19), in the road pass on the west side of the valley, contains more sodium chloride (common salt) and is much harder than most of the other waters analyzed.

Sample 21 came from a shallow dug well on the north flank of the Sierrita Mountains. The water contains considerable calcium and magnesium in addition to sodium and bicarbonate and hence is rather hard. The mineral substances probably are derived from Cretaceous rocks, which form the adjacent slopes. Sample 22, from the well on the Santa Margarita ranch near the southwest border of the valley, is fairly low in mineral content and is a soft water, as the principal substances are sodium and bicarbonate. Sample 23, from the Boice well near Arivaca, is also a water of fairly low mineral content, although it probably comes from Cretaceous rocks. It contains nearly five times as much calcium as sodium, however. It is essentially a calcium carbonate water and is therefore rather hard. Samples 24 and 25, from wells in the granite pediment near Sasabe, are low in dissolved mineral matter and are fairly soft.

The principal well at Oro Blanco is dug through the alluvium of a wash and a few feet into the underlying bedrock in the upper part of the pediment zone. Analysis 26 shows the water to be of fair quality.

Analyses of water from wells in Avra-Altar Valley, Arizona

Parts per million

No.	Total dissolved solids	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium and potassium (Na+K) (calculated)	Bicarbonate (HCO_3)	Sulphate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Total hardness as $CaCO_3$
1	203	--	--	15	7	57	183	20	14	--	--	66
2	241	--	--	30	4	60	195	25	26	--	--	91
3	270	--	--	48	14	37	188	8	63	0.0	7.8	177
4	184	--	--	30	7.9	32	184	10	9.0	.0	5.0	107
5	151	--	--	22	4	35	163	Trace	10	--	--	71
6	240	34	0.93	28	5	51	158	29	18	--	3.5	90
7	208	--	--	22	11	45	179	20	22	--	--	100
8	214	--	--	7	4	75	138	Trace	60	--	--	34
9	214	--	--	15	8	62	185	Trace	38	--	--	70
10	448	--	2.2	35	13	123	186	16	168	.2	1.5	141
11	249	32	.06	38	7.2	46	210	19	11	--	Trace	124
12	229	--	2.1	40	8.3	37	192	35	13	.6	.24	134
13	211	36	.08	37	5.7	32	166	14	10	--	8.1	116
14	192	--	--	49	11	12	212	4	9.0	.0	2.4	168
15	258	--	--	16	--	88	260	5	17	.8	3.9	57
16	509	--	--	66	31	84	376	46	66	.2	31	292
17	1,008	--	--	105	49	190	407	300	164	--	--	463
18	780	--	--	38	41	198	442	191	92	.8	.93	263
19	3,199	--	--	105	52	985	1,281	1,200	226	--	--	476
20	667	62	.3	73	30	143	460	26	122	--	12	306
21	452	--	--	52	22	97	407	40	40	--	--	220
22	181	--	--	22	4	45	163	20	10	--	--	71
23	184	--	--	47	11	10	200	3	10	.2	3.8	165
24	146	--	--	37	7.7	10	160	3	5.0	.0	4.9	124
25	109	--	--	20	--	14	78	4	10	.0	16	64
26	306	24	.15	46	15	31	214	27	29	--	0	176

The analyses were made by E. W. Lohr, A. A. Chambers, and C. H. Kidwell, United States Geological Survey; and Robert A. Green, Department of Agricultural Engineering, University of Arizona.

The water from wells 1 to 15 is derived from the valley alluvium, that from wells 16 to 26 from the rocks underlying the pediment zone.

Owner, location, and depth of wells, dates of collection of samples, and analysts

1 H. Alexander, NW¼ sec. 26, T. 12 S., R. 10 E. Depth 205 feet. Collected Apr. 19, 1932. Analyst, Robert A. Green.

2 E. Johanson, NE¼ sec. 29, T. 12 S., R. 11 E. Depth 225 feet. Collected Apr. 5, 1931. Analyst, Robert A. Green.

3 F. Garcia, SW¼ sec. 29, T. 13 S., R. 11 E. Depth 240 feet. Collected Feb. 5, 1934. Analyst, E. W. Lohr.

4 San Joaquin ranch, SE¼ sec. 9, T. 14 S., R. 11 E. Depth 180 feet. Collected Feb. 5, 1934. Analyst, E. W. Lohr.

5 Charles J. Phillip, SE¼ sec. 2, T. 15 S., R. 11 E. Depth 365 feet. Collected Oct. 2, 1930. Analyst, Robert A. Green.

6 Warren Bros., SE¼ sec. 26, T. 15 S., R. 10 E. Depth 200 feet. Collected Dec. 2, 1917. Analysts, A. A. Chambers and C. H. Kidwell.

7 Robles ranch, NW¼ sec. 34, T. 15 S., R. 10 E. Depth 185 feet. Collected Feb. 20, 1931. Analyst, Robert A. Green.

8 R. A. Dill, NE¼ sec. 27, T. 16 S., R. 9 E. Depth 195 feet. Collected Jan. 7, 1931. Analyst, Robert A. Green.

9 R. H. Coleman, SE¼ sec. 29, T. 16 S., R. 9 E. Depth 820 feet. Collected Feb. 18, 1931. Analyst, Robert A. Green.

10 F. Blacklidge, SE¼ sec. 3, T. 17 S., R. 10 E. Depth 820 feet. Collected Feb. 3, 1934. Analyst, E. W. Lohr.

11 Palo Alto ranch, SE¼ sec. 2, T. 18 S., R. 9 E. Depth 280 feet. Collected Dec. 10, 1917. Analysts, A. A. Chambers and C. H. Kidwell.

12 H. L. Manning, SE¼ sec. 13, T. 19 S., R. 8 E. Depth 550 feet. Collected Feb. 15, 1934. Analyst, E. W. Lohr.

13 Pozo Nuevo ranch, NW¼ sec. 22, T. 19 S., R. 9 E. Depth 360 feet. Collected Dec. 10, 1917. Analysts, A. A. Chambers and C. H. Kidwell.

14 Secundino ranch, NE¼ sec. 17, T. 20 S., R. 9 E. Depth 380 feet. Collected Jan. 17, 1934. Analyst, E. W. Lohr.

15 Buenos Aires ranch, NE¼ sec. 27, T. 21 S., R. 8 E. Depth 140 feet. Collected Feb. 11, 1934. Analyst, E. W. Lohr.

16 J. Burrell, SW¼ sec. 10, T. 14 S., R. 10 E. Depth 40 feet. Collected Jan. 22, 1934. Analyst, E. W. Lohr.

17 J. C. Fraps, SE¼ sec. 26, T. 14 S., R. 12 E. Depth 117 feet. Collected Feb. 5, 1932. Analyst, Robert A. Green.

18 P. Merriman, NW¼ sec. 35, T. 14 S., R. 12 E. Depth 105 feet. Collected Feb. 9, 1934. Analyst, E. W. Lohr.

19 O. F. Virch, NW¼ sec. 31, T. 14 S., R. 13 E. Depth 165 feet. Collected Aug. 25, 1929. Analyst, Robert A. Green.

20 Dobbs claim, NE¼ sec. 15, T. 16 S., R. 8 E. Depth 50 feet. Collected Nov. 26, 1917. Analysts, A. A. Chambers and C. H. Kidwell.

21 H. C. Keeney, SW¼ sec. 35, T. 17 S., R. 10 E. Depth 12 feet. Collected July 5, 1933. Analyst, Robert A. Green.

22 Santa Margarita ranch, NW¼ sec. 24, T. 20 S., R. 7 E. Depth 55 feet. Collected Dec. 20, 1931. Analyst, Robert A. Green.

23 C. G. Boice, SW¼ sec. 28, T. 21 S., R. 10 E. Depth 60 feet. Collected Feb. 6, 1934. Analyst, E. W. Lohr.

24 F. Escalante, NW¼ sec. 29, T. 22 S., R. 8 E. Depth 78 feet. Collected Jan. 23, 1934. Analyst, E. W. Lohr.

25 Mrs. A. Hardgrave, NE¼ sec. 30, T. 22 S., R. 8 E. Depth 90 feet. Collected Jan. 23, 1934. Analyst, E. W. Lohr.

26 Oro Blanco village, NW¼ sec. 24, T. 22 S., R. 10 E. Depth 45 feet. Collected Dec. 11, 1917. Analysts, A. A. Chambers and C. H. Kidwell.

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