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Water-Supply Paper 498

THE LOWER GILA REGION, ARIZONA

A GEOGRAPHIC, GEOLOGIC, AND HYDROLOGIC RECONNAISSANCE WITH A GUIDE TO DESERT WATERING PLACES

BY

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PREFACE.

By O. E. MEINZER.

The arid region of the United States, as outlined on Plate I, covers about 500,000 square miles, or one-sixth of the entire country. The vast region includes some large irrigation districts and well-watered mountains, but most of it is so arid that it can not safely be traversed by anyone who does not have adequate information regarding the location of watering places. The desert is not vanishing, although here and there relatively small tracts of it have been reclaimed by irrigation, and the aggregate number of watering places has been slowly increasing. It has, however, become much more accessible than formerly—first through the building of railroads and recently through the use of automobiles.

In 1917 the sum of $10,000 was appropriated by Congress for a survey of desert watering places, which had been authorized in an act approved August 21, 1916, as follows:

Be is enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the Secretary of Interior be, and he is hereby, authorized and empowered, in his discretion, in so far as the authorization made herein will permit, to discover, develop, protect, and render more accessible for the benefit of the general public springs, streams, and water holes on arid public lands of the United States; and in connection therewith to erect and maintain suitable and durable monuments and signboards at proper places and intervals along and near the accustomed lines of travel and over the general area of said desert lands, containing information and directions as to the location and nature of said springs, streams, and water holes, to the end that the same may be more readily traced and found by persons in search or need thereof; also to provide convenient and ready means, apparatus, and appliances by which water may be brought to the earth's surface at said water holes for the use of such persons; also to prepare and distribute suitable maps, reports, and general information relating to said springs, streams, and water holes and their specific location with reference to lines of travel.

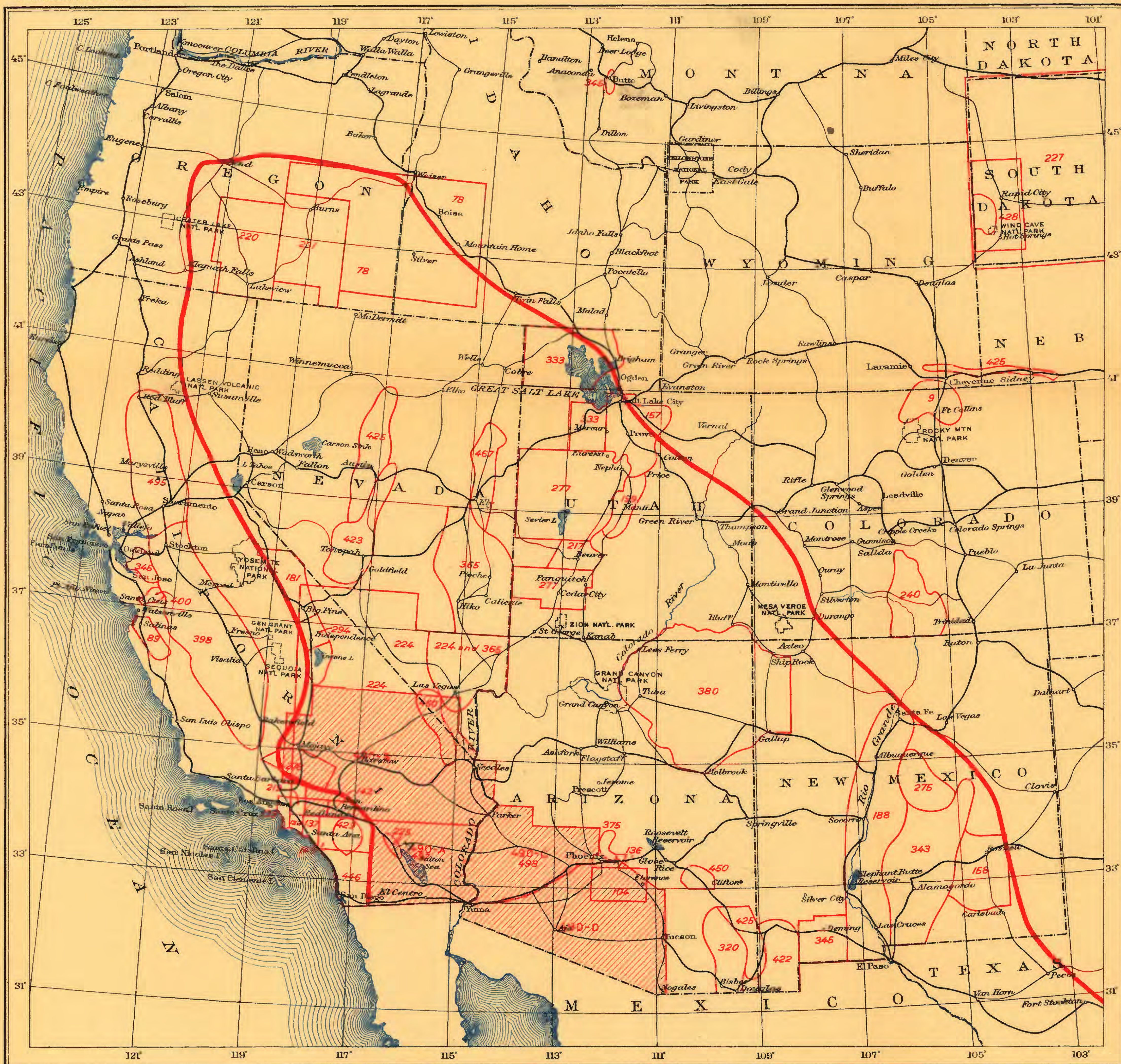
The work thus authorized was assigned to the United States Geological Survey. To the small appropriation made for this purpose was added a part of the Geological Survey's regular allotment for ground-water investigations in the United States, and the scope of the survey was enlarged so as to include a reconnaissance of the ground-water conditions in the area covered.

The area selected for survey lies in southeastern California and southwestern Arizona (see Pl. I) and occupies about 60,000 square miles, or somewhat more than one-tenth of the entire arid region. It is larger than the State of Illinois and nearly as large as New England. This is, on the whole, the driest and hottest area in the United States, and until the watering-place survey was made it was also one of the least explored and most poorly mapped. In a large part of the area the average annual rainfall is less than 5 inches. This slight rainfall and the high temperature together produce a high degree of aridity. The high temperature adds greatly to the danger of perishing by thirst.

The area was divided into four parts, each of which was covered by a geologist who was assisted by a nontechnical helper and was provided with a Ford automobile, a light camping outfit, a plane table, and other equipment. The four parts of the area are for convenience called the Salton Sea region, the Mohave Desert region, the lower Gila region, and the Papago country. (See Pl. I.)

Maps were prepared of the entire area showing the relief and the location of watering places, roads, and other features. (See Pls. II–IV and Fig. 1.) The watering places, with a few exceptions, were examined, about 160 samples of water were collected and shipped to the water-resources laboratory of the United States Geological Survey for analysis, and signs directing to water were erected at 305 localities. In order to give information as to the specific location of watering places with reference to lines of travel, logs were made of nearly all the roads, including those that lead into the remotest parts of the desert. Guide books containing the detailed maps, the road logs, and condensed information regarding watering places were published as Water-Supply Papers 490–A, 490–B, 490–C, and 490–D. Exploratory geologic maps of the area were made, and much information was obtained concerning its geography, geology, and ground-water conditions. Four comprehensive water-supply papers have been prepared, of which the present volume is the second to be published. The first covers the Salton Sea region and was issued as Water-Supply Paper 497; the other two, covering the Mohave Desert region and the Papago country, will be published as soon as funds for printing them are available.

Among the most valuable of the products of this desert survey are the large maps, which show the mountains and other land forms by relief shading in brown, in a manner that can be understood by anyone. This relief shading will help travelers greatly in keeping their bearings and will at the same time enable physiographers to gain an adequate understanding of the surface features of the region. The relief shading was done by John H. Renshawe, on the basis of copy furnished by the geologists who did the field work. Mr. Ren-



EXPLANATION

Boundary of arid region requiring guides to watering places

Area covered by guides to desert watering places
Published as Water-Supply Papers 490-A, 490-B, 490-C, and 490-D

240

Area covered by water-supply paper

(The number is the serial number of the paper. Only principal water-supply papers are shown. A complete list of publications relating to water resources and information as to areas covered by topographic maps can be obtained by writing to the U. S. Geological Survey, Washington, D. C.

Principal road

Other important road

MAP OF THE ARID REGION OF THE UNITED STATES

Showing areas covered by guides to watering places and other water-supply papers of the U. S. Geological Survey

Scale $\frac{1}{7,000,000}$

0 100 200 300 400 Miles

1923

shawe brought to this task not only the skill and esthetic appreciation of an artist but also an intelligent understanding of desert forms resulting from long experience as a topographer in the West. The

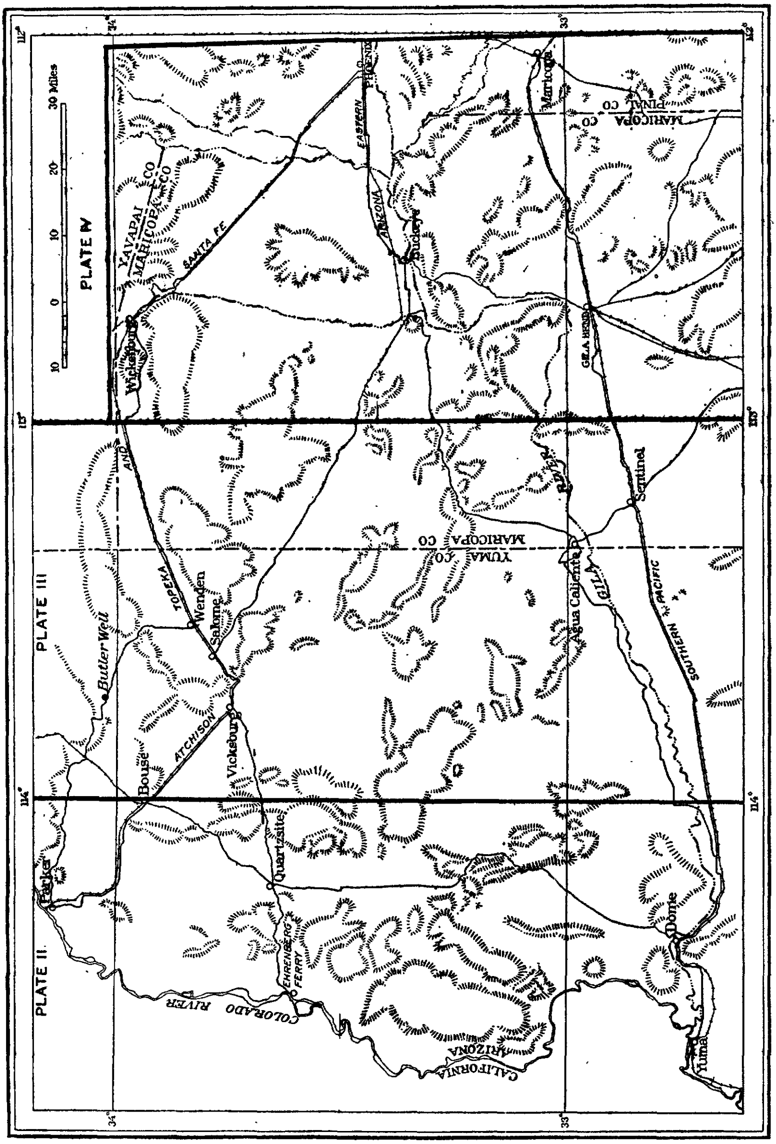


FIGURE 1.—Map of the lower Gila region showing principal roads and watering places and areas covered by detailed maps (Pls. II–IV).

reproduction of the relief shading on the printed maps, which involved serious technical difficulties, was the work of S. J. Kubel and his able assistants in the division of engraving of the Geological Survey.

The region described by Mr, Ross in this paper has been called the lower Gila region for want of a better name. In the vicinity of Phoenix and for a considerable distance down the Gila large tracts of land have been brought under irrigation, and in some other parts of the region smaller tracts have been developed. A large part of the region is, however, sparsely settled, very unproductive, and almost unknown except to a few men who have small mining or live-stock interests in it. This part of the region is about as nearly a no man's land as can be found in the United States, as will be appreciated by anyone who reads the detailed descriptions of the routes of travel. The region has, however, a variety of ground-water conditions and many problems of water supply. Large quantities of ground water occur along the Gila and the Colorado, and supplies adequate for domestic and stock use have been found by sinking wells at many points throughout the region. Some of the special features of this paper are a description of Gila River and its physiographic history, by Mr. Ross, a history of irrigation along Gila River, by C. R. Olberg, and a discussion of methods of storing and utilizing small supplies of surface water, by Kirk Bryan.

THE LOWER GILA REGION, ARIZONA.

By Clyde P. Ross.

INTRODUCTION.

LOCATION AND EXTENT OF THE REGION.

The region covered by this report lies mainly in central Yuma and western Maricopa counties, Ariz., but includes small parts of Yavapai and Pinal counties. The portion in Maricopa County is an irregular-shaped area with Phoenix at its east end, bounded on the north and northeast by the road from Phoenix through Wickenburg to Wenden and on the south by the Salt and Gila river valleys. In Yuma County the region is bounded on the north by the road between Wenden and Parker through Cunningham Pass, on the south by the valley of Gila River, and on the west by Colorado River, which is the western boundary of the county and the State.

SCOPE OF THE REPORT.

Plan.—This report is designed, first, to give specific information in regard to watering places and routes of travel within the region covered, and, second, to give general information in regard to the geography, geology, and hydrology of the region. It may be considered to be composed of three parts. The first part gives general information regarding the region as a whole. The second gives logs of all the principal routes and descriptions of the geography, geology, and water resources of the localities traversed by these roads. The third part gives detailed descriptions of all the known watering places in the region, with all the data available regarding the water at each place. The report also contains relief maps of the whole region showing the existing water supplies and a reconnaissance geologic map.

General chapters.—The general information presented was in part compiled from existing publications, but much of it is new. The historical sketch is entirely a compilation from existing publications. The chapters on climate, flora, and fauna are largely brief notes founded on field observations supplemented by published records. The geologic discussions are based very largely on data obtained during this investigation. Much still remains to be done before the geologic history of this interesting and somewhat complex region is known in its entirety. However, enough is known to give a general knowledge of the conditions and to furnish a satisfactory basis for detailed work in particular areas. The geology is presented in more complete form in another report.[1] The hydrologic data are all published here for the first time. They are rather fragmentary and incomplete but should nevertheless prove valuable in the further development of the water resources of the region. As much information as possible was gathered in regard to the wells throughout the region. Analyses of representative waters were made in the water-resources laboratory of the United States Geological Survey and are given in the descriptions of watering places. Discussions of the ground-water conditions in a number of localities are given in the route descriptions.

Route descriptions and logs.—The road logs are designed to enable a person unfamiliar with the region covered to follow the roads in this region. The accompanying route descriptions supplement the logs and give information of various kinds in regard to the routes and the country through which they pass. They are intended to aid the traveler in understanding the logs and in deciding which route to follow when alternative routes are available. They give all the local information obtained along the roads.

For the sake of uniformity distances between towns are given from railroad station to railroad station, or if there is no railroad station the distance to the post office is given. The logs mention all places at which water or other supplies on or near the route can be obtained and all road forks and crossings in existence when the field work was done that are likely to be confusing to the traveler. Road details change with surprising frequency in parts of this region, and changes have occurred since these logs were made. More roads that show evidence of being recently traveled will be found in the winter than in the summer, because the annual assessment work on many of the mining prospects is commonly done during the cool and comfortable winter season.

All the principal roads and as many of the minor ones as possible were traversed by automobile. The logs are based on speedometer readings, and most of them were checked by traveling the same road more than once. This method of measurement is subject to a number of unavoidable and indeterminate errors. An absolute check between the readings of speedometers on two different cars traveling the same road, or even those of one speedometer on the same car traveling the same road at two different times, can not be expected. However, it is believed that the logs here given are sufficiently accurate for practical purposes. For roads not actually traveled the best available information is given.

[1] Ross, C. P., Geology of the lower Gila region, Ariz.: U. S. Geol. Survey Prof. Paper 129, pp. 183–197, 1922.

Chapter on watering places.—The information in the chapter on watering places is believed to be essentially complete for the country immediately contiguous to the roads traveled during the investigation. For other parts of the region it is not quite complete but was gathered from the most reliable sources available and is sufficiently comprehensive and accurate to be of value to anyone not intimately acquainted with the region.

Maps.—The relief maps (Pls. II–IV) are regarded as one of the most valuable results of this investigation. They are the only reliable maps covering the whole of this region. The United States Geological Survey has published detailed contour maps of the country around Parker, Yuma, and Phoenix. The northern part of the region covered by this report is shown on Bancroft's map of northern Yuma County,[2] which, however, is the result of rapid reconnaissance work and is accurate only in a general way. The principal general maps of the region hitherto published are those of the early explorers, those made by the county engineers of Yuma and Maricopa counties, and the State map compiled by the General Land Office.[2a] The maps here given are compiled from a large amount of plane-table surveying by the writer, a plane-table survey of the country between Phoenix and Wickenburg by C. G. Puffer, field assistant, all data previously published, an unpublished map of the Santa Fe, Prescott & Phoenix Railroad, and miscellaneous data obtained by inquiry and correspondence. They are believed to be reliable in general, although for the most part not accurate in detail. For the territory close to the main roads the detail is sufficiently accurate to serve as a material aid in following the roads. The parts of the maps representing those portions of the region that were not visited during the investigation are much less reliable than the rest. This is particularly true of the area around the Chocolate and Trigo mountains.

All the main roads and many of the subordinate roads have been indicated on the maps, mainly from data obtained in the field. All forks of any importance along these roads are shown, but many of the branch roads and trails are not. Even for the areas where the roads and trails are not shown or are only approximately indicated the relief shading should be of great service in assisting the traveler to find his way through the country. The brief descriptions of watering places remote from main roads should also help in this connection.

The relief shading on the maps is the work of J. H. Renshawe, of the topographic branch of the United States Geological Survey. The

[2] Bancroft, Howland, Ore deposits of northern Yuma County, Ariz.: U. S. Geol. Survey Bull. 451, pl. 1, 1911.

[2a] The recently issued maps of Arizona prepared by the United States Geological Survey and the General Land Office incorporate the data obtained in this investigation.

light is assumed to come from the northwest, so that the southeast slopes are in shadow. Different depths of shading have been used to indicate the altitude of different parts of the region. The high portions are shown in the lightest shades. All portions shown in the same shade are at equal altitudes, except that areas which are in shadow are darker than areas equally high which are illuminated by light from the northwest. The data on which the shading was based were taken from many sources and vary greatly in reliability. Only in those relatively small portions of the area for which standard contour maps have been published by the United States Geological Survey can the shading be considered accurate in detail.

ACKNOWLEDGMENTS.

The data in this report were gathered from so many different sources that it is impossible to acknowledge all of them individually. The writer wishes to express his warm appreciation of the uniform kindness and hearty cooperation of nearly everyone with whom he came into contact during the field work. He is indebted to the officials of the Flower Pot Cattle Co., of Arlington; Mr. R. O. Worley, of Bouse; Mr. T. W. Bales, of Vicksburg; Mr. C. M. Hindman, county engineer of Yuma County; the Chamber of Commerce of Phoenix; and many others for assistance and valuable information. The Atchison, Topeka & Santa Fe Railway Co. supplied valuable data in regard to alinements and altitudes along its lines. Both this company and the Southern Pacific Co. also gave much information in regard to water supplies.

The work was done under the direction of O. E. Meinzer, chief of the division of ground waters of the United States Geological Survey. He and the other members of the division have given many valuable suggestions, and several other members of the Geological Survey have furnished data. In particular E. L. Jones has furnished information in regard to the topography and water resources of the S. H. Mountains and other parts of the area with which he is personally familiar.

GENERAL FEATURES OF THE REGION.

CLIMATE.

The healthfulness of the climate of Arizona is well known. The clear, dry air is invigorating and refreshing. The heat of midsummer is considerable but almost never oppressive. If the visitor chooses his food and clothing with discretion, he need never suffer from the heat at any season. A temperature of 110° or even 115° F. on the Arizona desert is far more endurable than one of 90° in an eastern seacoast city. At all seasons except midsummer the climate is delightful. In the winter in southwestern Arizona the temperature frequently drops at night to the freezing point, but rarely indeed does it go far below that point. The daily variations in temperature are marked, especially during the winter. In January and February the temperature may drop below freezing during the night and rise above 70° at noon.

The rainfall in this portion of the State is small, ranging from about 3 inches a year at Yuma to 7 or 8 inches at Phoenix. Scarcely a day passes in which the sun does not shine for at least a portion of the time, and even partly cloudy days are rare. This is indeed a land of almost perpetual sunshine. There are two relatively rainy seasons—one in winter and one in midsummer. The principal elements of the climate are shown in the table on page 6

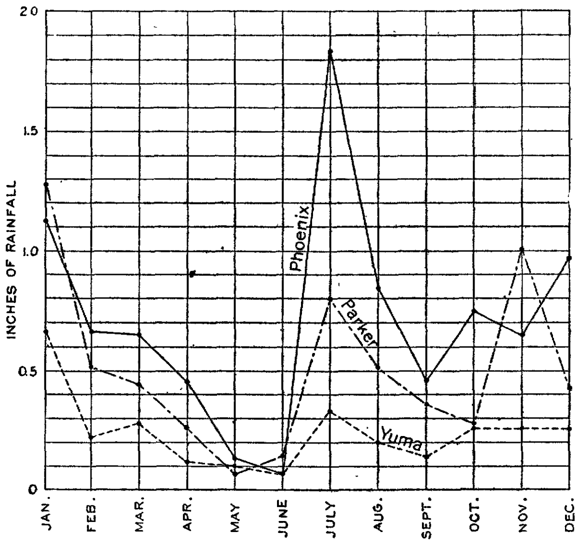


FIGURE 2.—Graph showing distribution of rainfall at Phoenix, Parker, and Yuma, 1910–1918.

for nine stations well distributed over the region. The table on page 7 gives rainfall data by months for stations at the three corners of the region for nine years, and Figure 2 summarizes the same information graphically for easy comparison. There are at times marked variations from the normal amount of rainfall. In 1905 the precipitation at Yuma was 11.41 inches, nearly 70 per cent of which fell in the first three months of the year. In 1899 the precipitation at the same place was only 0.60 inch. In 1904 the precipitation at Buckeye was 21.80 inches, and in 1891 at the same place it was 0.63 inch. Snow is almost unknown, and hail is rare. The scanty rainfall is a tremendous handicap to the devolpment of the region, but it adds to its attractiveness from the viewpoint of the tourist and the health seeker. As a result of the aridity the scenery has a desolate but majestic beauty which is almost unique, and the sunsets have a gorgeous splendor unknown in the humid portions of the continent.

Awe-inspiring tales of sandstorms on the Arizona desert are told and occasionally printed. Such storms occur, but though they may cause temporary discomfort, they are never the serious menace that they are sometimes asserted to be. None are so severe as to hamper travel seriously for more than a few minutes or, at most, hours.

The following description of a sand storm on La Posa Plain may serve to show what such storms are like. The storm came from the southeast and was preceded by showers of rain in the mountains bordering the plain. Before, during, and after the coming of the sand sharp claps of thunder in the southeast were heard. The first bodies of flying sand to be seen were long, thin pillars, reaching far up into the sky and resembling waterspouts on the ocean in shape and general appearance but moving with much greater velocity. These were followed by hurrying, fluttering, billowing clouds of sand, which were large but thin, so that the quantity of sand they transported was not great. Behind these thin clouds was the main mass, advancing in a series of dense waves of fine sand. When the sand waves struck the mountains to the right they were shattered, and the "spray" of sand whirled up as high as the summits of the foothills, much like hurricane-driven water striking a similar obstacle. In 10 or 15 minutes from the coming of the first sand most of it had passed. The wind remained high for a time, and small clouds of sand were scattered about. During the height of the storm it was impossible to travel, because the dense clouds of sand prevented the use of the eyes. Sand penetrated even into underclothing and filled the hair and every wrinkle in the skin not well protected by clothing, causing mild discomfort, but there was almost no cutting or burning of the skin. Sandstorms as severe as this are rare in the lower Gila region.

Climatic data of the lower Gila region.

[Compiled from records of the United States Weather Bureau.]

	Altitude above sea level (feet).	Length of record. (years).	Mean annual precipitation (inches).	Average number of days per year with 0.01 inch or more precipitation.	Temperature (°F.).		
					Maximum recorded.	Minimum recorded.	Mean.
Buckeye	980	26	7.36	28	117	11	68.2
Parker	353	22	4.93	19	124	9	69.8
Phoenix	1,108	[a]23	7.46	36	117	16	69.3
Quartzsite	800	6	6.53	23	119	9	69.6
Salome	1,875	11	10.11	31	118	16	66.4
Wickenburg	2,072	9	9.29	31	114	14	65.6
Yuma	141	[a]38	3.13	15	118	22	71.7

[a] Length of record of precipitation at Phoenix 40 years, at Yuma 50 years.

Monthly and annual rainfall at Phoenix, Yuma, and Parker, 1910–1918.

[Compiled from the records of the U. S. Weather Bureau. T, trace.]

Phoenix.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
1910	0.50	T.	0.61	0.29	T.	T.	0.65	0.14	T.	0.18	1.61	0.34	4.32
1911	1.14	0.66	.64	.02	0.00	T.	6.47	1.97	1.16	2.24	T.	.11	14.41
1912	.00	.00	1.96	.56	.58	.01	1.29	.72	.14	.82	.00	.83	6.91
1913	.38	1.93	.07	.51	.00	.00	.94	.32	.13	.01	.83	.28	5.39
1914	.30	.71	.92	.10	T.	.05	.21	.30	T.	2.30	1.00	3.09	8.88
1915	1.79	1.21	.33	.88	.17	.48	1.12	.25	.10	T.	.54	2.54	9.41
1916	2.34	.13	.37	.15	T.	.00	.77	.30	1.66	.65	.00	.39	6.76
1917	2.20	.95	.15	1.22	.45	.00	3.97	.11	.55	T.	.00	.00	6.60
1918	1.44	.45	.93	.02	T.	.08	1.02	3.47	.39	.52	1.92	1.16	11.40
Mean	1.12	.67	.66	.46	.13	.07	1.83	.84	.46	.75	.65	.97	6.22

Yuma.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
1910	0.56	0.00	0.02	T.	0.00	0.00	0.11	0.18	0.71	0.07	1.58	0.00	3.23
1911	.43	.63	.12	0.08	.00	.00	.44	.01	.23	.84	.00	T.	2.78
1912	.00	T.	.78	.10	.90	.62	.18	.14	T.	.17	.00	.22	3.11
1913	.12	.14	T.	.18	.00	.00	.17	.28	.00	T.	.15	.00	1.04
1914	.05	.33	.74	.30	T.	.01	.44	.00	T.	.79	.50	1.06	4.22
1915	2.56	.72	T.	.08	T.	.00	.34	.41	.10	T.	T.	.12	4.33
1916	.52	T.	.24	.01	.00	.00	.92	.02	.01	.00	.00	.73	2.45
1917	1.02	.06	T.	.24	T.	.00	.50	.23	.17	T.	.00	.00	2.22
1918	.81	.12	.72	.00	T.	.02	.02	.53	.02	.35	.07	.24	2.90
Mean	.67	.22	.29	.11	.10	.07	.33	.20	.14	.26	.26	.26	2.92

Parker.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
1910	0.96	T.	T.	0.22	0.00	0.00	0.52	0.31	0.30	0.00	4.49	T.	6.80
1911	1.52	0.87	T.	.00	.00	T.	.22	.00	.82	.05	.00	T.	3.48
1912	.00	.00	0.77	.50	.20	.50	1.78	.96	T.	1.45	T.	0.40	6.55
1913	.15	.70	.00	.00	.00	.00	.58	.64	.13	.00	1.49	T.	3.69
1914	1.11	1.33	.40	.89	.53	.42	.04	.20	.13	.90	.35	1.32	7.62
1915	2.85	.85	.00	.25	T.	.00	.61	1.02	.95	.00	.44	.19	7.16
1916	3.03	.20	1.77	T.	.06	.00	.00	.00	.88	T.	.00	.75	6.69
1917	1.68	.14	.15	.55	.00	.00	2.82	.70	T.	.00	T.	T.	6.04
1918	.23	.54	.85	.00	.00	.31	.65	.80	T.	.12	.12	1.14	4.76
Mean	1.28	.51	.44	.27	.08	.14	.80	.51	.36	.28	1.01	.42	5.89

HISTORY.

The part of Arizona described in this report was but little known to white men until some time after it had come into the possession of the United States. Except for a few journeys along Gila and Colorado rivers the Spaniards scarcely penetrated it. They established no missions or settlements within its borders, so far as known, although they may perhaps have opened the ancient mine workings reported to have been found at the Castle Dome mine and elsewhere.

Álvar Núñez Cabeza de Vaca brought the first reports of the country now included in Arizona and New Mexico to the Spaniards in Sonora in 1536. His accounts, founded on the statements of the natives, incited the Spaniards to explore this country, which up to that time had never been visited by white men. Marcos de Niza, when he passed through the Santa Cruz Valley in 1539 on his way to Zuni, was the first Spaniard to enter Arizona. The next year he led

Coronado over the same route. Hernando Alarcón explored the Gulf of California and the lower Colorado River at this time. In 1582 Espejo, the explorer of New Mexico, visited the Hopi pueblos and found silver ore 45 miles west of Oraibi. Juan de Oñate in 1604-5 went from New Mexico to Williams River and followed it and Colorado River to the Gulf of California. He passed Gila River and named it Río del Nombre de Jesús. The present name was first recorded in 1697. Oñate's expedition returned to New Mexico over the same route by which it came.

Father Eusebio Kino, in 1691, began the labors of Jesuit missionaries in southern Arizona. In January, 1697, Kino placed cattle, sheep, goats, and mares with the Indians of San Xavier del Bac, south of Tucson, and supplied live stock to the Indians on San Pedro River. The Jesuit missions of San Xavier del Bac and San Miguel de Guevavi, both south of the present city of Tucson, seem to have first had resident fathers about 1732, though the foundations for a large church at San Xavier were laid by Kino in April, 1700. They were probably maintained continuously for the rest of the Jesuit period. Arizona south of Gila River had been explored repeatedly by this time. There is no evidence of mining for precious metals during this period except to a small extent near Tubac, although the Jesuits did some prospecting. Of Kino's fourteen journeys in Arizona, four were attempts to find a land route to California. He reached the vicinity of the present settlement of Dome in the spring of 1699, and on another trip in the fall of 1700 he reached the Colorado below Yuma. In November, 1701, he crossed the Colorado below Yuma, and in 1702 with Father Manuel Gonzales he reached the mouth of Colorado River.

In 1744 Father Jacobo Sedelmair followed the north bank of the Gila from the vicinity of Casa Grande probably to Agua Caliente, being the first to explore the Big Bend of the Gila. From Agua Caliente or some point near by he went across country to Colorado River, reaching that stream at a spring, perhaps near the modern Ehrenberg. He followed Colorado River to Williams River and then returned. This is the only recorded Spanish expedition of importance which penetrated into the interior of the region described in this paper. Sedelmair made two more expeditions in 1748 and 1750. In the first of these he noted the pictographs in what are now known as the Painted Rock Mountains and named the ranchería at the hot springs below and on the other side of Gila River Santa María del Agua Caliente. Thence he followed the north bank of the Gila and reached the Colorado at a point about 2 leagues above the junction of the two rivers. Subsequently he followed Colorado River to the last Yuma ranchería below the Gila and then returned by the same route.

The Jesuit missionaries were expelled by order of the King of Spain in 1767 and replaced by Franciscans in the following year. The presidio of Tucson was established in 1776. The missionaries had numerous conflicts with Apache and other Indian tribes between 1767 and 1790. From 1790 to 1820 there was peace with the Apaches and comparative prosperity. Some mining was carried on during this time, and there was stock raising and farming near the presidios.

Father Francisco Garcés made four expeditions from his mission at San Xavier del Bac into the northern country during this period. In 1768 Garcés set out from San Xavier and descended Gila and Colorado rivers to the Gulf of California, thus repeating the work of Kino and Sedelmair. In 1774, with a military expedition, he made the overland journey to California by way of Yuma, opening the earliest transcontinental route. The next year, with a second expedition on its way to California, Garcés left the others at Yuma, visited the tribes along the Colorado, and finally leaving the Colorado near Needles went overland to California, exploring Mohave River for the first time. Returning from California by the same route, he struck east from Needles to the vicinity of the modern Kingman. Going up the plateau, he visited the Havasupai Indians in the Grand Canyon and later the Hopis at Oraibi. Being rebuffed by the Hopis, he returned to San Xavier by the previous route along Colorado and Gila rivers. This intrepid explorer was killed in a revolt of the Yuma Indians on July 17, 1781, at a mission and presidio which had been started at Yuma the year before.

Mexico won its independence from Spain in 1822. From that time until the Arizona country came into the possession of the United States little was accomplished there. All the presidios except Tubac and Tucson were temporarily abandoned, and Apache troubles were renewed. In 1827–28 an order of expulsion against Spaniards caused many of the friars to leave, and after this the establishments in Arizona were almost entirely abandoned.

The only explorations of Arizona in Mexican times, with the exception of short trips of troops in pursuit of Apache raiders, were those of foreign trappers, chiefly Americans from New Mexico. Kit Carson is supposed to have trapped on Gila River, perhaps as early as 1826. Among other early American pioneers in this region were the Patties, Pauline Weaver, who discovered the gold placers near La Paz, Ewing Young, and David Jackson. The Apaches are said to have been friendly to the Americans until about 1836, when Americans treacherously killed one of their chiefs with many of his people.

In 1848, as a result of the Mexican War, New Mexico, including Arizona north of Gila River, was ceded to the United States

During the war Arizona was occupied and traversed by a military expedition under Gen. Philip Kearny. Col. Philip Cooke, Lieut. W. H. Emory, and other officers of the expedition obtained and published much important geographic knowledge.

The discovery of gold in California caused a great migration from other parts of the United States and from Mexico. Many parties passed through the valleys of Santa Cruz and Gila rivers on their way to the land of promise. The number of emigrants crossing the Colorado near the mouth of the Gila before 1851 has been estimated at 60,000, which is probably somewhat too high.

By the Gadsden Purchase of 1854 the part of Arizona south of Gila River was bought by the United States for $10,000,000. The international boundary was surveyed in 1855, and the United States took possession in 1856 by sending troops to Tucson.

Several more or less successful attempts to navigate Colorado River with small steamers were made about this time. Ferries were put in operation at Yuma. The first stage line in Arizona, known as the Butterfield stage, was started in 1856 and ran between San Diego, Calif., and Marshall, Tex., following the Gila Valley in southwestern Arizona. This line ceased operation at the outbreak of the Civil War.

The settlement at the present site of Yuma was established in 1854. It was first called Colorado City, then Arizona City, and finally Yuma. Gila City, at the place now called Dome, was established in 1858 because of the discovery of gold placers but had a short life. In 1862 placers were found on the Colorado, and La Paz, Ehrenberg, and Mineral City grew up as a result of the ensuing excitement.

At the beginning of the Civil War the troops were withdrawn from Arizona. As a result the Apaches resumed their raids on a large scale, and nearly all the whites were killed, driven from the country, or forced to concentrate in Tucson. It has been estimated that the white population of Arizona was reduced to 500 or 600 people at this time. Mining and other industrial enterprises practically ceased to exist for the time being.

When Arizona was ceded to the United States it was made part of the Territory of New Mexico, and the Gadsden Purchase was also included in that Territory. This did not suit the inhabitants of Arizona, who claimed that they were not and could not be adequately governed from so distant a place as Santa Fe, the capital of New Mexico. In 1856 a convention at Tucson sent a delegate to Congress and petitioned for independent Territorial government, but the petition was refused. In 1860 a convention at Tucson drew up a provisional constitution to remain in force "until Congress shall organize a Territorial government and no longer." The new Territory was to include all of New Mexico south of latitude 33° 40′ N. Officials were appointed and New Mexican legislation was ignored, but nothing further was done. In 1861 Tucson was occupied by Texan troops, declared for the Confederacy, and sent a delegate (who was not admitted) to the Confederate Congress. That body in January, 1862, passed an act organizing the Territory and including New Mexico in it. This act did not take effect, however, as in May of that year the Texans were driven out by Federal troops from California. Arizona Territory was finally organized by act of Congress of February 24, 1863. It was defined as that part of New Mexico west of the meridian of 109°. The Territorial capital was at Prescott from 1863 to 1867, at Tucson from 1867 to 1877, and at Prescott again from 1877 to 1889 and was finally moved to Phoenix.

The lower Gila region was never the scene of such extensive and bloody Indian warfare as some other parts of Arizona, because of the character of its aboriginal inhabitants and of the scarcity of white settlers in the early days. The region was so inhospitable that it supported only a meager Indian population. The Pimas, the Maricopas, and some Papagos dwelt on the banks of Gila River near the junction with Salt River. The Gila furnished water for the extensive irrigation systems for which the Pimas and Maricopas are so well known. These tribes were from the first friendly to the whites and foes of the savage Apaches. Near the junction of Gila and Colorado rivers were the Yumas, originally a powerful and warlike tribe. Their reception of the first Spanish explorers was cordial. Although they later revolted and killed the priests and Spanish soldiers living among them, they were in general not very troublesome to the whites. They suffered much in wars with other tribes, and their strength was broken in 1857 by a decisive defeat at the hands of the Pimas. North of them on the Colorado were the Mojaves and related tribes, who maintained a precarious livelihood by farming on the bottom lands of Colorado River, depending for their water on overflow during floods. The Yavapais or Apache-Mojaves lived in part in the region between Colorado and Gila rivers. They were in early days inclined to be friendly toward the whites, but after being subjected to outrage from the whites in 1866 to 1868 went on the warpath until about 1872. The vicious and warlike Apaches, who have left so bloody a record in other parts of the State, did not trouble the few white settlers in the lower Gila region because the whites had nothing worth stealing and the distance and difficulties of travel from the Apaches' mountain fastnesses were too great.

The only attractions for white men in this region in the early days were the possibilities of trapping and hunting in the valleys of Gila and Colorado rivers and the reported mineral wealth. The trapping and hunting carried on by hardy adventurers added to the knowledge of the region and helped to attract Americans to it but did not result in permanent settlements. The gold excitements on Gila and Colorado rivers and the resultant mushroom cities have already been mentioned and will be referred to again in the route descriptions. In 1863 the lead and silver deposits of Castle Dome and the gold ores of Vulture were discovered. These deposits yielded rich returns for a number of years. The copper deposits at Planet were early found and worked. These and later mines are referred to in the chapter on mining and in the route descriptions. Agriculture and stock raising are both comparatively late developments in the lower Gila region. The Mormon settlement made in 1876 near the present city of Phoenix was one of the first agricultural enterprises of any importance attempted by white men in this region. Since 1885, when the last serious Apache outbreak occurred, there has been a steady increase in population and prosperity.

Yuma County is one of the four original counties into which, in 1864, Arizona Territory was divided. The others were Pima, Mohave, and Yavapai. Maricopa County was created in 1871 out of parts of Pima and Yavapai counties.

In accordance with an act of Congress of June 16, 1906, the inhabitants of Arizona and New Mexico voted November 6, 1906, on the question of uniting the two Territories into a State to be called Arizona. New Mexico was favorable to this measure, but it was defeated by the Arizona vote. By presidential proclamation of February 14, 1912, Arizona became a State. New Mexico had received statehood January 6, 1912.

The following books are the principal authorities on the history of the region and are the sources of most of the information in this chapter:

Bancroft, H. H., History of Arizona and New Mexico.

Bolton, H. E., Kino's Historical memoir of the Pimería Alta, 2 vols., Cleveland, 1919.

Coues, Elliot, On the trail of a Spanish pioneer, New York, 1900.

Reports of the Territorial governor of Arizona.

Hodge, F. W., Handbook of American Indians: Bur. Am. Ethnology Bull. 30, 2 parts, 1910.

INDUSTRIAL DEVELOPMENT.

Mining.—This portion of Arizona has been extensively prospected. Mineral deposits are now known to occur in every mountain range and in many of the groups of hills within the region. The only hills in which mineral deposits have not and in all probability will not be found are those composed exclusively of Quaternary basalt.

The types of ore deposited and the minerals found are many and diverse. Mining has been carried on in this region for gold, silver, copper, lead, zinc, mercury, iron, and manganese. There has been some prospecting for tungsten, but no mining. Fluorite occurs in the Castle Dome district and possibly elsewhere but has not been extensively developed. Gypsum occurs in some places in the region, but no deposits of commercial importance are known.

Mining is in progress in several of the mountain ranges in this region, but no large mines are being operated at present. In the past the Vulture mine, in the Vulture Range; the mines about Kofa, in the S. H. Mountains; the Harquahala or Bonanza mine, in the Little Harquahala Mountains; and some less well-known properties have shipped considerable gold ore. Silver and lead were mined for some years in the Castle Dome district, in the mountains of the same name. Gold placers were worked for some years along Colorado River near La Paz and Ehrenberg, in and near the Dome Rock and Plomosa mountains, and at Gila City, on Gila River at the site of the present town of Dome. Placer mining is still in progress in the Plomosa and Dome Rock mountains, but elsewhere it has almost entirely ceased. The scarcity of water appears to be the principal obstacle to the successful development of the placers. In the old vein mines the richer and more accessible portions of the ore bodies have been worked out, and lack of transportation facilities and of capital has prevented further development. Work at the Harquahala mine was resumed in 1918 with the hope of finding copper ore. It is possible that many of the mines now abandoned could again be made profitable producers by development in depth.

At the present time there is considerable activity in the small copper mines in the vicinity of Cunningham Pass, in the Harcuvar Mountains. Mining for copper and other metals is being carried on in the Buckskin and Plomosa mountains and to a small extent elsewhere. More or less desultory prospecting is in progress in all the mountain ranges. In 1918 plans were being considered for reopening some of the mines in the vicinity of Kofa.

Agriculture.—Within the lower Gila region there are only two irrigation projects of major importance—the Salt River valley project and the Yuma project—but the best land under each project lies outside of this region. Small irrigation districts are served by the Buckeye, Arlington, Air Line, Avondale, Enterprise, and Gila River Land Co.'s canals along Gila River west of Salt River valley. Forage crops are the principal ones raised in these districts, but wheat, corn, and long-staple cotton are grown to some extent, especially near Buckeye. The ranch of the Southwest Cotton Co., north of Avondale, was still in the development stage at the time of visit in 1917. Numerous irrigation projects have been attempted in the past along Gila River west of those named above, but all were unsuccessful, or successful for a short time only. At present small areas are being irrigated near each of the towns on the river, but no important projects are in progress, although one, the Gillespie project, is reported to be nearly prepared to start irrigation. A historical account of irrigation along the Gila is given on pages 95–108.

There is a little irrigation near the towns on the Santa Fe, Prescott & Phoenix Railroad and in Hassayampa and La Posa plains and Butler and Harrisburg valleys, but no large areas have been brought under irrigation, nor does it seem likely that any will be in the future. A considerable part of the Colorado River Indian Reservation near Parker is under irrigation, principally by the Indians. There is reported to be a thriving bee industry and some irrigation in Cibola Valley.

The following notes will give a general idea of the possibilities for future agricultural development, so far as these can be judged from the information now available. Sufficient data have been obtained to show that the ground water lies so deep in a large portion of the region as to preclude its development for irrigation from pumped wells. The Harquahala Plain, most or all of the Ranegras Plains, and the Middle Well country, except that near Gila River, certainly are in this class. Irrigation farming in Butler and McMullen valleys and Hassayampa Plain, where water is 100 feet or more below the surface, would probably prove too expensive under present conditions. The valleys of Gila and Colorado rivers, the Harrisburg Valley, and the districts in the immediate vicinity of Bouse and Parker have fairly shallow ground water. Attempts at irrigation on the lower Gila have so far met with poor success. Possibly development more intelligently directed would be successful in some parts of this valley. When better transportation facilities are available several fertile tracts on Colorado River will probably be irrigated.

Castle Dome Plain and a considerable portion of Palomas Plain do not seem well adapted for agriculture even if water were available, as the soil does not appear to be suitable. The same can be said of large portions of Cactus Plain, although it is quite possible that some parts of this plain might prove productive if irrigated.

Of the country examined during the present investigation only La Posa Plain remains to be considered. The greater portion of this plain is rather far from railroad facilities. There is, however, a good road 24 miles long betweeen Quartzsite, near its center, and Bouse, on the Atchison, Topeka & Santa Fe Railway. Very little development of the ground water has been undertaken in La Posa Plain. Placer-mining men are said to have sunk some rather deep wells, but the records of these wells are not available. The wells in Quartzsite show that water is present at depths of about 40 feet. The soil in parts of the plain appears to be of good quality. It is probable that in the future both stock raising and farming will increase here.

The country in the vicinity of Alamo Springs, where Clanton & Smith report that they have a well only 35.5 feet deep, was not visited. In any event, this locality is rather too far from any railroad for profitable farming at present.

The geologic discussions in this report will make it clear to the reader that the structure is not favorable for the development of artesian flows from the rock formations. So far as is known the structure of the valley deposits does not fulfill the conditions necessary for obtaining artesian flows, except perhaps in river bottoms, such as those of the Colorado, where flows may be obtained.

Stock raising.—Cattle raising is at present being carried on successfully in Arlington, Clanton, and Butler valleys and Hassayampa, Ranegras, Harquahala, and La Posa plains and to a minor extent elsewhere. Cattle and sheep range on the north side of the Bighorn Mountains and in the vicinity of Wickenburg. The scarcity of water and of forage grasses and the difficulties of transportation make very intensive use of the region for stock raising somewhat doubtful. However, medium-sized ranches will continue to be successful in the region, and as transportation facilities and the demand for cattle increase the stock business will doubtless improve.

FLORA.

The desert of southwestern Arizona has an abundant and diversified flora of a type found nowhere else in the United States. The surprising number of large woody plants in this arid region has given rise to the term "arboreal desert." No part of southwestern Arizona is so dry that it is without plants. All are strange to dwellers in more humid regions, and the weird and fantastic forms assumed by many of them are one of the most fascinating features of the region.

The types of plants found in any particular area are closely controlled by the altitude, topography, soil, and depth to ground water. In the river valleys, where ground water is shallow, are found arrow weed, willow, salt grass, and dense thickets and miniature forests of creeping and arboreal mesquite. In places where the ground water lies sufficiently near the surface to be reached by the roots, mesquite grows to heights of 20 and even 40 feet. Along Colorado River there are groves of cottonwood. Old settlers say that 40 years ago cottonwoods were abundant along the Gila also, but they are practically all gone now from the banks of that stream in this region. At Osborne Well, in the Buckskin Mountains, far from any permanent streams, are several good-sized cottonwood trees, but it is probable that these have been planted by men and are not native to the locality.

In the interior valleys creosote, ironwood, palo verde, various bunch grasses, and some cacti occur. The cacti are more plentiful in the higher valleys and the mountains, but some barrel cactus, prickly pear, and cholla grow in nearly all the valleys. Plate V shows typical desert vegetation near Buckeye. Mesquite grows in a number of valleys where the ground water is certainly too deep to be reached by the roots (see p. 40), but in such localities it is always stunted and poor and usually occurs in the path of flood waters. Ocatilla grows in most of the valleys but appears to be most abundant in the higher parts of the valleys and on the lower slopes of the mountains.

In the mountains there is much less vegetation than in the valleys, because many of the slopes are bare rock or covered with rock talus. The various cacti are abundant here. The stately sahuaro is the most striking representative of this family. These plants are abundant in many places on the lower slopes of the mountains. In some of the small valleys within the mountains cholla is the predominating form of vegetation. Creosote, ironwood, various cacti, besides those mentioned above, some palo verde, and subordinate amounts of bunch grasses also occur in the mountains.

FAUNA.

Most of the wild animals in this region are small and not very abundant. A tourist might very readily travel through the country in an automobile several times without seeing any of its native four-legged inhabitants. A number of interesting animals make their homes here, however. Whitetail deer live in some of the mountain ranges but are rather rare. Rocky Mountain sheep can still be found in some of the more inaccessible and rocky parts of the mountains. Mountain lion and wildcats are occasionally met. Coyotes advertise their presence almost every night by discordant vocal concerts which must be heard to be appreciated. Foxes are fairly plentiful. They are shy but curious animals and frequently come into camp at night. In some of the valleys jack rabbits are abundant. Cottontail rabbits are common in most of the mountains and in the river bottoms. Kangaroo rats and other small rodents are numerous in several localities.

Quail are very common throughout the winter and fall in the valley of Gila River and are found in less abundance elsewhere in the region. Turtle and mourning doves are to be seen in the irrigated districts, sometimes in considerable numbers. Cranes, jack-

DESERT VEGETATION IN BUCKEYE VALLEY.

Foothills of White Tanks Mountains in the background.

snipe, and similar birds frequent the river bottoms. There are several types of small birds, some of them attractive songsters, but they are more common in the irrigated districts than elsewhere. Crows are, at times, all too common in irrigated districts. Turkey buzzards are omnipresent but are seldom noticed except when there is carrion in the vicinity.

Reptiles constitute a characteristic part of the desert fauna. Active little lizards are found everywhere. The torpid Gila monster is occasionally found. Many awe-inspiring tales are told regarding this lizard, the only one whose bite is at all poisonous, but they rest on only a meager foundation of fact. Snakes of several kinds are present; they are rather abundant in some localities. The only dangerous one is the rattler, and even he asks only to be let alone. Land turtles live in the mountains, but they are seldom seen.

Scorpions, vinegarroons, tarantulas, and centipedes are fairly abundant but not enough to be particularly troublesome. Flies and mosquitoes are nuisances in the vicinity of bodies of surface water but are absent over most of the region.

TOPOGRAPHY.

The lower Gila region contains numerous rugged mountain ranges, most of which are relatively short but have a pronounced elongation in one direction. Between successive mountain ranges there are broad, smooth intermontane valleys, deeply filled with detrital material. All the valleys in the region, with probably one exception, have openings in their inclosing walls through which the drainage finds outlet. The probable exception is the valley between the Bighorn and Vulture mountains, the floor of which is reported to be covered with a shallow sheet of water for several months after heavy rains.

The region lies in the drainage basin of Colorado River. Gila River is the principal tributary of the Colorado and drains nearly all of the region except an area in the northern part that is tributary to Williams River and a rather narrow belt along the west side that drains directly into the Colorado. The Gila is the only tributary of Colorado River in the region except Williams River that contains water in considerable portions of the bed at all seasons. Even the Gila, however, is a through-flowing stream only after heavy rains. The principal tributaries of Gila River in this region are Agua Fria and Hassayampa rivers. They contain flowing water after rains and have water in certain sections of their beds during most of the year. This is particularly true of the Agua Fria. The other streamways in this region are washes that contain flowing water only in times of flood. A few of these contain water in small natural tanks during most of the year. Many of the washes lose their identity in the sand of the valleys, and the water which in times of flood fills these washes with roaring torrents rarely remains above the surface until it flows into the Colorado or the Gila, except where the water has its source very close to one of these main streams. The largest of the dry washes is Centennial Wash, described on pages 39–41.

There are thirty mountain ranges and about fifteen groups of hills in the region. The average length of the ranges is a little over 20 miles, and the average width about 6 or 7 miles. The height of the mountains varies considerably. The average height of the principal peaks above the bordering valleys is more than 2,000 feet. The highest peak is Harquahala Mountain, which is reported to reach an altitude of 5,669 feet above sea level and which rises abruptly 3,300 feet above McMullen Valley, at its northern base, and even higher above the Harquahala Plain to the south. The valleys range in altitude from about 125 feet above sea level at Yuma to more than 2,000 feet in McMullen and Butler valleys.

The topography of the mountains is of three general types, which are directly related to their geology. Ranges composed essentially of metamorphic rocks, including gneisses, are in general rather elaborately carved, have serrate profiles, and are fairly symmetrical with respect to their divides. The line of summits along the divide of such a range is a definite and pronounced feature. The slopes of these mountains are usually steep and the outlines are jagged.

In marked contrast to the ranges of metamorphic rocks are those composed principally of volcanic rocks other than basalt. In these erosion has worked on a number of beds of lava and tuff cut by intrusive pipes, dikes, and sills. The result is a bewildering maze of buttes, mesas, peaks, and pinnacles. Sheer cliffs and castellated summits are the rule. As the ranges are fault blocks they have definite trends, but in each there is an almost total lack of anything approaching symmetry. Their surface features are further complicated by minor normal faulting, which has locally tipped lava blocks to considerable angles.

The buttes capped with basalt of probable Tertiary age (see pp. 22–23) present a third type of mountain form. They are flat or somewhat rounded on top and not greatly dissected, but their sides are sheer cliffs in the upper parts, usually with talus slopes below. They are prominent features of the landscape, rising 500 feet or more above the surrounding country. Yellow Medicine Butte rises 1,300 feet above its northern base, and there are others of comparable height.

Many of the hills are small replicas of the mountains, but those built up of Quaternary basalts (p. 27) are of a different type. They are rounded or conical hills, none of which are very high. Isolated cones and hills with two conical peaks are common. Associated with these are mesas, 100 feet or so high, formed by flows of basalt. The mesa on which Stanwix, Sentinel, and Tartron are situated has an area of more than 200 square miles. This is by far the largest of the lava mesas, but some of the others are also prominent topographic features.

The valleys between the ranges have slopes that average roughly 20 to 30 feet to the mile. In some places—for example, the Ranegras Plains south of Vicksburg—the surface is covered with a deposit of fine silt laid down by sheet floods from the mountains. Such plains have much less slope and are typically not cut by washes, whereas the more usual type of valley has numerous washes extending out from the mountains and persisting with definite channels through all or most of the length of the valley. The washes have a tendency to interlace with one another, forming a braided pattern. This is especially well developed in Castle Dome Valley, southwest of the Castle Dome Mountains. The line of demarcation between valley and mountain is in many places sharp, and the change in grade is abrupt. In places, however, there is an intermediate rock-floored surface, similar to the mountain pediment described by Bryan.[3] These surfaces are, however, by no means as pronounced features as the mountain pediments in the Papago country, south of the Gila.

GEOLOGY.[4]

The commercial development of such a region as that here described is intimately related to the geology. The hope of finding mineral deposits usually furnishes one of the initial incentives for pioneering in such regions. When promising deposits are found, towns spring into existence, and the settlement of the country commences. In the early days in southwestern Arizona fur trapping vied with prospecting as an occupation for the adventurous frontiersmen. When the country became a little better known and more settled, cattle raising and farming were introduced. Both of these industries, particularly farming, depend on a supply of water for their success. The available surface water here soon proved insufficient, and recourse was early had to utilization of the ground water by means of wells. The distribution, quantity, and quality of the ground water in any region are directly dependent on the geology and physiography of the region.

[3] Bryan, Kirk, Erosion and sedimentation in the Papago country, Ariz.: U. S. Geol. Survey Bull. 730, pp. 52–65, 1922.

[4] For a more complete description of the geology of this region see U. S. Geol. Survey Prof. Paper 129, pp. 183–197, 1922; see also the route descriptions on pp. 152–194.

ROCK FORMATIONS.

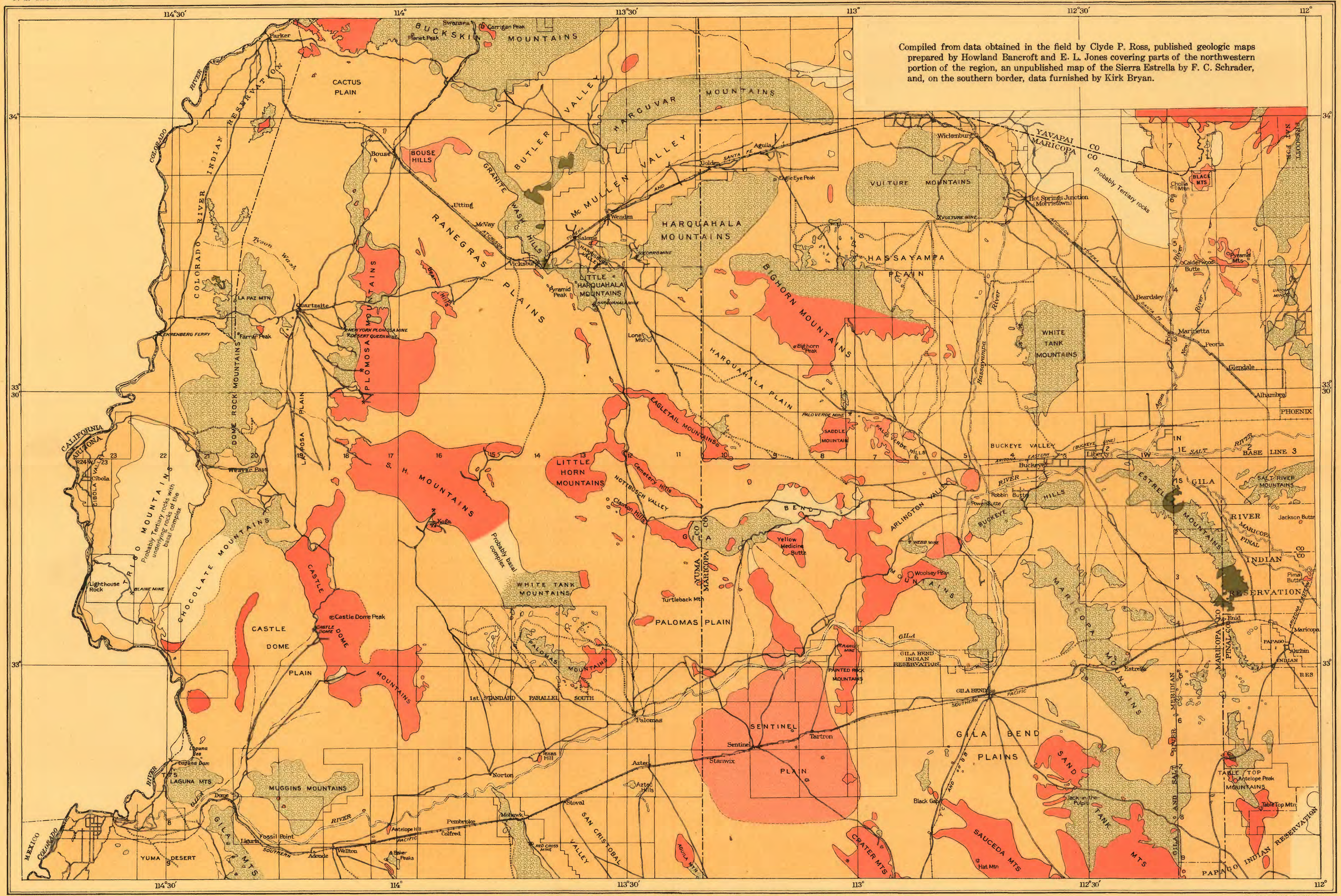
At first glance most of the mountains in this section of the country present a very similar appearance. Examination soon shows, however, that they are composed of a number of very diverse types of rocks. (See Pl. VI.) There are great masses of ancient metamorphic rocks, of granite and granitic gneiss, of lava and tuff belonging to at least two distinct ages, and of subordinate amounts of sedimentary rock associated with the older lava and tuff. Sand, clay, and gravel fill the valleys between the ranges. More detailed work will undoubtedly result in still further subdivision of the rocks. The metamorphic rocks are certainly of two and probably of more than two ages. The granitic rocks belong to at least two periods of intrusion.

BASAL COMPLEX.

Highly metamorphosed sediments with associated granitoid gneiss and other rocks of igneous origin make up the whole or a large part of many of the mountain ranges in this region. These rocks will be referred to collectively as the basal complex. They may be divided into four general groups—(1) igneous rocks, (2) highly metamorphosed schistose rocks, probably in the main of sedimentary origin, (3) thoroughly metamorphosed but much less schistose sedimentary rocks separated from No. 2 by an unconformity, (4) metamorphosed but not schistose limestone and quartzite, which are the youngest sedimentary rocks in the basal complex. The igneous rocks may be further subdivided into batholithic masses with associated dikes and a group of somewhat younger dikes which cut the less metamorphosed portions of the basal complex.

This ancient complex is present in every mountain range and almost every range of hills in the region. Even in those mountainous areas where it is not shown on the geologic map (Pl. VI) outcrops can be found in stream beds that have cut through the younger formations which elsewhere cover it. In some of the hills, however, especially those which are composed of basaltic lavas, such as the Bouse Hills and Palo Verde Hills, metamorphic rocks do not occur.

There can be little doubt that the granitoid gneiss and associated metamorphosed sedimentary rocks, with the possible exception of the youngest of the sedimentary rocks, are of pre-Cambrian age. The fact that no fossils that can be used to determine the age of the beds have yet been found in any of the rocks examined during the present investigation makes all the determinations of the age of the formations somewhat uncertain. However, it can not be questioned that these metamorphic rocks are very old. Some of them may



RECONNAISSANCE GEOLOGIC MAP OF LOWER GILA REGION ARIZONA

By Clyde P. Ross

Scale $\frac{1}{500{,}000}$

5 0 5 10 15 20 Miles

1923

EXPLANATION

QUATERNARY

Recent stream deposits, valley fill of unconsolidated or locally consolidated gravel and sand, and older somewhat consolidated and disturbed beds in and near the mountains

TERTIARY

Basalt
(Lava flows and related intrusive plugs)

Lava, tuff, agglomerate, and related fine-grained intrusive rocks, and subordinate amounts of sedimentary beds of arkose, sandstone, shale, and calcareous rocks.

PROBABLY MESOZOIC

Granitic rocks intrusive in basal complex

PRE-CAMBRIAN AND PERHAPS IN PART PALEOZOIC

Basal complex
(Granitic gneisses, micaceous quartzite, arkose, and chloritic schist, metamorphosed quartzite, limestone, and dolomite. Includes also small amounts of later rocks, particularly undifferentiated intrusives)

NOTE: White areas left uncolored for lack of information be as young as Paleozoic, but the absence of fossils is a strong argument against this supposition. The fact that all these rocks, with the exception of the youngest group, are very much more metamorphosed than the known Paleozoic formations to the north and east is another strong reason for believing that they are pre-Cambrian, rather than Paleozoic. There is no reason for believing that there has been more metamorphism in this area since the Paleozoic era than has occurred in the Ray and Globe mining districts. The limestone and quartzite of the youngest group are not much if any more metamorphosed than similar rocks of Paleozoic age at Ray and Globe and may well be of similar age.

TERTIARY LAVAS.

Lavas occur throughout the lower Gila region and extend far beyond its limits. The series consists of a number of superimposed flows of varying thickness, with widely different superficial characteristics, associated with some tuff and agglomerate and a very subordinate amount of sedimentary rock. It reaches its maximum development in the S. H. Mountains, where the total thickness is certainly more than 2,000 feet. A number of the individual flows are several hundred feet thick.

Volcanic rocks similar in occurrence and general characteristics to rocks of this series have been reported from a number of localities in the Southwest.

These rocks have all been referred to the Tertiary, and most of them are supposed to be Miocene. This supposition is based principally on their field relations to rocks of known age, the paleontologic evidence within the series themselves being scanty or altogether lacking.

Overlying the Tertiary beds and associated with the unconsolidated or partly consolidated Quaternary sand and gravel are basalt flows of early Quaternary age. These are described under Quaternary formations (p. 27). The faulted and uplifted basalts that cap many of the mountains, however, are considered to be Tertiary.

The amount of sedimentary material associated with the Tertiary lavas is small compared to the total thickness of these lavas. The sedimentary rocks are of geologic importance, however, for they furnish clues as to the conditions existing at the time these great flows were poured out. They comprise sandstone, in part arkosic, shale, and calcareous beds.

The Tertiary lavas are almost as widely distributed in this region as the metamorphic complex just described. They were found in every mountain range examined during this investigation except the

Harquahala and Little Harquahala mountains. Some of the ranges, such as the S. H., Eagletail, and Castle Dome mountains, are composed exclusively of rocks of this series resting on a metamorphic basement, which is visible in only a few small areas.

The lavas are for the most part light-colored acidic rocks, but some are basalts. They display a wide range and variety of coloration, which is particularly striking in the Eagletail Mountains. In that range a thickness of over 1,000 feet of nearly horizontal lava flows with interbedded tuff is exposed. The flows and tuffs are cut by pipes, dikes, and sills of felsitic igneous rock. Nearly every flow is different in color from those above and below it, and each stands out from the others with clean-cut boundaries. Among the colors are brilliant yellow, soft green, vivid red, somber brown and dun, and creamy white, with streaks of purple, heliotrope, and other shades. The petrographer who is interested in Tertiary igneous rocks would find much to study here and in the other ranges in this region where similar rocks occur.

The basalts appear in most places to be the youngest of the flows, for they cap the others and form the summits of the mountains. Everywhere in the region the Tertiary basalts are subordinate in amount to the acidic lavas. Thicknesses of 300 feet of basalt are rare, but 1,000 feet or more of acidic lava occurs at numerous places. The Tertiary basalts are best developed in the Gila Bend Mountains north of Point of Rocks.

Interbedded with the acidic flows are beds of siliceous agglomerate and of rhyolitic tuff. The tuff is white or cream-colored and forms conspicuous beds, which are in places scores of feet thick. It is widely distributed throughout the region. The flows and tuffs are cut by pipes, dikes, and sills of felsitic igneous rock.

Bancroft[5] considered all the basalt in this part of Arizona to be Quaternary. Basalts occur on the summits of a number of mountains in the region. The erosion that has occurred since these basalts were poured out is measured in thousands of feet, so that if they are Pleistocene, some of the most imposing mountain ranges in the region have been produced in large part at least during later Pleistocene or Recent time. At Point of Rocks, on Gila River in western Maricopa County, basalt flows capping unconsolidated gravel of the valley abut against the eroded edges of lava mountains. Hence the basalt flows that cap these mountains must be older than the lava in the valley. As the valley lava caps unconsolidated gravel it is clearly Quaternary, and it is so much dissected by erosion and so much weathered as to show that it is early

[5] Bancroft, Howland, Reconnaissance of the ore deposits in northern Yuma County, Ariz.: U. S. Geol. Survey Bull. 451, pp. 32–33, 1911.

Pleistocene. From these facts it is evident that the older basalts that cap the mountains belong to the Tertiary series. It is, however, very difficult or impossible to determine to which age many of the flows belong.

TERTIARY SEDIMENTARY FORMATIONS.

Limestone and calcareous conglomerate occur in at least three widely separated localities in this region. Further work would probably disclose many other outcrops. The known localities are Osborne Wash, in the vicinity of Osborne Well, near Parker; Saddle Mountain; and the Clanton Hills and the valley north of them. Sandstone was found in Antelope Hill, in many places in the Gila Bend Mountains, near Osborne Well, and in the Clanton Hills. Shale is associated with some of the sandstone in the Gila Bend Mountains.

Antelope Hill, at the south end of the concrete bridge across Gila River east of Wellton, is composed of grayish arkose, a sandstone formed from granitic débris. The rock is, as a whole, somewhat coarser grained near the base of the hill than farther up the slope. The average diameter of the grains ranges from 1 to 6 millimeters. The beds have a very gentle southerly dip. The hill is about 580 feet high, so that fully 500 feet of sandstone is exposed. Related but coarser sandstone and conglomerate occur farther to the south.[6]

Red sandstone crops out in several places in the Gila Bend Mountains, notably at and near Woolsey Tank. Near the Dixie mine, in the Gila Bend Mountains, red and purplish shale is associated with the sandstone.

The relations of these sedimentary rocks to the Tertiary lavas show clearly that they are of similar age. Like the lavas, they have been disturbed by post-Tertiary faulting so that the beds now dip in various directions. The Clanton Hills, about 25 miles north of Palomas, consist almost exclusively of flat-lying gray cherty fine-grained limestone with numerous concretions, some of which resemble fossils in superficial appearance. Some of the beds contain small and indistinct fossils of probable Tertiary age. At the west end of the hills is exposed a bed of reddish sandstone composed of quartz grains in a calcareous cement, about 30 feet thick. In the limestone there are some faults along which the rock has been considerably brecciated. Subsequent to the faulting hot solutions circulated through the fault breccias, as is shown by iron stains and by marked silicification of the limestone fragments. No definite evidence of valuable mineralization was found.

Near Osborne Well are considerable exposures of sedimentary rocks. Time did not permit a detailed examination of these ex-

[6] Bryan, Kirk, Erosion and sedimentation in the Papago country, Ariz.: U. S. Geol. Survey Bull. 730, p. 26, 1922.

posures, but the scattered observations made may be of interest. To the west and south of the well are hills with cliffs cut by the large wash that passes between them. In these cliffs are exposures of well-bedded conglomerate with a calcareous matrix, capped by a basalt flow. The pebbles in the calcareous rock are in no place very abundant, and the lower portion contains none. Farther north up this wash are outcrops of red sandstone with concretions, a minor amount of quartz sandstone, and a few small beds of conglomerate. A short distance still farther north red vesicular basaltic or andesitic lava is interbedded with the red sandstone.

Exposures of sedimentary rock are found for about 8 miles west of Osborne Well along the road to Parker. There are numerous outcrops of thin-bedded limestone that is similar in appearance to the matrix of the conglomerate at the well but is entirely free from any but very small pebbles. Several of these outcrops are capped with vesicular olivine basalt. They contain rather numerous small and indistinct fossils similar to those found in the Clanton Hills and a few small angular fragments of quartz and feldspar. Blanchard [7] considers these calcareous beds to be tuffaceous.

Interbedded with the lavas of Saddle Mountain, in Maricopa County, are considerable thicknesses of fragmental rocks ranging from agglomerate and breccia of distinctly igneous character to rocks that have angular fragments of lava about an inch in diameter in a white calcareous matrix.

QUATERNARY SEDIMENTARY FORMATIONS.

The unconsolidated and poorly consolidated gravel, sand, and silt that fill the valleys and floor the flood plains of the rivers in this region are of Quaternary age. Basalts that are clearly also Quaternary are interbedded with or rest upon these sediments.

The valleys throughout this area, like nearly all the desert valleys of the Southwest, are deeply filled with detrital material, most of it unconsolidated or poorly consolidated, derived from the mountains. The thickness of this material in the valleys has not been determined. It is certainly to be measured in hundreds if not in thousands of feet, as is indicated by well records in a number of the valleys.

The character of the valley fill varies greatly, as is to be expected in sediments laid down by generally short and usually disconnected streams under arid conditions. In the flood plains of Gila and Colorado rivers and in certain clay flats or playas in interior valleys there are very fine silts or clays, but the major portion of the fill in the valleys is sand and gravel, commonly very coarse. Much of it is poorly assorted, consisting of coarse sediments in a

[7] Blanchard, R. C., The geology of the western Buckskin Mountains, Yuma County, Ariz.: Columbia Univ. Contrib. Geol. Dept., vol. 26, No. 1, pp. 24–26, 1913.

clayey matrix. The surface layers in most of the valleys contain silty soil more or less mixed with gravel. This soil where it has been properly irrigated has proved to be highly productive. In Castle Dome Plain, Palomas Plain, and to a less general extent in a number of the other valleys in the area, the surface silt has been removed by the wind, leaving a residual floor of gravel. Sand dunes are common in Cactus Plain and also occur in Eagletail Valley.

In almost all the fill that is indurated to any extent the cement is a calcareous material called "caliche," "cement," or "hardpan." Lee[8] has described the mode of occurrence of caliche and discussed the theories as to its origin. He concludes that the caliche in the Salt River valley, which is essentially similar to that in the lower Gila region, has been formed in part by the deposition of carbonates and other salts held in solution in the ground water, and in part by the evaporation of water percolating downward from the surface. On the old road across the Gila Bend Mountains, west of Woolsey Tank, are gravel beds with a calcareous cement which has set so firmly as to form a hard though friable rock. These are exceptionally indurated, but beds of caliche so hard that it is very difficult to penetrate with pick and shovel are common in a number of places in the region. Such beds are known elsewhere in the Gila Bend Mountains, Nottbusch Valley, Castle Dome Plain, and other localities. Wells sunk in La Posa Plain and McMullen Valley usually penetrate beds of caliche below unconsolidated gravel and sand. On the flanks of the Plomosa Mountains, on the east side of La Posa Plain, are thick deposits of gravel cemented with caliche, some of which is auriferous.[9] On the flanks of the Dome Rock Mountains, west of this plain, are similar deposits.

Beds of green and yellow banded clay are exposed in the terraces of the Colorado in the Colorado River Indian Reservation near Parker. Fossil fresh-water shells have been found in some of these beds. E. L. Jones,[10] who made an examination of the reservation for the United States Geological Survey in 1914, states that these are lake beds.

Along washes within the mountains and on the borders of the ranges are beds of gravel and sand similar to those of the valley fill. These beds are cut by the present washes. Although they are clearly similar to the material in the modern streamways and were deposited under conditions very similar to those existing to-day, the position of many of these beds indicates that they were

[8] Lee, W. T., Underground waters of Salt River valley, Ariz.: U. S. Geol. Survey Water-Supply Paper 136, pp. 107-111, 1905.

[9] Bancroft, Howland, A reconnaissance of the ore deposits in northern Yuma County, Ariz.: U. S. Geol. Survey Bull. 451, p. 88, 1911.

[10] Personal communication.

laid down in streams whose courses had little or no relation to those of the present streams. All this gravel and sand is somewhat consolidated. In the wash that parallels the new road where it emerges from the Gila Bend Mountains on the west side the unconsolidated or slightly consolidated gravel of the valley fill can be seen lapping up on the gently inclined and smooth surface of gravel having a calcareous cement. The cemented gravel is continuous with gravel of the same type in the mountains just described. Similar exposures were noted near the road between Wenden and Butler Well on the north side of Cunningham Pass, in the Harcuvar Mountains. Outcrops of gravel of similar appearance, which are being eroded by the present streams, were noted in Osborne Wash, north of Osborne Well, in the Buckskin Mountains.

The partly consolidated detrital beds in the mountains are in places cut by normal faults and tilted to angles of 20° and even more. The best exposures found are in the Gila Bend Mountains. Tilted blocks of gravel were noted near both of the roads that cross this range, but they are especially well exposed along the portion of the old road that lies in the mountains. Outcrops of such material were also found along the large wash followed by the old road on the west side of the mountains. Slight folding in gravel beds was observed in some outcrops near Woolsey Tank along this road. Tilted beds of gravel and sand are exposed at the north end of the Gila Mountains, near Dome. Some of the more consolidated alluvium in the Dome Rock and Buckskin mountains is probably tilted. Beds of gravel and sand that have been disturbed by earth movements doubtless exist elsewhere in the region but were not noted during this investigation.

It is evident that Quaternary sediments belonging to at least three periods of deposition occur in this region. These are (1) the somewhat consolidated beds exposed in and near the mountains, which have been disturbed by faulting; (2) the unconsolidated or only locally consolidated flat-lying valley fill; and (3) the recently deposited material in the washes and playas of the desert valleys and the flood plains of the larger streams. This conclusion is in accord with the results of Lee's work in adjoining areas and in parts of the region here considered.[11] He has given formational names to the two older divisions of the Quaternary formations in the vicinity of Colorado River. The oldest group of gravels and sands he calls Temple Bar conglomerate. The unconsolidated material resting upon the Temple Bar conglomerate and exposed in terraced bluffs along Colorado River and elsewhere he calls Chemehuevis gravel. He gives no

[11] Lee, W. T., Geologic reconnaissance of a part of western Arizona: U. S. Geol. Survey Bull. 352, pp. 17–18, 1908; Underground waters of the Salt River valley, Ariz.: U. S. Geol. Survey Water-Supply Paper 136, pp. 111–114, 1905.

specific name to the recent material that floors the river flood plains. The Temple Bar conglomerate is lithologically similar to the oldest of the three groups of Quaternary formations herein described, but the thicknesses reported by Lee along the upper Colorado are far greater than any found in this region. The two may perhaps be of similar age and history. The Gila conglomerate, described by Gilbert,[12] is similar to the Temple Bar, being a thick formation of coarse alluvium in the upper Gila Valley. The correlation of these formations awaits the complete unraveling of the physiographic history of southwestern Arizona in Quaternary time.

QUATERNARY BASALT.

Associated with the gravel and sand of the valley fill in places in this region are flows of olivine basalt. Such rock caps the fill, is interbedded with it, and also cuts it in the form of dikes and intrusive masses, generally small and irregular. The basalt masses that rise above the present surface of the fill have produced land forms of two general types—flat mesas formed by flows that have spread out over the surface of the fill, as at Point of Rocks and Gillespie dam, both along Gila River, and groups of low, in places more or less conical hills, of which the Bouse Hills, near Bouse, and the Palo Verde Hills, northwest of Arlington, may be mentioned as examples. The mesas consist of flows 100 feet thick or less, with a few thicker ones. Few of the hills are over 200 or 300 feet high, and many are less than this. The conical shape of many of these hills suggests that they are volcanic cones, but all are dissected by erosion, and in none of them was a definite crater found. All the basalt masses, in both mesas and hills, are dissected by erosion and have a weathered appearance. The basalt in this area is not nearly as fresh in appearance as much of that in California described by Darton.[13] The relation of the basalt to the valley fill proves it to be Quaternary, but it is probably not younger than early Pleistocene.

STRUCTURE.

Normal faults are the most conspicuous structural features of the rocks of this region. Thrust faults have not been found, and folding appears to have been of minor intensity since early pre-Cambrian time. There appear to have been three general periods of faulting—one before and one after the outpouring of the Tertiary lava and a third after the deposition of the older Quaternary alluvium. The

[12] Gilbert, G. K., U. S. Geol. Surveys W. 100th Mer. Rept., vol. 3, pt. 5, pp. 540–541, 1875.

[13] Darton, N. H., and others, Guidebook of the western United States, Part C, The Santa Fe Route: U. S. Geol. Survey Bull. 613, pp. 154–155, 1915.

faults of these three periods of movement can not be sharply differentiated—indeed, it is probable that some movement along fault planes has been in progress almost continuously from the beginning of pre-Tertiary faulting to the present day. A few of the mountain ranges in the region show no evidence of being faulted, either because they had a different origin or because erosion has entirely removed the evidence.

GEOLOGIC HISTORY.

EARLY PRE-CAMBRIAN TIME.

The remnants of the oldest pre-Cambrian rocks in this region are so few, so scattered, and so intensely metamorphosed that almost nothing can be learned from them as to the events of that ancient time. These rocks comprise the micaceous and chloritic schist, quartzitic schist, and metamorphosed limestone found included in gneiss in the Buckskin and Gila Bend mountains. Some of them have the appearance of highly altered sediments, but that such is their nature is by no means certain. The large amount of chlorite in some of the schists suggests an igneous origin, but nothing more definite is known regarding them. The record shows only that in early pre-Cambrian time certain rocks, principally of sedimentary origin but perhaps also in part of igneous origin, were formed here. These rocks were buried, metamorphosed, and finally intruded by batholithic masses of granite and kindred rocks. The period of intrusion was followed by a very long period of erosion. Nearly all the ancient schists were removed and the granitic rock was exposed. Meanwhile the granites had been rendered gneissoid, and the blocks of other rocks included in them had suffered intense dynamic metamorphism.

LATE PRE-CAMBRIAN TIME.

The next event recorded was sinking of the land and influx of the sea. A thick series of sandstone and limestone with some mudstone was laid down in this sea.

Various dikes, principally of diabase and pegmatite, are associated with the metamorphic formations. Some of them are to be correlated with the ancient batholithic intrusions and are older than the pre-Cambrian sedimentary rocks. The field work was not sufficiently detailed to make it possible to differentiate these rocks. In the northern part of the region Bancroft found evidence indicating that volcanism occurred during the period of marine sedimentation.

PALEOZOIC AND MESOZOIC TIME.

No sediments of known Paleozoic or Mesozoic age occur in the region. Limestone and quartzite that may be Paleozoic are found in the Harquahala Mountains and elsewhere. (See pp. 20–21.) These beds represent either sedimentation near the end of pre-Cambrian time or a continuation of marine sedimentation in the Paleozoic, but the evidence at hand is not sufficient to determine which. If any other Paleozoic or Mesozoic sediments were ever deposited in this region they have since been almost or entirely removed by erosion. It is possible that small amounts of such rocks occur in those parts of the region that were not visited during the investigation. Enough is known, however, to warrant the statement that no large areas of such rocks are present anywhere in the lower Gila region.

The region was again uplifted at some time after the period of marine conditions recorded by the pre-Cambrian sediments. Erosion was resumed and was long continued. If the marine sediments covered the whole of the area at the end of pre-Cambrian time, they were completely removed over large areas and the gneiss was once more laid bare. There is abundant evidence, however, that the surface over which the Tertiary lavas flowed was by no means a plain. The country was rolling and hilly. Some of the small mountain ranges of to-day existed then, although they were probably not as high or as rugged as they are now.

Granitic stocks or small batholiths accompanied or immediately followed by dikes of various types were intruded into the rocks of this region at some period after the pre-Cambrian and before the Tertiary. The writers who have previously described such rocks consider them to be Mesozoic. This correlation seems to be probable and entirely in accord with the facts so far as they are known. Rocks of this type have been reported from the Dome Rock Mountains,[14] S. H. Mountains,[15] and Harcuvar Mountains[16] and were also noted during the present investigation in the Buckskin Mountains. A number of similar intrusions are known in adjoining regions.

The pre-Cambrian rocks were considerably metamorphosed during the period between their deposition and that of the Tertiary lavas. The metamorphism probably took place in pre-Cambrian time, for Paleozoic rocks in adjoining regions show no evidence of having been affected by it. There has been no close folding since the deposition of the later pre-Cambrian rocks. Thick masses of such rocks now exposed show no folding and little tilting. Faulting took place during some period prior to the eruption of the Tertiary lavas, and it is believed probable that the major areas of uplift which

[14] Jones, E. L., Gold deposits near Quartzsite, Ariz.: U. S. Geol. Survey Bull. 620, p. 48, 1916.

[15] Jones, E. L., A reconnaissance in the Kofa Mountains, Ariz.: U. S. Geol. Survey Bull. 620, p. 155, 1916.

[16] Bancroft, Howland, Reconnaissance of the ore deposits in northern Yuma County, Ariz.: U. S. Geol. Survey Bull. 451, pp. 29–30, 1911.

form the present mountains may have been then blocked out, at least in part.

TERTIARY TIME.

The Tertiary was a period of pronounced volcanism. Great sheets of lava were piled up in flow upon flow. Agglomerate and tuff are associated with the lavas, but in very subordinate amount. Quiet outflows rather than eruptions of explosive violence were the rule. Bancroft[17] states that volcanic plugs are present in several places in the area in northern Yuma County which he examined and are apparently more numerous near the lower portion of Williams River than elsewhere. These plugs may represent remnants of Tertiary volcanoes. Plugs of latitic rock occur near Saddle Mountain, west of Quartzsite in the Dome Rock Mountains, and elsewhere in the region covered by this report, but such remnants of Tertiary volcanoes are rare. Quite possibly most of the eruptions were of the fissure type, and there were no volcanoes, except a few small ones. Probably lava flowed over much of this region during the Tertiary period, covering most of the hills then existing. Apparently, however, some ranges were never capped completely by the lava. The Harquahala, Little Harquahala, and Harcuvar mountains belong to this class. Portions of the Buckskin Mountains and of some of the other ranges may also have escaped being covered. Felsitic Tertiary intrusives and possibly some lavas occur in the Dome Rock Mountains, but this range is built almost exclusively of rocks of the basal complex. If the range was ever lava-capped, all the lava has since been removed by erosion. Comparatively little is known in regard to the geology of the Laguna, Trigo, and Chocolate mountains, but possibly portions of these ranges escaped the general flooding of the region by the sheets of lava. Probably there was more than one period of extrusion. Much more detailed work is required to determine this point.

The amount of sedimentary rock of Tertiary age in this region is small indeed compared to the many hundreds of feet of lavas. Unquestionably volcanism, not sedimentation, was the dominant feature of the Tertiary period. Much of the sedimentary rock is very probably of terrestrial origin and was deposited under conditions not very different from those of the present. This fact is better shown in the exposures of Tertiary formations south of Gila River, where stream-laid conglomerates occur.[18]

The calcareous sediments found in several places within this region and in adjoining parts of California tell a very different story.

[17] Bancroft, Howland, op. cit., pp. 30–31.

[18] Bryan, Kirk, Erosion and sedimentation in the Papago country, Ariz.: U. S. Geol. Survey Bull. 730, p. 26, 1922.

(See pp. 23-24.) These were unquestionably laid down in large bodies of quiet water and are lacustrine or estuarine. A glance at the map will show that the exposures of these deposits are scattered over an area of approximately 2,000 square miles. Only one of them, that near Osborne Well, is in an area covered by an accurate topographic map, hence the exact altitude of the others is not known. The best estimates available, however, show that all the exposures, including those in California, are at altitudes of approximately 700 feet above sea level. Unfortunately, the paleontologic evidence available is not conclusive as regards the character of the waters in which these beds were deposited. It is possible that they were formed in lakes lying between the mountain ranges. Much more probably, however, they were deposited in an estuary, or estuaries, extending north from the Gulf of California. In late Miocene or Pliocene time the gulf extended much farther north than at present, flooding southern California in the region of the Salton Basin.[19] Possibly the calcareous beds in the lower Gila region mark the northern limit of this incursion of marine waters.

Much normal faulting occurred in the Tertiary period, some of it on a large scale. Probably there was more than one period of faulting, and possibly a number of such periods. The faulting resulted in the formation of structural valleys between the upthrown blocks. Folding either did not occur or was of very minor intensity.

QUATERNARY TIME.

The record of Quaternary events in this region is more detailed and complete than that of the events of older geologic periods. However, there is much that is still uncertain or entirely unknown regarding the Quaternary history. One of the greatest difficulties encountered in interpreting the record is that of differentiating between the older and younger valley fill, which show a very close lithologic similarity.

Some uncertainty exists as to the division between Tertiary and Quaternary time in this region. Lee[20] believes that the uplift that initiated the cutting of the Grand Canyon of the Colorado marks the beginning of the Quaternary period. This uplift was very probably essentially contemporaneous with that which resulted in the deep cutting of the desert valleys. However, Lee elsewhere[21] makes the sugestion that the lower portion of the fill in the Salt

[19] Kew, W. S. W., Tertiary echinoids of the Carrizo Creek region in the Colorado Desert: California Univ. Dept. Geology Bull., vol. 8, No. 5, pp. 39-60, 1914.

[20] Lee, W. T., Geologic reconnaissance of a part of western Arizona: U. S. Geol. Survey Bull. 352, pp. 62-63, 1908.

[21] Lee, W. T., Underground waters of Salt River valley, Ariz.: U. S. Geol. Survey Water-Supply Paper 136, p. 114, 1905.

River valley, which he considers may be lacustrine in origin and notably older than the detrital material above it, is of Tertiary age. This suggestion is strengthened by the discovery by Bryan and Gidley [22] of Pliocene vertebrate fossils in alluvial deposits in San Pedro Valley. Deep-well records show that there is a considerable thickness of clay or other fine material beneath the coarser detritus in the Salt River valley. Records of wells in Buckeye and Arlington valleys and at Gila Bend show that similar conditions exist there also. Considerable clay was encountered in several of the Southern Pacific Railroad wells on Gila River west of Gila Bend. Fossil or other evidence may eventually be found which will prove that these deposits and the partly consolidated alluvium that crops out in places are of Tertiary age. The recently found evidence in San Pedro Valley makes this seem probable. Because of the advantage of having a definite and easily recognized datum, the deep cutting of the valleys, originally in large part of structural origin, is assumed in this report to be the opening event of Quaternary time in this region. Any sediments, whatever their origin, lying in these valleys, would then be of Quaternary age. As the valley cutting followed a structural disturbance of some magnitude, it is, in the absence of fossil evidence, a logical event to assign for the beginning of a geologic period.

After the valley cutting conditions were so altered that the streams began to aggrade and the recently excavated valleys were filled to great depths with detrital material. Basalt flows, the continuation of the basaltic effusions at the end of the Tertiary, occurred at this time. As has already been stated, volcanism did not continue to as recent time in this region as it did in some other portions of the Southwest, notably southern California, but it continued intermittently to a time considerably later than that in which the first valley fill was deposited.

When the valleys had been very largely filled with detritus renewed uplift occurred. In places the recently deposited sediments were faulted and somewhat folded. Degradation recommenced, and much of the material with which the valleys had just been filled was swept out of them again.

Before all of the first valley fill had been removed, aggradation was resumed and the younger fill was deposited. Some volcanism appears to have occurred during this epoch, but it was much less pronounced than that of the time just preceding it. Near Bouse, Yuma County, volcanic ash occurs in the fill not far from the present surface. This is probably comparatively recent. Several of the lava flows may be of corresponding age.

[22] Gidley, J. W., Preliminary report on fossil vertebrates of the San Pedro Valley, Ariz.: U. S. Geol. Survey Prof. Paper 131, pp. 120–121, 1922.

In comparatively recent time erosion of the younger fill has commenced, as is shown by terraces cut in it. The present flood plains of the streams lie between the lowest of these terraces. Along both Colorado and Gila rivers other terraces can be discerned above these, but they are discontinuous and apparently of small significance.

At the present time both rivers are aggrading in their lower courses. The channels are gradually being filled by the deposition of fine silts. Both rivers carry large quantities of silt during floods and are remarkably muddy at all times.

GROUND WATER.

GROUND WATER IN ROCK.

Within the lower Gila region ground water occurs almost exclusively in the valley fill. Some shallow wells in or near mountains obtain water from Tertiary lavas and sediments, but the yield of all such wells is too small to be used for irrigation on any but a very small scale. The water is, however, generally of good quality, so that such wells may constitute important sources of supply where large quantities of water are not required. The Webb Well, in the Gila Bend Mountains, is a good example of such a well. (See p. 226.)

It is unlikely that artesian flows of any magnitude can be developed from any of the consolidated formations in this region. In only a few places are these formations sufficiently porous to be good aquifers, and as they are apparently not continuous or uniform over large areas, the sources from which they can obtain water are necessarily small. The prevalence of normal faulting and the lack of folding militates strongly against the occurrence of structure favorable to any considerable artesian flow.

GROUND WATER IN VALLEY FILL.

Large amounts of water can, on the other hand, be obtained from wells in valley fill in several localities. A number of wells used for irrigation in Buckeye Valley have yields of 200 gallons a minute, more or less. Some land along Gila River west of Buckeye Valley is now being irrigated from wells. These wells are shallow and do not have very large yields, but doubtless better and more reliable supplies could be obtained by sinking deeper. Some of the wells in the northern part of the region, particularly at Parker, yield enough to be considered possible sources of water for irrigation. (See pp. 115–117.) In every valley that has been prospected for ground water some has been found. No wells have been sunk, so far as known, in Castle Dome Plain or in Cactus Plain except at Parker. Some of the smaller valleys have also not been prospected. There is every reason to suppose that water would be found in the fill in these areas also. In most of the valleys at a distance from Colorado and Gila rivers the water table is so far below the surface and the yield is so small that it is doubtful if irrigation on a large scale will ever be practicable. Enough water for watering stock and for small amounts of irrigation can be developed in nearly or quite all the valleys and plains. In Harrisburg Valley and at Bouse and Quartzsite the ground water lies at comparatively shallow depths. If, as is entirely possible, considerable amounts of water of sufficiently good quality can be developed in these three localities, irrigation may prove successful there.

The analyses of water from wells in several localities in the region are not very encouraging. In few wells can the water be said to be really good. The average amount of total solids in the 26 analyses made in the laboratory of the Geological Survey is over 1,000 parts per million. However, only a few of the analyses indicate that the water can not be successfully used if other conditions are favorable and care and skill are used in irrigating with it. Water of sufficiently good quality to be used for irrigation can certainly be found in McMullen Valley, near Parker, in Buckeye Valley, and probably in a large number of other localities in the region.

The water in the valley fill is the accumulation of the rain that falls on its surface and the run-off from the neighboring mountains. As practically all the valleys are open, the ground water drains slowly out of them in the direction of one or the other of the two through-flowing rivers, instead of being held and stored up as it would be in inclosed basins. This fact and the large excess of evaporation over rainfall in the region explain why large quantities of water are not found in the interior valleys. The fill in the valleys of Gila and Colorado rivers receives supplies of water not only from the area immediately bordering the streams in this region, but also from the much better watered upper portions of these valleys. Hence much larger quantities of ground water are to be expected from the fill in these valleys.

The fill in the interior valleys does not appear to be a promising source of artesian water. It consists of beds that are poorly sorted and too discontinuous to afford favorable artesian structure. Moreover, the mountain ranges are too small and have too little rainfall and too much evaporation to supply any large quantities of water to the valley fill. Only a small part of the rain that falls on the mountains probably finds its way into the valley fill. It is possible that artesian conditions may exist in favorable localities in the valleys of Gila and Colorado rivers, although no indications of such conditions are known in the lower Gila region.

TYPES OF SURFACE WATER SUPPLIES.

By Kirk Bryan.[a]

The problem of finding water for man and beast increases in difficulty with the aridity of a region. In southwestern Arizona and southeastern California aridity reaches its climax in the continental area of the United States. Consequently water supplies that in more humid regions would be wholly or almost wholly neglected are here of great importance. In the following pages is presented a study of the characteristics of watering places due to rainfall and its direct run-off, in contradistinction to wells, which are dependent on the circulation of water in the ground. The examples cited are drawn in part from the lower Gila region and in part from the Papago country, which lies south of Gila River. A report on the Pagago country now in preparation will contain a somewhat fuller discussion of many of the watering places here mentioned. The two regions have in common the same marked aridity and a similar geologic structure and history. Their watering places are therefore similar in kind and of equal importance to the scant population and the traveling public. Travel proceeds from watering place to watering place, settlements are established at or near water, and consequently even the maps reflect the importance of water supply. Woolsey Tank, Deep Well, and Winter's Wells are significant American place names; and Agua Caliente (hot water) and Agua Fria (cold water) record the travel and settlement of the Spaniards. South of Gila River Cubo, Tonukvo, and Moivavi are watering places and Indian villages whose equivalent names in English would be Big Pond, Ridge Pond, and Many Wells.

STREAMS AS WATERING PLACES.

Streams vary in importance as sources of water supply according to their size and habits. In southwestern Arizona there are no large, permanent streams except Colorado River, along its western border. All the other streams are intermittent, interrupted, or ephemeral.

INTERMITTENT AND INTERRUPTED STREAMS.

Intermittent streams flow for a part of the year, usually for a month or more. This period of flow is fairly definite in its time and

[a] This section, originally written as part of a paper by Kirk Bryan, entitled "The Papago country: a geographic, geologic, and hydrologic reconnaissance" (in preparation), has been adapted for use in this report by Clyde P. Ross. Data on streams in the lower Gila region have been added, examples of tanks and other features from that region have been given, and most of the examples from the Papago country have been omitted.

usually comes in the spring, after winter rains or the melting of snow, or follows the summer rains. No very large streams of this character can originate in such a region as southwestern Arizona. They commonly have their headwaters either in humid regions or in large areas of mountainous country, which are not found within this portion of the arid belt. Such a stream is Gila River, which rises in the rugged and wooded Mogollon Mountains of western New Mexico. The muddy floods of this river have been a constant temptation to the agricultural speculator from the days of the primitive Pimas throughout the period of settlement by the whites. At times these floods attain considerable proportions. A run-off of probably 185,000 second-feet in one flood has been recorded on the Gila at Yuma.[24] The average annual run-off at the same place is 2,750,000 acre-feet.

Many intermittent streams are also interrupted—that is, they have a permanent flow over short stretches of their courses throughout the year. It is this characteristic of Gila River which has made its valley the best practicable route from the Rocky Mountains to California across the southern desert regions. Throughout its length are stretches which have perennial water, and along these stretches there has been more or less permanent settlement and irrigation by the Indians and later by the whites.

Similarly, Santa Cruz River, which rises in the relatively high mountainous area east of Nogales, is a more or less continuous watering place from the international boundary northward to Tucson. Throughout this portion of the valley irrigation was practiced by the aboriginal Sobaipuri, and perhaps also by Papagos. North of Tucson there is no permanent watering place on the Santa Cruz much above its junction with the Gila, but throughout this territory a certain amount of flood-water irrigation has always been carried on. In other words, this interrupted stream through the upper part of its course has a small permanent flow, but in the lower part it is wholly intermittent.

The only intermittent streams in the lower Gila region are Gila River, already mentioned, and Agua Fria and Hassayampa rivers, which have their sources within the region. They are also interrupted and near their sources are perennial. Water can be found in pools and reaches in the channel of Gila River near its junction with Colorado River, at Antelope Bridge, near Aztec, at Gillespie dam, and at numerous other places. Even where little or no water remains above ground in the channel it can frequently be obtained by digging a short distance into the sand. The river water should not be used for human consumption except in an emergency. If the

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[24] Cory, H. T., The Imperial Valley and the Salton Sink, p. 1200, San Francisco, John J. Newbegin, 1915.

water is drawn from a hole dug 2 feet or so into the sand instead of being dipped directly from the river or pool, it can be used with little danger, especially if it is boiled.

Hassayampa and Agua Fria rivers are much smaller than the Gila. The Hassayampa has little or no perennial water in its channel. The excess water from the Buckeye project drains into it near Palo Verde, so that the lower portion of its channel contains water a large part of the year. Agua Fria River is a somewhat larger stream and may have water at the surface in some localities during most or all of the year. A table showing the available data on the discharge of Hassayampa and Agua Fria rivers in the upper portions of their courses is appended. Data on the discharge of the Gila at the stations in the lower Gila region are given on page 107.

Monthly discharge of Agua Fria and Hassayampa rivers.

Agua Fria River near Glendale.[a]

Month.	Discharge in second-feet.			Run-off in acre-feet.
	Maximum.	Minimum.	Mean.	
October, 1914	725	2	43.0	2,640
November	16	3	7.3	434
December	800	6	164	10,080
January, 1915			2,470	152,000
February	3,320	20	870	48,300
March	420	70	148	9,130
April	158	22	41.3	2,460
May	1,050	11	161	9,900
June	18	8	9.9	589
July	1,300	8	88.5	5,440
August	480	37	104	6,410
September	600	4	40.8	2,430
The year		2	345	250,000

Hassayampa River at Walnut Grove.[b]

Month.	Maximum.	Minimum.	Mean.	Run-off in acre-feet.
November 21-30, 1912	1.2	1.0	1.04	21
December	3.8	.9	1.13	69
January, 1913	1.0	0.5	0.94	58
February	22	1.0	2.16	120
March	29	1.0	14.2	873
April	29	2.0	16.0	952
May	2.0	.0	.68	42
June	.0	.0	.00	0
July	13	.0	.53	33
August	86	.0	3.33	205
September	235	.1	10.4	619
October	2.9	.1	.29	18
November	8.5	2	1.3	76
December	1.5	.3	.42	26
January, 1914	32	.3	1.8	111
February	46	.0	10.8	600
March	8	.3	1.55	95
April	.3	.2	.25	15
May	59	.0	2.0	123
June	12	.0	1.2	71
July	108	.0	13.8	849
August	56	.0	0.5	584
September	.5	.0	.19	11
The year	108	.0	3.57	2,580

[a] U. S. Geol. Survey Water-Supply Paper 409, p. 225, 1918.
[b] U. S. Geol. Survey Water-Supply Paper 359, p. 251, 1916; Water-Supply Paper 389, p. 188, 1917.

Monthly discharge of Agua Fria and Hassayampa rivers—Continued.

Hassayampa River near Wagener.[c]

Month.	Discharge in second-feet.			Run-off in acre-feet.
	Maximum.	Minimum.	Mean.	
October, 1914	160	0.0	14.2	873
November	194	1.0	22.0	1,310
December	10	1.5	2.2	135
January, 1915	250	1.5	14.9	916
February	210	25	105	5,850
March	175	55	106	6,520
April	110	10	28.7	1,710
May	460	25	130	7,990
June	100	1.0	26.3	1,560
July	660	1.5	81.2	4,990
August	660	.5	70.9	4,360
September	25	1.0	2.8	168
The year	660	0.0	50.2	36,400

[c] U. S. Geol. Survey Water-Supply Paper 409, p. 227, 1918.

EPHEMERAL STREAMS.

Ephemeral streams flow only during or after rains and as an immediate result of the rain. The largest of them rise on the steep and rocky sides of the mountains or on the broad slopes of higher alluvial plains. They furnish water for drinking by man and stock for only short periods, but these periods are important, for they may permit journeys into districts that are at other times without water, and they enable stock to spread out immediately after a rain into territory where they are ordinarily unable to graze. It is a curious feature of the desert that a comparatively large amount of irrigation is carried on there by means of flood water. For agriculture of this type the conditions of aggradation that prevail in most of the valleys are peculiarly favorable. In many parts of the arid West the channels of the ephemeral streams are intrenched from 5 to 40 feet below the adjacent flood plains, making irrigation by flood waters extremely difficult. However, where aggradation is taking place, as in most of southwestern Arizona, the flood waters spread from one side to another of a narrow valley between hills or over vast alluvial slopes at the foot of the mountains. Such sheet floods may be utilized for irrigation with much more than usual success. The Papago from prehistoric time to the present has been dependent for his living upon crops raised by this method of farming. In the Papago country ephemeral streams are therefore by no means an unimportant part of the water supply. White men do not commonly utilize this source of water for agriculture, however, and consequently in the country north of Gila River, where Indians are rare, ephemeral streams are valuable principally as watering places for cattle and for men distant from more reliable supplies.

CENTENNIAL WASH.

The large dry streamway that in its upper course is called the Cullen Wash and in its lower course Centennial Wash forms the longest continuous drainage channel in the lower Gila region, except the two through-flowing rivers, the Colorado and the Gila. (See Pls. II-IV.) The name "Centennial" is said to have been given because this wash was supposed to be 100 miles long. If Cullen Wash is included this is not a great exaggeration. The combined length is certainly nearly 90 miles and may be more. It will serve as a good example of an ephemeral stream.

Cullen Wash drains southwestward through McMullen Valley, in which Wenden is situated, and receives water from the Harquahala and Harcuvar mountains. The exact length of this wash was not determined, because the northeastern part of McMullen Valley was not visited during the present investigation, but as it has a strongly marked channel at Wenden, it evidently rises far above that town. Where it leaves McMullen Valley and enters the west end of Harrisburg Valley it makes a right-angled bend and leads toward the southeast. Just above this turn it is 200 or 300 feet wide and is bordered by banks of soft silt about 4 feet high.

From the point where the wash enters Harrisburg Valley to the point where it discharges into Gila River, a distance of nearly 60 miles, it is known as Centennial Wash. It drains Harrisburg Valley, the Harquahala Plain, Eagletail Valley, and a large part of Arlington Valley. It receives water from the Harquahala, Little Harquahala, Eagletail, Bighorn, and Gila Bend mountains and from Lone Mountain, Saddle Mountain, and the Palo Verde Hills.

The characteristics of this stream vary markedly in different parts of its course. In Harrisburg Valley it has a well-defined gravel-bottomed channel, bordered by mesquite and palo verde trees. A peculiarity of the drainage in this valley is that the tributaries from the north leads southwestward, whereas Centennial Wash leads southeastward, suggesting that the valley originally drained toward the northwest. This is not well shown on the map (Pl. III), because not enough topographic detail is given, but if a detailed contour map were prepared this fact would be brought out. Ground water is encountered in Harrisburg Valley at depths of 18 to 30 feet, as compared with 100 feet and more in McMullen Valley and 290 to 400 feet on the Harquahala Plain. This condition is probably due to the fact that the valley fill is much shallower in Harrisburg Valley than in either McMullen Valley or Harquahala Plain. At Tolladay's Well, at the east end of Harrisburg Valley, the depth to bedrock is 76 feet, and the wells on Mr. Reid's ranch, about a mile west of Tolladay's Well, are only 38 to 42 feet deep and are reported to reach bedrock. The southeast end of Harrisburg Valley, through which the stream emerges, is narrow and gorgelike, as compared with the wide northwestern entrance, and these facts all tend to indicate the possibility that there have been marked drainage changes here in recent geologic time. It seems likely that Centennial Wash, eating back by headward erosion across Harquahala Plain, cut through a divide just east of the present site of Tolladay's Well. The stream would then have been able to tap the drainage of Harrisburg Valley and cause it to flow east; but before this capture the water from Harrisburg Valley probably flowed northwest into Cullen Wash, which then continued west, perhaps escaping from McMullen Valley through Granite Wash Pass, instead of making an abrupt turn into Harrisburg Valley as at present. The preparation of an accurate contour map of this section of the country would do much to prove whether or not this hypothesis is correct.

Centennial Wash keeps its well-defined channel only a short distance beyond Harrisburg Valley and then begins to split up into several channels, fingering out downstream. A few miles southeast of the point where the wash leaves Harrisburg Valley no channel exists, but lines of mesquite bushes extend across the adobe plain. These lines of green join and part again, forming a pattern very similar to that produced by the channels of a braided stream, but they follow no visible channels. The slope of the plain is not great. It was not measured but can hardly be as much as 25 feet to the mile. The tributary washes that enter the Harquahala Plain spread out likewise a short distance from the mountains. Their channels disappear, and their courses are marked only by growths of galleta and other grasses and by scattered palo verde and mesquite bushes.

Where Centennial Wash enters Eagletail Valley it forms another well-marked channel perhaps 200 feet wide with banks 2 to 4 feet high lined with palo verde and other bushes. In this valley it receives several large tributary washes that head in the mountains on either side.

The channel disappears almost immediately on leaving Eagletail Valley, and thence to Gila River the line of flow is marked only by a luxuriant growth of mesquite trees. So dense, however, is this thicket near the river that the cow punchers can not penetrate it with their horses. If cattle get into it, they are in a sanctuary, safe from pursuit until they wander out again. There are a number of discontinuous runways, most of them only a few inches wide, cut in the adobe soil in the mesquite thicket, but nothing like a continuous and definite channel. These little runways apparently change with every rain. Along Centennial Wash in Arlington Valley are some discontinuous terraces and gravel eminences whose origin is obscure. It is suggested that they may be related to the lake that must have temporarily filled this valley when the lava flow dammed Gila River at the present site of the Gillespie dam. (See pp. 70–71.) Several large washes enter Arlington Valley from the Gila Bend Mountains and persist as gravel-bottomed channels almost or quite to Centennial Wash. The wash that emerges from the mountains where the old road to Agua Caliente enters them forms in the lower part a gravelly channel between distinct terraces a quarter of a mile apart. The channel is only 50 feet wide and is bordered with palo verde trees.

It is to be noted that wherever Centennial Wash or its tributaries have channels with well-defined banks the characteristic bush is palo verde, usually with more or less ironwood and other bushes, and wherever they spread out over adobe flats the characteristic vegetation is mesquite, commonly accompanied by bunch grasses. This rule appears to hold in general for all the washes in this part of Arizona.

Centennial Wash does not have anything like a uniform grade throughout its length. The grade in Harrisburg and Eagletail valleys appears to be distinctly greater than it is elsewhere, and the channels in these valleys contain much coarser material than elsewhere. That in Harrisburg Valley is gravel, which increases in coarseness downstream. At the east end of the valley boulders 2 feet in diameter were noted in the gravel, but most of it is composed of pebbles much smaller than this. In Eagletail Valley the channel is floored with coarse sand and gravel. Cullen Wash (the upper end of Centennial Wash) contains coarse sand. Its grade would appear to be greater than those of the portions of Centennial Wash in Harquahala Plain and Arlington Valley but less than those of the portions in Harrisburg and Eagletail valleys. The part of Centennial Wash lying in Harquahala Plain apparently has a lower grade than any other part.

LAKES AND PONDS.

In humid regions lakes and ponds are common. Glaciated regions are characteristically dotted with lakes. In arid regions, on the contrary, lakes are relatively rare, not because there are in such regions no sufficient causes to produce lake basins, but because the basins formed are rapidly filled up and obliterated by sediment brought in by muddy streams, or they may be but seldom filled with water by feeble streams, or they may be rapidly dried up by excessive evaporation. The chief causes of lake basins in an arid region are earth movements, the blocking of valleys by sediment brought in by tributary streams, by wind-blown sand, or by flows of lava, and the scouring out of hollows by wind erosion.

The lakes and ponds that occur in such a region are therefore important. The only natural water bodies in the lower Gila region large enough to be called ponds are the sloughs and shallow ponds along Colorado River. In the silt-floored valley between the Bighorn and Vulture mountains water is reported to stand to a depth of 1 or 2 feet over a considerable area for some months after a heavy rain, thus constituting a temporary lake. Shallow sheets of water are at times, after exceptional rains, formed in other localities, such as the Ranegras Plains near Desert Well, but these are of very brief duration.

CHARCOS.

In the Papago country the term "charco" is applied to a natural water hole in an adobe flat or a wash, but in other parts of the Southwest the same type of water hole is called a "mud hole" or "mud tank" or is not distinguished from other types of tanks or "tanques." "Charco" is a Spanish word signifying a pool of standing or stagnant water and has the advantage of being a distinctive name. The word "tank" may then be reserved for a natural reservoir in rock.

Charcos are found as single pools or a series of pools along the streams that deposit fine-grained material, usually sandy clay or adobe. They vary in size from shallow pans 18 inches deep and 3 feet wide by 6 feet long to depressions 5 to 6 feet deep, 15 to 30 feet wide, and more than 1,000 feet long. They constitute an important source of water supply in the Papago country but are rare or absent in the lower Gila region.

ROCK TANKS.

DEFINITION.

A rock tank is a watering place consisting of a cavity or depression in rock which fills periodically with rain or flood water. The Mexicans commonly and many Americans use the Spanish word "tinaja," meaning a bowl or jar, in speaking of a rock tank. These cavities may occur either away from stream channels or in stream channels. (See Pl. VII, *B*.)

ROCK TANKS AWAY FROM STREAM CHANNELS.

In mountains or hills small rock pockets are found which are due to the unequal weathering of rock surfaces. They range in size from depressions a few inches across and half an inch deep to pans 5 to 20 feet across and 6 to 8 inches deep. Such pockets hold water for longer or shorter periods after a rain. They are of little value as watering places, yet the experienced hunter and traveler knows well how to take advantage of their existence for the few hours or days that they hold water. On the upper portions of Saddle Mountain, for example, are a number of such pockets. They are very shallow, but some are reported to be 10 feet or more in diameter.

ROCK TANKS IN STREAM CHANNELS.

The largest rock tanks are those due to irregularities in the rocky beds of streams, which contain pools of water after floods. These irregularities are produced by eddies and vagaries of the current, which tend to erode the stream bed unequally. They are probably no more common in ephemeral streams than in the permanent streams of humid countries. The beds of ephemeral streams are, however, exposed throughout their length during the greater part of the year, and on this account undrained depressions in them are easily found.

The common depressions are of five types—joint-block irregularities, scour depressions, riffle hollows, normal potholes, and plunge pools. Most rocks are divided into blocks by sets of intersecting fractures or joints. The impact of the current and of the sediment which it carries tends to break out blocks of rock in the stream

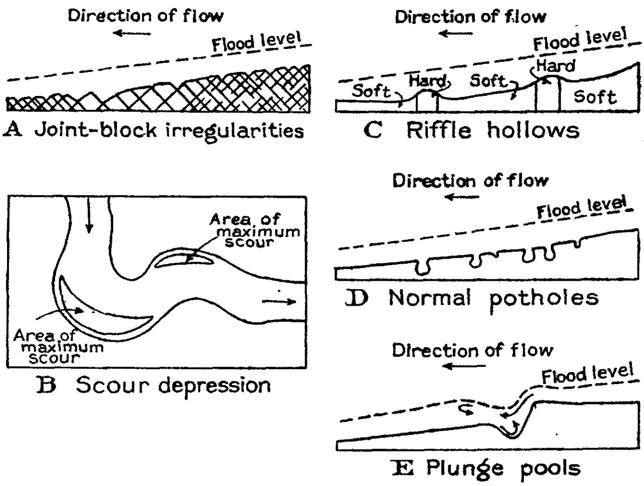

FIGURE 3.—Diagram showing five types of depressions in stream beds.

channel. This process of plucking results in irregularities of the channel, as shown in Figure 3, A.

Where the joints are widely spaced the blocks are large and the depressions are correspondingly large. Closely spaced joints, however, produce a rough but comparatively even-floored channel. It is obvious that very wide spacing of joints will produce joint fragments too large to be easily removed, and for any stream there is an optimum spacing of the joints that will produce the maximum roughness of channel floor. In these depressions water remains after a flood, but few of them are of great importance as watering places. Commonly the process of joint-block plucking is combined with the processes detailed in the following paragraphs. The fractures must be water tight or nearly so in the bottom and downstream wall of the tank, else the water will drain rapidly. In some tanks it is evident that joints on the upper side of the cavity are open and that through them small amounts of water seep into the tank for short periods after floods.

Where the channel of a stream is curved the swiftest thread of the current is near the outside of the bend. The maximum erosive force of the current is exerted over a crescentic area in the bend, as is shown in Figure 3, B. Such an area is likely to be scoured below the grade of the stream, producing a hollow of the type here called scour depressions. In combination with joint-block plucking and the formation of potholes this scouring process is likely to form good-sized tanks in hard rock.

Riffle hollows occur where the bed of a stream is composed of alternate layers of hard and soft rock, as illustrated in Figure 3, C. Erosion of the softer rock is carried below the grade established by the harder rocks, which project in the stream bed and constitute obstacles to the stream flow. Such depressions are commonly from 3 to 12 inches deep and vary in size according to the spacing of the harder portions of the rock in the stream bed. Riffle hollows make very shallow pools unless they are deepened by pothole action or unless they grade into plunge pools.

A pothole is formed by a rotary grinding or drilling of an original hollow in a stream bed by sand, pebbles, or boulders carried by the current. The top of a pothole is nearly circular, and the diameter increases below, as shown in Figure 3, D. The diameter may range from 3 inches to 10 feet or more, and the depth from 6 inches to 8 feet or more.[25] Potholes are developed in all streams that are actively eroding their channels in consolidated rock, but they are more likely to be found in gorges and below waterfalls. They are thus associated with and grade into plunge pools.

A plunge pool is formed by the impact of water and the sand and gravel which it carries, at the foot of a waterfall (Fig. 3, E). A fall differs from the protuberances in a stream bed described above in that it is usually great enough to cause a flexure in the flood surface of the stream. Consequently a very high velocity, accompanied by eddies and back currents, is present at the foot of the fall. The erosive effect at the foot of the fall increases with the discharge of the stream in flood and the quantity of the sediment carried, though it depends to some extent on the character of the sediment. The ordinary stream in southwestern Arizona is competent to erode pools about 10 to 20 feet in diameter and 3 to 10 feet deep.

[25] Elston, E. D., Potholes, their variety, origin, and significance: Sci. Monthly, vol. 5, pp. 554–567, 1917; vol. 6, pp. 37–51, 1918.

The shape of the pool depends on the character of the rock and the amount of modification due to joint-block plucking and pothole formation. Plunge pools constitute the largest type of channel irregularity and consequently hold the largest pools of water. Most rock tanks are of this class. Horse Tanks (p. 210 and Pl. XXIII, *A*), Ladder Tanks (p. 211), and McPherson Tanks (p. 213), in the Castle Dome Mountains, are typical examples.

PHYSIOGRAPHIC RELATIONS OF ROCK TANKS.

From the foregoing discussion it is obvious that the largest rock tanks are plunge pools at the foot of falls, and that even channel depressions of the other types are likely to be larger in the parts of a stream near falls and rapids. The factors governing the occurrence of falls are thus of importance. Falls occur in southwestern Arizona at localities of at least three types—where there are marked differences in the ability of adjacent parts of the rock to resist erosion, where dissection of a mountain pediment on a new grade produces headwater falls, and where renewed uplift of fault-block mountains produces falls on a stream that crosses the fault line.

FALLS DUE TO DIFFERING EROSIVE RESISTANCE OF ROCK.

Falls due wholly to an unusually resistant rock were found in only one locality and on a minor scale; but the site of falls due to other causes may be determined by a resistant bed, as at Horse Tanks (p. 210).

FALLS DUE TO CHANGES IN STREAM GRADE.

Many of the mountains of southwestern Arizona are surrounded by plains known as pediments,[26] which slope to the intermontane valleys. These plains are underlain by hard rocks similar to those of the mountains. The streams that once wandered more or less at will across them are now intrenched in steep-walled gullies or little canyons, which are deeper toward the mountains. The canyons increase in length by headward erosion. At the head of each little canyon is a fall or rapid that marks the separation between the old grade and the new. These relations are brought out in Figure 4. As each stream that heads in the mountains suffers such a change in grade there are many falls. Though not every fall produces a plunge pool large enough to make an effective watering place, the prevalence of falls due to the dissection of mountain pediments is the principal reason for the large number of rock tanks in the

[26] Bryan, Kirk, Erosion and sedimentation in the Papago country, Ariz.: U. S. Geol. Survey Bull. 730, pp. 52–58, 1922.

desert region. The local conditions at each fall determine the size and effectiveness of the plunge pool and associated potholes as watering places.

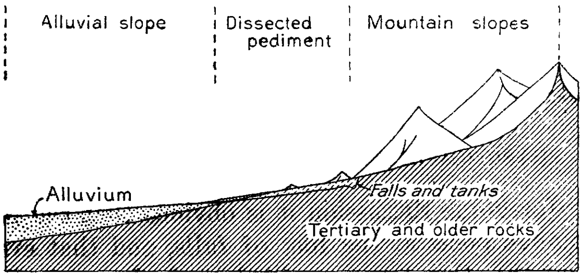

FIGURE 4.—Diagram showing the production of falls and tanks by the erosion of a mountain pediment on a new grade.

FALLS DUE TO RENEWED UPLIFT.

Most of the mountains of southwestern Arizona are narrow uplifted strips of the earth's crust bounded by faults on one or both sides. After uplift streams cut canyons and established smooth grades from the crest of the mountains to the adjacent valleys. In certain ranges renewed uplift took place on one side of the mountains only, probably along the same fault plane on which the original uplift occurred. This uplift resulted in flattening the old stream grade in the higher part of the mountains and produced a cliff or fault scarp across the stream channels on that side of the range. Streams immediately began to cut headward through this fault scarp, and it has generally been removed. However, in certain ranges, the Sierra

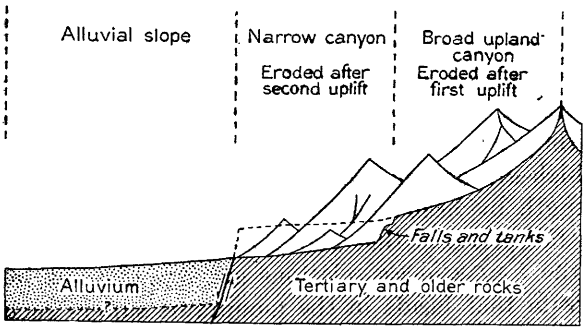

FIGURE 5.—Diagram showing production of falls and tanks by renewed uplift of eroded fault-block mountains.

Estrella and the Tinajas Altas Mountains in particular, the new grade has not yet reached the crest of the range and is separated from the old by falls, as illustrated in Figure 5.

SAND TANKS.

Sand tanks are a variety of rock tanks formed in stream channels in the several ways above outlined and differing from other rock tanks only in being filled with sand. They are produced when the tail end of a flood carries sufficient sand to fill the cavities; when the later part of the flood is relatively clear the rock tanks are filled with water only. The sand thus deposited in the rock basins is saturated with water. The upper portion quickly dries, but because the pore spaces between the grains are relatively large and capillary action is unable to bring the water to the surface, further evaporation can not take place. Though for the same size of cavity the volume of water in a sand tank is less than a fourth that of a rock tank, the water commonly remains in it for a longer period after a flood. The use of the water by animals is restricted by the necessity of digging holes down to the water level and throwing the sand out of the tank. Coyotes are able to do this with great ease, but horses, burros, and cattle have great difficulty in digging in the sand. Many rock tanks, on the other hand, are so accessible to wild animals and stock that within a few days after they are full all the water has been used.

DIRECT UTILIZATION OF RAIN WATER.

RAIN WATER SHED FROM ROOFS.

The saving of rain water by various devices has long been practiced in localities where other supplies are inadequate or where the water available is distasteful. Many prospectors' tents are equipped with gutters that direct rain water shed from the tent roof into cans and other receptacles.

In and around Ajo during the long period of development of this camp miners and prospectors have contended against the disadvantage of inadequate water supply. Not only was the amount of water small, but many of the wells furnished water containing salts of copper. During the period of construction of the plant of the New Cornelia Copper Co. in 1914 and 1915 the population was about 5,000 and drinking water was sold by the bucket in stands and peddled on the streets by hucksters. To make up the deficiency in well water, nearly every house was equipped with gutters and tanks to save rain water. A common form of apparatus is shown in Plate VIII, *B*. Cistern water of this kind was used for drinking and cooking only and thus made to last for a considerable length of time.

Wherever the need is great enough roofs for the sole purpose of collecting rain water might be erected. Such structures have been used successfully on roads in the deserts of Australia.[27]

[27] Gregory, H. E., Australia, The lonely continent: Nat. Geog. Mag., vol. 30, p. 554, 1916, and personal communication.

WATER CATCHES.

"Water catch" is a term in use in Bermuda, India, and other British colonies for a natural or artificial surface constructed solely for the collection of rain water.[28] Such a system of obtaining water has many advantages.

The construction of a water catch involves selection and preparation of the site and construction of a cistern or container. The site selected should have the maximum of bare rock surface and the minimum of soil and vegetation. It is obvious that such places are mostly slopes. Excessively large drainage areas should be avoided, because of the expense involved in cleaning and fencing them. Granite and gneiss are most likely to furnish suitable surfaces. Lava is likely to have many cracks, and some lava beds are so porous that the run-off from them in small showers is likely to be almost nothing. Places can be found, however, where the lavas are very thick, uniform, and free from cracks. Certain massive conglomerates erode with great bare rock surfaces, but they absorb considerable rain, so that on such rock larger drainage areas should be provided.

Where the rock surface does not drain naturally to a single outlet, masonry or concrete walls should be built to direct the water. The cracks in lavas may of course be cemented, or wholly artificial surfaces of concrete may be constructed on hillsides of soft material, but it is thought that in general the expense involved in such work is too great. On ordinary rock surfaces all the bushes should be cut, the soil swept up, and the loose rock piled. Free movement of rain water can then take place, and a minimum of dirt and trash will be carried to the cistern. A strong fence, preferably of woven wire, should be provided to prevent contamination by animals.

The cistern or water container may be built above or below the ground. The simplest arrangement is a shaft, but the difficulty of providing a suitable screen to prevent the entrance of trash with the water and to exclude animals is great. A cistern built partly or wholly above ground has the advantage that water is readily taken from the bottom and suitable screens may be provided. Figure 6 shows such a cistern providing a storage capacity of 12,000 gallons. It has a base 13 feet square inside and an inside height of 10 feet. It requires 30.8 cubic yards of concrete, which, with a mixture of 1 cement to 2 sand and 3 gravel, and plastered inside, will require 56 barrels of Portland cement. If reinforced with iron rods spaced 8 inches apart it will require 690 feet of ½-inch rods.

The area of prepared surface required to fill a given cistern is difficult to estimate. It is obvious that the smoother and less

[28] Gregory, H. E., The Navajo country: U. S. Geol. Survey Water-Supply Paper 380, p. 120, 1916.

absorptive the surface and the greater the slope the more efficiently will the water catch work. At the Fortuna mine (Pl. IX, *A*) the catchment surfaces are very imperfect, yet the smallest, having a surface of only 25,000 square feet, furnishes water sufficient for the prospect hole, which has a capacity of about 15,000 gallons.

SANITARY CONSIDERATIONS.

Rain water conveyed over a bare rock surface to a clean tank or cistern remains clean and palatable if it is protected from contamination. At some places the water saved by the water catches contains

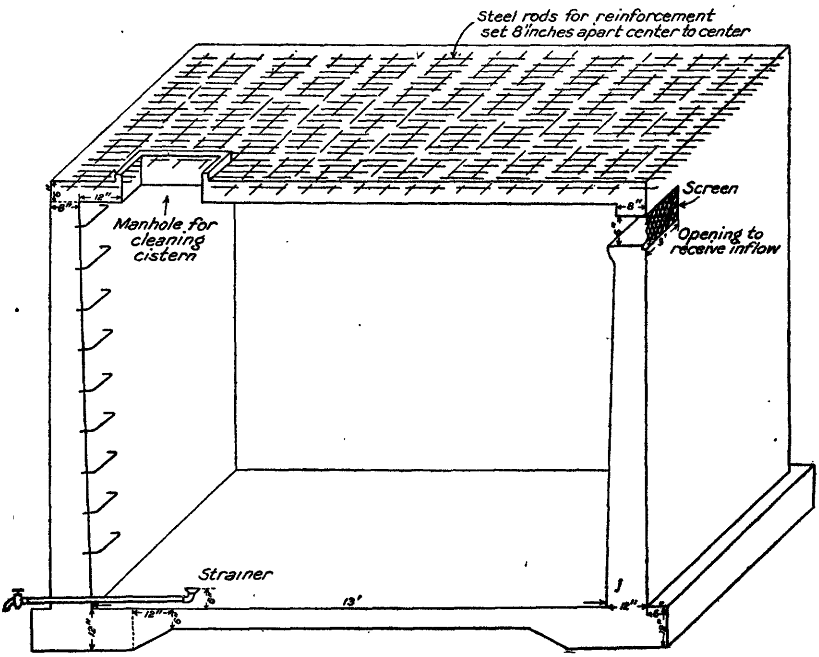

FIGURE 6.—Reinforced-concrete cistern for water catch. Designed by A. J. Ellis.

trash and vegetation of various kinds, which rots or putrefies. This putrefaction is due to bacteria that thrive in darkness, for in all the examples noted the stored water is protected from direct sunlight. After the organic matter is broken down and liquefied a further oxidizing action takes place, and the water becomes clear and only slightly discolored. If the water were stored in open pans or reservoirs and not protected from sunlight, other bacteria and many algous plants would grow in the water, die, and in turn decompose. Thus a continuous process would keep the water unfit for drinking. It is therefore essential that light should be excluded from the cistern. Any leaves or twigs that pass the protective screen will be decomposed in a single period, at the conclusion of which the water will be fit for drinking. The cleaner the water catch the shorter this period will be. With thorough precautions against admitting any organic matter to the cistern, no putrefaction will ensue.

All bodies of water in the desert attract animals, and many watering places are defiled by their dead bodies or excreta. The smooth, shelving sides of rock tanks are veritable death traps for mountain sheep. As the water gets low the sheep take greater and greater risks in drinking and sometimes fall in and drown. Rats, mice, and rabbits are similarly trapped. For smaller animals an inclined path may be built which will enable them to drink at any water level. Efficient screening is, however, best, because by using a sufficiently fine mesh bees may also be excluded. Bees are common in the desert, hiving in the caverns and crannies of the rock. They drown in large numbers, and their dead bodies give water an unpleasant taste and odor. In the design of cistern recommended the same screen that excludes trash serves to exclude animals also.

The chance of the introduction of disease germs into a cistern is much reduced in a desert region because of the sparse population. Even crude devices are not likely to be contaminated by disease germs. Travelers may protect themselves if water from such a supply looks particularly foul by boiling it before use. Boiling will probably make the danger from disease germs negligible but will not increase the palatability of really foul waters.

RESERVOIRS.

PURPOSES.

In southwestern Arizona many small reservoirs for the storage of flood water are built by individuals and small companies, largely without expert advice. The number of such enterprises could be increased with great benefit to the region. The following paragraphs review the conditions under which dams must be built and point out the best practice. Large irrigation and power projects are not likely to be considered for most of this region because of the absence of great rivers. Moreover, such enterprises present many special problems in engineering and finance, the correct solution of which can be arrived at only by large organizations with a competent technical staff.

The problems involved in constructing the smaller reservoirs vary somewhat according to the purposes for which they are built. Four general purposes are common—supplies for mines, stock-watering places, domestic supplies, and irrigation.

Mines require comparatively large quantities of water for milling operations and the use of the people employed. Shallow wells in the near-by hills usually suffice for prospecting, but when larger

A. HEAD OF CHARCO NEAR LA QUITUNI, EAST OF AJO MOUNTAINS.

Photograph by Kirk Bryan.

B. TINAJAS ALTAS FROM THE TERRACES AT THE FOOT OF THE MOUNTAINS.

Photograph by Kirk Bryan.

A. THE UPLAND VALLEY AT TINAJAS ALTAS.

Photograph by Kirk Bryan.

B. HOUSE IN "OLD AJO," PIMA COUNTY.

Showing spacious roof, equipped with gutters to catch rain water and metal tank into which the gutters drain. Photograph by Kirk Bryan.

A. WATER CATCH NEAR FORTUNA MINE, YUMA COUNTY.

Photograph by Kirk Bryan.

B. ARTESA POND, PIMA COUNTY.

Photograph by Kirk Bryan.

A. REPRESO EAST OF DOBBS BUTTE, PIMA COUNTY.

Photograph by Kirk Bryan.

B. REPRESO AT PISINEMO, PIMA COUNTY.

Photograph by Kirk Bryan.

operations begin a larger water supply must be obtained. The mines of the region are at the edge of or within the mountains. Wells of good yield can be obtained only near the centers of the larger valleys, at a distance from the mines. Water obtained from such wells must be pumped against a high head through a long pipe line. The old mines at Welden, in the Quijotoa Mountains, Pima County, and the Fortuna mine, in the Gila Mountains, Yuma County, were so supplied. The recently developed water supply for the New Cornelia Copper Co. at Ajo, Pima County, is an example of this solution of the problem. However, reservoirs to store the flood waters of mountain canyons may often be equally advantageous. The Allison mine, in the Baboquivari Mountains, and the Montana mine, in the Tumacacori Mountains, both in Pima County, have masonry dams and reservoirs.

Reservoirs for stock-watering places are usually small and are built in the edge of the mountains or more commonly in the plains. Their location is fixed by the position of grazing lands and the absence of other supplies. Locations for reservoirs in the foothills may be so chosen that the dam will have a rock foundation, or at least a rock spillway. In construction such reservoirs resemble those in the mountains. Reservoirs in the plains have their special problems discussed at length below. As stock-watering places reservoirs have many advantages, for if properly located and built they require attention at only infrequent intervals and are likely to have the most water during the season when the grass is best. They are relatively inexpensive, and so many sites are available that the stock can be widely spread over the range, with the great advantage of preventing overgrazing of parts of the region while other parts are undergrazed. The reservoirs are full just after rains, and the stock can use the forage around them, while the vegetation in areas around permanent water is growing under the most advantageous conditions.

The use of reservoirs for domestic water supplies is not common among the white population, except at certain mines where the drainare area is usually free from contamination and reasonable sanitary precautions are taken.

The storage of flood water for irrigation seems without investigation a most natural line of development in a dry country in which the work of flood water stands out so prominently to even the casual traveler. On every hand are large channels in which drift wood, overturned trees, and great boulders testify to the passage of large quantities of water. Yet the difficulties of profitable storage of water in amounts sufficient for irrigation are very great. The available reservoir sites are few, and some of them are useless because of difficulties in construction, others because the total water discharged from the drainage area is insufficient to fill a reservoir. All flood-water projects suffer also from the disadvantage that the desert flood waters carry so much sand and silt that the reservoir will soon fill with sediment and thus be useless. An irrigation enterprise based solely on the storage of flood waters from the ephemeral streams of the desert is an extrahazardous venture, which should be undertaken only with a thorough knowledge of local conditions and with expert advice.

RESERVOIRS IN THE MOUNTAINS AND FOOTHILLS.

A mountain reservoir is usually built at a constriction of a mountain valley above which there is a sufficient basin to form the reservoir. Rock foundations are available or can usually be obtained by trenching the loose sand and gravel in the bottom of the valley. The drainage area must be large enough to supply the water required. Unfortunately data on the flow of streams are available for only a few places. Very large spillways are necessary. The drainage area should be well cloaked with grass or so rocky that the flood waters carry but little sediment, else the reservoir will soon fill up. The kind of dam to be built, whether earth, rock fill, masonry, or concrete, is an ordinary engineering problem and depends on local costs and available labor.[29]

In the foothills there are many small reservoir sites, which differ from those in the mountains in that rock foundations are commonly not available. Earth dams are also easier to build at such sites because of the availability of soft material. Such sites resemble those described below, but many are easier of construction because rock spillways can be made.

Certain possibilities of location in foothill regions are shown in two reservoirs in Pima County. Artesa Pond (Pl. IX, *B*) is created by an L-shaped embankment projecting outward and upstream from the rocky spur from which the photograph is taken. Flood waters gathered in the northern part of Baboquivari Valley flow westward around the north end of the Artesa Mountains. At this part of their course they spread over an adobe flat without definite channel. The open end of the L-shaped embankment intercepts part of the flood, and the excess flows around the embankment. Plate X, *A*, is a view of an unnamed represo in the hills east of Dobbs Butte. The drainage of a large area to the west (left in the view) spreads over an adobe flat from which it escapes through two gaps in the hills to Altar Valley. In the southern gap has been placed the

[29] Fortier, Samuel, and Bixby, F. L., Earth-fill dams and hydraulic-fill dams: U. S. Dept. Agr. Office Exper. Sta. Bull. 249, pt. 1, 1912; Timber dams and rock-fill dams: U. S. Dept. Agr. Office Exper. Sta. Bull. 249, pt. 2, 1912.

dam, with its ends resting on the rocks of the hills. No spillway is provided, for the excess water flows out through the northern gap.

RESERVOIRS IN THE PLAINS AND VALLEYS.

In the alluvial plains and valleys no foundations exist for masonry or concrete dams, and thus only earth dams can be built. The reservoirs are commonly small and shallow, though in exceptional locations large ponds can be made. Most of these reservoirs are used for watering stock. The American cattleman calls such a reservoir a "tank"; the Mexican uses the word "represo" (literally dam) and also "charco."

Reservoirs may be constructed either directly on a stream channel or at one side. The problems involved in these two types of structure will be discussed separately. It is obvious that if a dam is built across a channel the reservoir must be sufficiently large to hold all the water carried by the stream or else a spillway must be provided. A successful spillway requires care in building and must be kept in repair. Its capacity also must not be exceeded by the largest flood or the earth dam will be overtopped and breached. The very large number of failures with this type of reservoir in all parts of the arid West testify to the difficulty in meeting these requirements.

Southwestern Arizona is an exceptional region because of the relatively large number of streams that have so small a flow that all or nearly all the water may be held in a single reservoir. The lake at Buenos Aires, in Altar Valley, is the largest and best example. Even here a spillway is provided and is required in exceptional years. Many smaller represos built on small streams rising within the alluvial plains are equally successful in holding all the water of a single flood.

A reservoir at one side of a stream channel depends for its water supply on a diversion dam and ditch or simply on flood water that overflows the channel. The streams of the alluvial slopes of southwestern Arizona are peculiarly favorable for reservoirs of this type. After issuing from the little canyons that cross the rock-cut plains surrounding most of the mountain ranges the streams spread out in numerous diverging channels. In many places the ephemeral streams carry only fine material, mostly mud with a minimum of sand and gravel. Such localities are particularly favorable because of the relatively low velocity of the floods and the possibility of water-tight reservoirs. Channels hardly exist; the floods spread as broad sheets of mud-laden water. Usually the main thread of the current runs between natural levees in a shallow channel somewhat above the level of the surrounding plain. The natural levees form a broad, low ridge similar to the channel ridges of the Sacramento Valley,[30] though not so marked.

The form of such a channel ridge is shown in Figure 7, which is a diagrammatic map of a typical alluvial slope, though based on the conditions at Big Fields, in the Papago country. The contours are modeled on those shown on an excellent map of this part of the Papago Reservation made by Percy Jones, jr., for the United States Indian Service. In addition to the ridge along the main flood channel, there are other low ridges which mark the former location of the flood channel. In the low ground between such an old ridge and the active channel ridge is the reservoir, surrounded by a U-shaped embankment. This reservoir receives water through a ditch from the flood channel, but during large floods no ditch is necessary, for

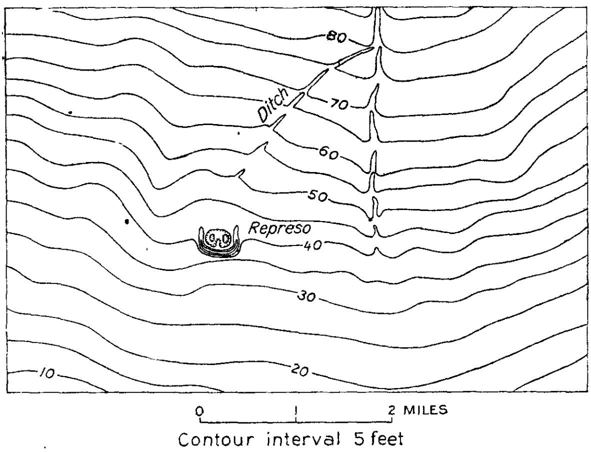

FIGURE 7.—Diagrammatic map showing location of represo at one side of main flood-water channel.

the natural overflow from the channel will be caught by the open embankments of the reservoir.

The main streams of the larger valleys have beds of two types—broad indefinite flats marked by shallow discontinuous minor channels and beds that lie in definite channels with bordering flood plains of various widths on either side, and these flood plains in turn bordered by bluffs.

The beds of the first type particularly are suitable for small reservoirs: the floods spread widely and have a low velocity, and a low embankment will turn the necessary flood water to a reservoir. The slopes, however, are so gentle that usually only the excavation made to form the embankment will contain water of sufficient depth to be

[30] Bryan, Kirk, Geology and ground-water resources of Sacramento Valley, Calif.: U. S. Geol. Survey Water-Supply Paper 495, pp. 28–30, 1923.

valuable. The represo at Pisinemo, Pima County (Pl. X, *B*), is of the U shape common in these localities. In many places it is possible to enlarge a charco and thus gain an increased capacity with small effort. Sand dunes occur on some of these broad flats. They divert the flood waters by tortuous routes within the flat and in places create basins favorable for reservoirs. The Papago ponds or represos at Tonukvo and Comovo, in Pima County, are built on such sites.

In the valleys close to and tributary to Gila River and in the valleys that are surrounded by mountains higher than the average the stream beds are of the second type and lie in flood plains bordered by bluffs. The concentration of flood waters usually maintains a well-defined stream channel, with banks from 5 to 10 feet high. A diversion dam is necessary to obtain water for a reservoir either in the flood plain or at the mouth of a tributary valley that breaks through the bluffs. With proper construction reservoirs in these localities are very successful, but they require a great deal more upkeep and attention than reservoirs along streams of the type previously described.

An ingenious method of obtaining a water supply for small reservoirs has proved successful in the Sitgreaves National Forest, in northern Arizona.[31] The run-off from road ruts is diverted by a low mound across the road and conveyed through a short ditch to the reservoir. The reservoirs are small and are usually built on a gentle slope below a steeper slope, as shown in Figure 8. The run-off from a large area of hillside can thus be obtained. Road ruts are much more successful conveyors of such run-off than plowed ditches, because traffic on the road keeps them packed hard and free of vegetation.

CONSTRUCTION OF RESERVOIRS.

Useful as the reservoirs or represos of the Papagos are, both to the Indians and to the wayfarer, their usefulness is impaired by faulty construction. In general a Papago represo consists of an earth dam constructed with scrapers, more or less irregular in height and width and having a horseshoe shape. The material of the embankment is taken from the upstream side, thus increasing the capacity of the reservoir. In many represos the only water stored is held in the borrow pits, because the ends of the embankment do not continue far enough up the slope to hold any considerable quantity of water. (See Fig. 9.) The embankment also is made with a very steep slope on both sides and usually has no wave protection.

[31] Personal communication from Hugh M. Bryan, formerly grazing examiner, U. S. Forest Service.

A properly designed earth dam should have a flat slope on the water face of not over 1 in 3. On the rear face the slope may be as steep as 1 in 1½. A firm bond to the underlying ground should be obtained by removing all vegetation and loose soil for at least 6 inches, digging a trench at least 2 feet deep and 6 feet wide, and filling it with new material similar to the rest of the dam. On many adobe flats, however, simple plowing will be sufficient. The crest of the dam should not be less than 5 feet above the bottom of the spillway, except in a small reservoir, where a height of 3 feet is sufficient. A type of cross section that has proved successful in Wyoming and South Dakota[32] is shown in Figure 10.

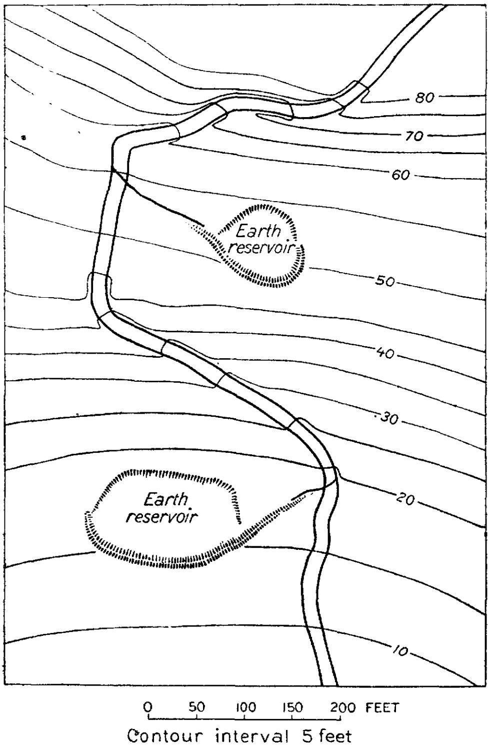

FIGURE 8.—Idealized map showing use of run-off from road ruts and relation of reservoirs to slope.

PROTECTION OF THE EMBANKMENT.

An earth dam should be protected by a fence from loose stock, which destroy the smooth slopes and often wear trails deep enough to lower the dam considerably. In a large reservoir waves rapidly erode the dam, especially if the water body lies on the

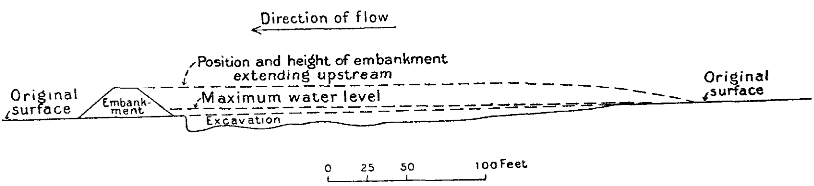

FIGURE 9.—Profile through typical Papago represo.

windward side of the dam. Protection against waves can be made by riprapping with rock or brush or by building a wave fence.

[32] Hermann, F. C., Small reservoirs in Wyoming, Montana, and South Dakota: U. S. Dept. Agr. Office Exper. Sta. Bull. 179, 1907.

A wave fence [33] is constructed of 1-inch boards 8 feet long pointed at the end and driven into the embankment at high-water level. The boards are given a slope about 1 in 5 away from the water and driven in as close together as possible, about 3 feet in the ground. The fence should be made rigid by two strings of 1 by 10 inch board, one nailed near the top and the other near the bottom of the fence. Braces fastened to deadmen should also be installed. Wave fences are very effective and with ordinary repairs will last seven or eight years.

Brush protection of the face of the dam, if properly constructed, is as good as a wave fence, and the large quantities of mesquite, palo verde, and creosote brush available in most localities in southwestern Arizona make this the natural and cheapest thing to use. The brush should be made up in bundles about 1 foot in diameter and of any convenient standard length. At least two layers of bundles should be laid at right angles to each other on the face of the dam, and the whole should be firmly wired to strong stakes

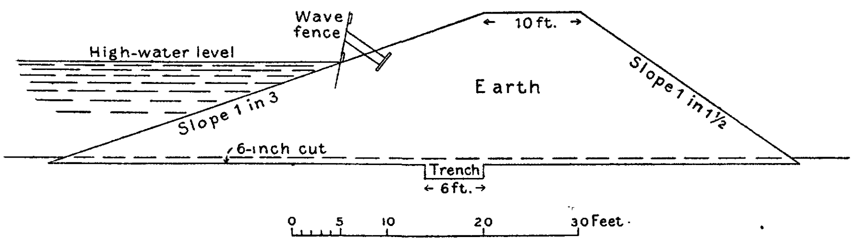

FIGURE 10.—Cross section of earth dam.

driven into the dam. This form of brush protection will probably be more effective than the brush fences that have been used on a number of dams.

DIVERSION DAMS AND PROTECTION OF SPILLWAY CHANNELS.

Diversion dams in rocky channels can easily be constructed of plank or cribbing or, where the expense is justified, of masonry. In channels where no firm foundation exists diversion dams are usually constructed of brush and rock held in place by strong stakes. Such dams are likely to be washed out by any flood. If the washout occurs during the only flood of the year that is sufficient to fill the reservoir the consequences are serious.

W. E. Kibbey, formerly of the La Osa Land & Loan Co., has used with success for a number of years the structure illustrated in Figure 11. The channel is cleared of loose sand, and the banks are cut in sufficiently to give a good bond. The largest logs obtainable are then laid end to end across the channel at the toe of the dam.

[33] Hermann, F. C., op. cit., p. 30.

Mesquite trees and large branches, each so trimmed that one branch makes a hook at the end, are laid over the logs with the branches upstream, and the hooks are forced down over the logs as shown in the diagram. The dam is raised by laying successive rows of logs, breaking the joints and holding each row in place with brush. Each row lies upstream from the last, so that the face of the dam has a slope that tends to break the force of the flowing water. The crest should slope from the banks to the center, so as to divert the water away from the ends of the dam. The upstream end of the dam is covered with earth, and each flood augments this material up to the level of the top of the dam. It is obvious that as water flows over the dam the transverse logs can not be loosened and carried away, because they are held by the brush, and if the toe of the dam is undermined the somewhat flexible structure will settle, without, however, shifting in position. If the dam settles so far as to be ineffective it may be built higher by adding one or more additional layers.

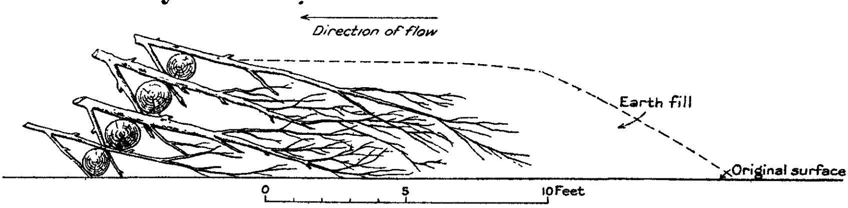

FIGURE 11.—Diagram showing the use of logs and brush for diversion dams and spillways.

A reservoir that is built without a wasteway in the expectation that it will hold all the flood discharge of a stream may have such a structure built at one end of the dam. It can be completely covered with dirt and in the damp soil will rot very slowly. By leaving this part of the crest low or by opening with a shovel, a safe emergency spillway will be available for any exceptional flood that may threaten the dam.

Erosion in wasteways due to abnormally steep grades often menaces reservoirs. Where the site does not provide a rock spillway the waste water may cut a channel which, beginning in a sharp cliff, works up the spillway channel with great rapidity. A structure somewhat similar to the one just described has been used as a water drop to prevent such erosion.[34] Figure 12 is a cross section of this structure, which was built of brush and old railroad iron. The larger posts were old boiler flues, and the smaller stakes old bolts and fish plates. The brush was made up in bundles about a foot thick, with wire binding, and the bundles were wired to one another and to the stakes. Where mesquite is plentiful, mesquite posts would probably

[34] Hermann, F. C., op. cit., p. 33, pl. 7, fig. 1.

be cheaper and as serviceable. By concentrating the fall at one point the grades of the other parts of the channel are reduced sufficiently to prevent erosion.

DÉBRIS-FILLED RESERVOIRS AND ARTIFICIAL SPRINGS.

ADVANTAGES.

Throughout southwestern Arizona evaporation from water bodies is excessive and the annual loss in open reservoirs is more than 5 feet. This loss is serious in small reservoirs and, together with the use of water by stray stock and wild animals, makes many rock tanks uncertain water supplies. Sand tanks of the same size do not suffer these losses and with proper protection are more sanitary. If reservoirs full of clean sand and gravel could be constructed, they would also have these advantages, though their water capacity

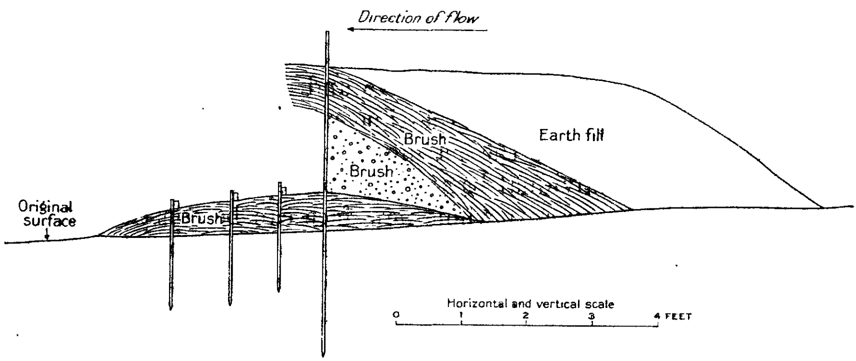

FIGURE 12.—Diagram showing construction of a water drop to prevent erosion in a channel.

would be less than a fourth of that of ordinary reservoirs. General plans for such reservoirs are proposed in the following paragraphs, in the hope that they may be a guide in constructing watering places in localities where other water supplies are difficult to obtain.

METHODS OF CONSTRUCTION.

The filling of such a reservoir must be composed of clean rock particles, preferably of nearly the same size, in order that the maximum porosity may be attained. To reduce expense the dam should be so constructed as to permit the accumulation of the filling under natural processes as far as possible.

In southwestern Arizona proper material for filling such reservoirs can be obtained only from streams in the mountains or in the belts of rocky plains around the mountains. In these localities the sands and gravels of the stream beds are clean and coarse and have about 25 per cent of pore space. An ordinary dam thrown across such a stream checks the current so much that not only sand and gravel but mud also is deposited. To obtain débris freed of mud for the reservoir, the dam must be built up gradually, the current being allowed to rework the accumulation of each flood, or else a dam must be constructed that will check the current only enough to hold the coarse material and will let the finer material go through.

A dam that may be built up gradually was constructed in California of boulders held in wire baskets. Chicken-yard netting of 2-inch mesh and No. 14 gage galvanized-iron wire was used to inclose bundles of boulders, which were 2 feet wide, 1 foot thick, and 8 feet long. The bundles were laid side by side along the dam. In the second layer the bundles were staggered and lapped 4 feet inside the lower edge of the first layer. The outer downstream slope was thus 1 on 6; the inner slope was 1 on 2. The dam was 150 feet long and 35 feet high and resisted not only the weight of the débris behind it but a continuous overflow of flood water for a period of five weeks.[35] Such a dam built up by adding one to three layers after each flood would be very effective and easy to construct. Its life is, of course, dependent on the time necessary to rust the wire netting and on the wear on the netting by boulders tumbled over the face of the dam. Individual baskets can be replaced, however, and when it becomes necessary a whole new face can be constructed.

There are also in many mountain ranges places where the mountain streams after running on comparatively flat grades narrow and then run on steep grades. These narrows are natural dam sites, and many of them are bordered by high cliffs. It seems probable that without much drilling, but by taking advantage of open cracks and joints, the cliffs could be blasted down into the narrows. The mass of material thrown down would be of all sizes, but many of the blocks would be too large for the stream to move even in its greatest floods. As many blocks as possible should be obtained. By shifting the material and relaying it, especially on the downstream face of the dam, the larger fragments could be made to protect the smaller. Floods on striking this dam would flow through but with diminished velocity. The sand and gravel which they carried would be largely deposited in and behind the dam, while the mud would be carried through. Figure 13 is a diagram showing a cross section of a dam of this type, somewhat more regular in form than is strictly necessary, though an effort should be made to have the downstream face as flat as possible. A dam of this type merely reproduces the conditions found in many canyons, where great boulders too large for the stream to carry block the channel and cause sand and gravel to accumulate behind

[35] Palmer, L. A., A novel débris dam: Min. and Sci. Press, July 10, 1915, pp. 43–46.

them. The larger the blocks blasted down the more successful the project is likely to be. Such a rock-fill dam can be blasted down in a short time and with only a few men. On this account the project could be undertaken at distant and inaccessible spots, where the cost of transportation of water and supplies is great.

The reservoir once filled with débris is stable unless the rocks of the dam are loosened during floods, and at each flood the débris will be saturated with water. The water will seep out at the toe of the dam as a spring for a shorter or longer time, depending on the volume of the reservoir and the porosity of the material that fills it. The size of the reservoir is regulated by local conditions but should be as large as possible. The porosity of the material will be somewhat less than 25 per cent, and the size of the pore spaces will depend on the size and arrangement of the rock particles. These conditions can be controlled in part during the process of filling.

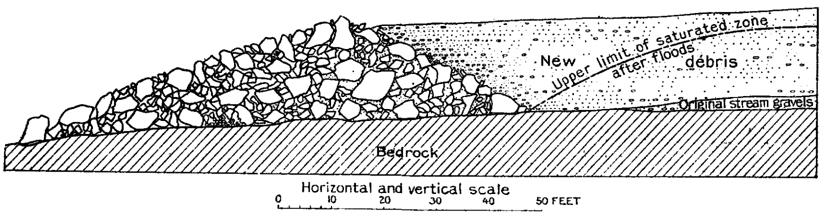

FIGURE 13.—Diagram showing rock-fill dam for an artificial reservoir.

However, it is impossible to predict what size of pore space will be large enough to absorb water rapidly and yet allow the same water to flow out with sufficient slowness to produce a perennial spring.

There is no question that the structure described above will produce a spring. The risk in constructing it lies in the possibility that the spring may have so large a flow as to exhaust the reservoir within a month or two after each flood.

GILA RIVER.

Much has been written about Gila River, yet much remains not only unsaid but unknown. In spite of the considerable amounts of money, skill, and energy that have been expended on the study of various problems connected with this stream, many of the most fundamental questions with regard to it remain unanswered. During the present investigation the lower portion of Gila River was examined and additional information in regard to some of these questions has been obtained. In this account the data so collected, together with some of the general data previously published, have been assembled. The information available is too scattered and incomplete to permit the final solution of many of the problems.

Enough is known, however, to afford a partial history of the varied events in the life of the stream. It is hoped that the facts stated and theories advanced herein may be of some value in future investigations of the river.

GENERAL FEATURES.

Gila River, in its course of more than 500 miles from its source in New Mexico to its junction with Colorado River at Yuma, Ariz., passes through country of several widely different types. The Gila itself is formed by the junction of the streams in Whitewater and Whitetail canyons at an altitude of about 7,500 feet above sea level, but Willow Creek, one of the headwater sources of its Middle Fork, rises in the rugged Mogollon Mountains, some distance farther west, at an altitude of 9,993 feet. The Mogollon Mountains form a pine-clad range culminating in Whitewater Baldy at an altitude of 10,892 feet. The creeks that here coalesce to form the Middle Fork of Gila River have steep gradients and narrow valleys, and many of them are intermittent. From its source the Gila flows with many turns in a general westerly direction through a mountain region in New Mexico, in which the average annual rainfall ranges from over 20 inches in the higher portions of the Mogollon Mountains to less than 15 inches at Gila, N. Mex.[36] The river enters Arizona about 113 miles from its source and passes for 190 miles through a rough mountain country in a series of alternating narrow detritus-filled valleys and steep-sided rock canyons. In this region the annual rainfall is about 12 inches. The character of the river changes markedly westward from The Buttes, east of Florence, where it emerges from the mountain region. From this point throughout its westward course to the Colorado, except at a few places, it winds over deep deposits of alluvium in broad valleys between short and discontinuous mountain ranges. Descriptions of its course in these valleys are given below. The annual rainfall ranges from about 10 inches at Florence to less than 3 inches at Yuma. The river receives few tributaries of importance below the place where it leaves the mountains. Its volume steadily decreases, and in the lower 150 to 200 miles of its course there are long stretches of its bed which are dry throughout much of the year.

Until accurate topographic maps of the region drained by Gila River and its tributaries have been prepared, close estimates of its drainage area are impossible. Davis[37] estimates the total drainage area to be 72,000 square miles. Of the water that falls as rain on a large portion of this area, part is evaporated, part seeps down

[36] Rainfall data from records of U. S. Weather Bureau.

[37] Davis, A. P., Irrigation near Phoenix, Ariz.: U. S. Geol. Survey Water-Supply Paper 2, p. 16, 1897.

through the soil and becomes ground water, and only a fraction reaches the river. Part of the ground water eventually finds its way to the valley of Gila River and joins the underflow of that stream. A great deal of it is, however, used up by deep-rooted plants or by other means.

The altitude of the river where it enters the Colorado is 125 feet above sea level.[38] Willow Creek rises at an altitude of 9,993 feet, and at The Buttes the altitude of the Gila is 1,592 feet. Consequently the fall in the course of 303 miles through the mountains is about 8,400 feet, and in the 266 miles through comparatively open country west of The Buttes the fall is 1,467 feet.

TRIBUTARIES.

Among the principal tributaries of Gila River are San Francisco, San Carlos, San Pedro, Santa Cruz, Salt, Hassayampa, and Agua Fria rivers. It receives also numerous creeks, especially near the source in New Mexico, and countless arroyos in which water flows only in response to exceptionally heavy rainfall.

San Francisco River heads in New Mexico not far from the source of the Middle Fork of the Gila and flows in a general southwesterly direction through mountain canyons to its junction with Gila River about 12 miles below Clifton, Ariz. San Francisco River is over 100 miles long and forms the principal source of water supply for the town of Clifton, for the mines and ore-dressing plants near by, and for some irrigation.[39] It has a drainage area of 2,895 square miles,[40] of which about one-fifth is covered with timber. The water north of Clifton is reported to be of excellent quality, but near that town it becomes more saline on account of the numerous tributary salt springs. The country near the source of the San Francisco[41] is extremely rough and broken, with narrow valleys and canyons. Erosion is proceeding at so rapid a rate, according to Olmstead, as to menace the life of the timber within its drainage basin.

San Carlos River is an intermittent stream emptying into the Gila at San Carlos. It rises in several branches in the western part of Ash Flat Plateau and is about 30 miles long. The stream bed is dry a part of each year.

San Pedro River rises in Mexico and flows in a direction a little west of north for about 170 miles to its junction with Gila River

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[38] The altitudes given in this account are taken from United States Geological Survey topographic maps and the profiles of the Southern Pacific Railroad. The distances are taken from General Land Office maps of New Mexico and Arizona and from United States Geological Survey topographic maps, including the maps herewith, Pls. II–IV.

[39] Lindgren, Waldemar, U. S. Geol. Survey Geol. Atlas, Clifton folio (No. 129), p. 13, 1905.

[40] Olmstead, F. H., A report on flood control of the Gila River in Graham County, Ariz.: 65th Cong., 3d sess., S. Doc. 436, p. 64, 1919.

[41] Olmstead, F. H., op. cit., pp. 64, 65.

near Winkelman. It is perennial[42] but, like all other streams in this general region, fluctuates greatly. The maximum recorded yearly run-off is 149,837 acre-feet at Fairbank, Ariz., in 1914,[43] and the minimum recorded at the same place is 25,500 acre-feet in 1913.[44]

Santa Cruz River is an intermittent stream that rises in southern Arizona east of the Patagonia Mountains, flows south into Mexico and then northwest, reentering Arizona near Nogales, and empties into Gila River near Gila Crossing. It has a total length of more than 200 miles. But little water flows from the Santa Cruz into the Gila except during floods. At Tucson the total discharge of Santa Cruz River was 57,200 acre-feet in 1914 and 24,700 acre-feet in 1915.[45] Nearly all of this water is evaporated or sinks into the ground before reaching Gila River.

Salt River is the largest tributary of the Gila. It rises in the mountainous region of southern Apache County, Ariz., and flows for over 200 miles in a southwesterly direction to its junction with Gila River below Phoenix. Its course lies in a mountainous region, which in most places has an annual rainfall of considerably more than 10 inches. Roosevelt Reservoir, which has the largest dam for the storage of water for irrigation so far made, is on this stream. The run-off of Salt River near Roosevelt was 629,500 acre-feet in 1914, and 1,440,100 acre-feet in 1915.[46]

Below the mouth of Salt River no perennial streams enter the Gila. Agua Fria and Hassayampa rivers are the only ones in which water flows at the surface except in immediate response to heavy rains. These streams are described on pages 36–38.

GILA RIVER IN EARLY DAYS.

The accounts of the early explorers and even of old settlers still living in the region show that Gila River has changed materially since it was first seen by white men. At one time it contained more water and had a more luxuriant vegetation along its banks than now.

The available accounts of the early Spanish explorers do not contain definite estimates of the amount of water in Gila River, but it is evident that they regarded the stream as a reliable watering place for their expeditions, some of which were large and included herds of live stock. The writings of Father Kino,[47] one of the

[42] U. S. Geol. Survey Twelfth Ann. Report, pt. 2, p. 305, 1891.
[43] U. S. Geol. Survey Water-Supply Paper 389, p. 169, 1917; Water-Supply Paper 409, p. 199, 1918.
[44] U. S. Geol. Survey Water-Supply Paper 359, p. 230, 1916.
[45] U. S. Geol. Survey Water-Supply Paper 389, p. 172, 1917; Water-Supply Paper 409, p. 208, 1918; Water-Supply Paper 439, p. 170, 1919.
[46] U. S. Geol. Survey Water-Supply Paper 389, p. 176, 1917; Water-Supply Paper 409, p. 212, 1918; Water-Supply Paper 439, p. 173, 1919.
[47] Bolton, H. E., Kino's Historical memoir of Pimería Alta, vol. 1, 1919.

earliest and most enterprising of the Jesuit missionaries, contain numerous references to the river, some of which are here quoted. In regard to Gila River near the present town of Wellton he writes, "This Río Grande we named Río de los Santos Apóstoles. To this it may be added that all its inhabitants are fishermen and have many nets and other tackle, with which they fish all the year, sustaining themselves with abundant fish and with their maize, beans, and calabashes." On November 6, 1700, Kino was near Wellton going toward Dome and says: "On the way they gave us great quantities of fish, both raw and cooked; for, although they had their little fields of maize, beans, calabashes, and watermelons, the beans and maize were not yet ripe." A year later he states: "On the 17th [of November] we set out from San Pedro westward for San Dionisio, a great ranchería at the confluence of the Río Grande de Hyla and the very large Río Colorado; and, having crossed the Río Grande on horseback by the only ford which it had in that vicinity, with a following of more than 200 Yumas and Pimas from San Pedro, at nightfall we arrived in safety at San Dionisio, where also they received us with great affection." San Pedro is near the site of Wellton, and the ford mentioned is near the present town of Dome.

Fish still exist in Gila River and are occasionally caught, but they form no considerable part of the food of those who live on the banks of the stream. The few that are obtained are generally caught in small pools in the otherwise dry river channel during dry seasons. Fishing in the Gila is now considered to be rather a useful amusement for boys than an occupation for men. The river can be forded by horses in many places in this vicinity without difficulty except during times of unusually high water, which would not be expected in November.

Emory[48] makes several references to Gila River. On November 9, 1846, when he was at or near The Buttes, east of the present site of Florence, he wrote, "The Gila at this point, released from its mountain barrier, flows off quietly at the rate of 3 miles an hour into a wide plain." At the Pima village near the junction of Gila and Salt rivers he wrote, "The bed of the Gila, opposite the village, is said to be dry, the whole water being drawn off by the zequias of the Pimas for irrigation; but the ditches are larger than is necessary for this purpose, and the water which is not used returns to the bed of the river with little apparent diminution in its volume." On November 14 he wrote that the course of the Gila is marked by green cottonwoods. On November 17, when he was perhaps somewhere between Agua Caliente and Palomas, he wrote, "The

[48] Emory, W. H., Notes of a military reconnaissance from Fort Leavenworth in Missouri to San Diego in California: 30th Cong., 1st sess., S. Doc. 167, 1848.

bottoms of the river are wide, rich, and thickly overgrown with willow and a tall aromatic weed, and alive with flights of white brant, geese, and ducks, with many signs of deer and beaver." The bottoms on this portion of the river at present are desolate wastes of sand and silt with clumps and thickets of arrow weed, which looks dry and almost dead during large portions of the year. The game mentioned by Emory has long since departed. On November 18 he wrote, "We found the river spread over a greater surface, about 100 yards wide, and flowing gently along a sandy bottom, the banks fringed with cane, willow, and myrtle." In describing the junction of Gila and Colorado rivers, Emory speaks of the "sea-green waters" of the Gila as contrasted with the "chrome-colored hue of the Colorado." By no stretch of the imagination could the present-day mud-laden water of the Gila be considered "sea-green."

The Pimas, the Maricopas, and some Papagos lived in the valley of Gila River and supported themselves by raising irrigated crops. There are said to have been about 6,000 Indians on the Gila in 1742.[49] A like number could not now grow sufficient food for their own use by the primitive methods of agriculture then employed. Of course, a large part of the decrease in water in Gila River below Salt River is the result of taking out water for irrigation farther upstream on the Gila and its tributaries, but this can not account for all of the change which appears to have taken place.

On November 1, 1849,[50] a flatboat reached Colorado River at the present site of Yuma. It had made the voyage down Gila River from the Pima villages, carrying three men and the family of one of them. This boat was 16 feet long by 5 feet 6 inches wide. It was used for some time as a ferry across Colorado River. A boat of this size, carrying so many people with their baggage, could not float down this portion of the Gila now at any season. During floods the current is too swift and during the rest of the year there is insufficient water. This boat was equipped with wheels for use on land. If it attempted the trip to-day, it would have to forsake the river and resort to its wheels very promptly. In October, when this trip is reported to have been made, long stretches of the river bed are usually dry, as the summer rains are over, and those of the winter have not yet started.

More recent information is furnished by Mr. John Montgomery, a ranchman residing in Arlington, who has had many years' experience in southwestern Arizona. He states[51] that in the summer of 1889, when a boy of 12, he was in camp near Powers Butte, on Gila

[49] Hodge, F. W., Handbook of American Indians: Bur. Am. Ethnology Bull. 30, pt. 1, p. 806, 1910.

[50] Bancroft, H. H., History of Arizona and New Mexico, p. 489, 1889.

[51] Personal communication.

River. At that time the river had a well-defined channel with hard, sloping banks lined with cottonwoods and bushes. The water was clear, was 5 or 6 feet deep, and contained many fish. The grazing lands near the river were in much better condition then than now. Several varieties of grass then abundant have since died out. Mr. Montgomery attributes the change in the character of the river largely to the practice of cattlemen of burning the heavy brush that once covered its banks in order to drive out wild cattle which had sought shelter there. This destroyed the natural protection and left the soft silty soil exposed to rapid erosion. The disastrous floods of 1890 and 1891 did much to break down the river's confining banks, partly filled the channel with sediment, and in general interfered with the equilibrium that had been established.

Mr. Millett, who, in conjunction with Mr. Montgomery and others, has had the direction of the Enterprise canal and dam, states[52] that, in his opinion, based on observations at the dam, aggradation in the Gila is increasing at this place. He states also that when the water flowing in the canal is comparatively clear the grade is 2 or 3 feet to the mile, but that when the water carries a heavy load of sand, the grade established is 4 or 5 feet to the mile. These statements are based on his own level measurements and indicate that the grades in the canal are the same as those in the river channel under like conditions.

GILA RIVER VALLEY BELOW SALT RIVER.

BUCKEYE VALLEY.

Buckeye Valley, which lies just west of the land irrigated under the Salt River project, is in general appearance a typical detritus-filled valley of the desert region. Irrigation by means of the Buckeye and other canals and by wells has demonstrated that it has large agricultural possibilities, but it still contains many hundred acres of unreclaimed land. Much of the unreclaimed land is on the north side, where the land slopes upward toward the White Tank Mountains. Near these mountains the surface is in part mantled with gravel, which would make cultivation difficult, but much of the soil is such as to give promise of rich returns to the farmer, if it could be supplied with water. Irrigation from the river is obviously impossible for much of this land, as it lies at too high an altitude. The wells already put down, however, show that large stores of ground water exist in the valley, and much of what is now desert waste will doubtless eventually be converted into productive farm land by

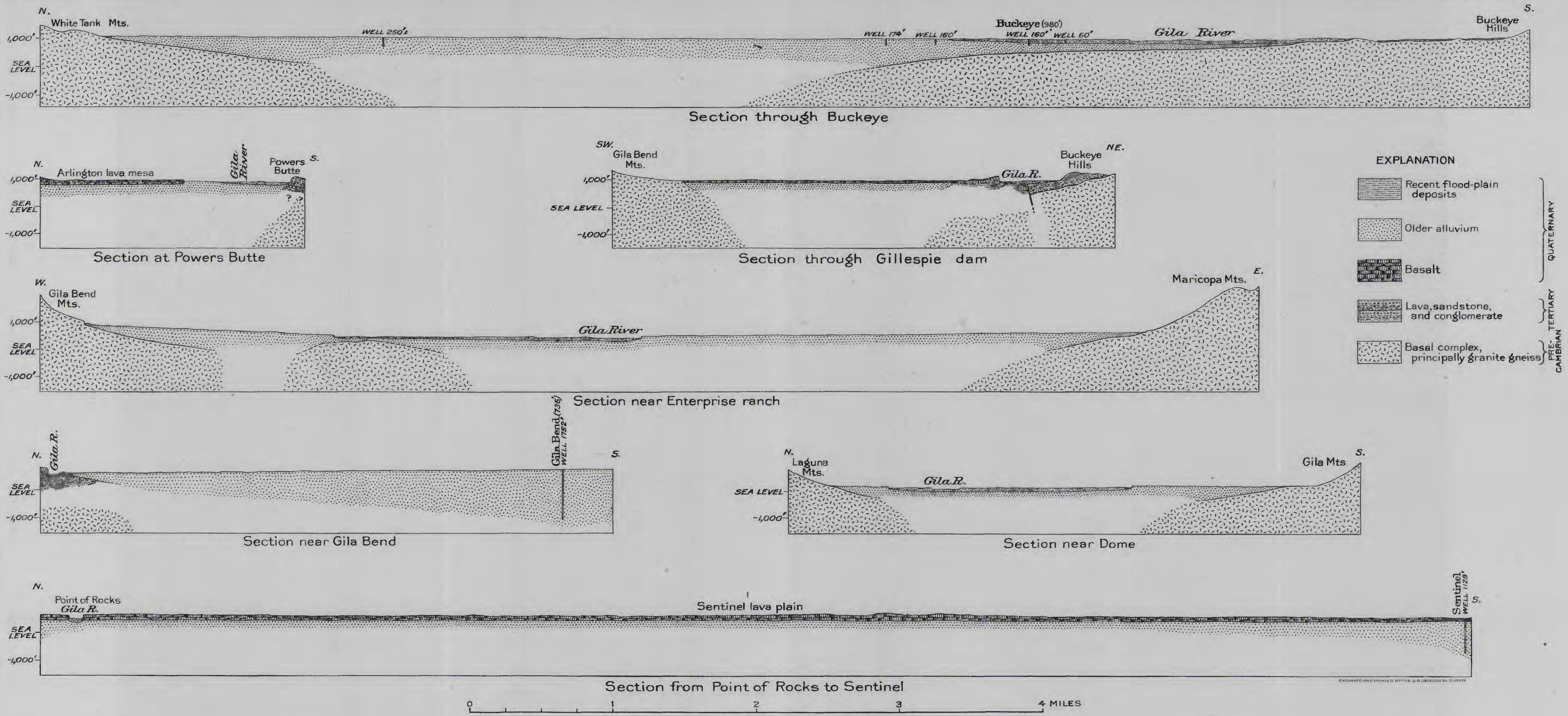
[52] Personal communication.

means of water obtained from wells. The failure of some projects north of Buckeye and Palo Verde shows that success in such a venture will not come easily nor to any but able and experienced men.

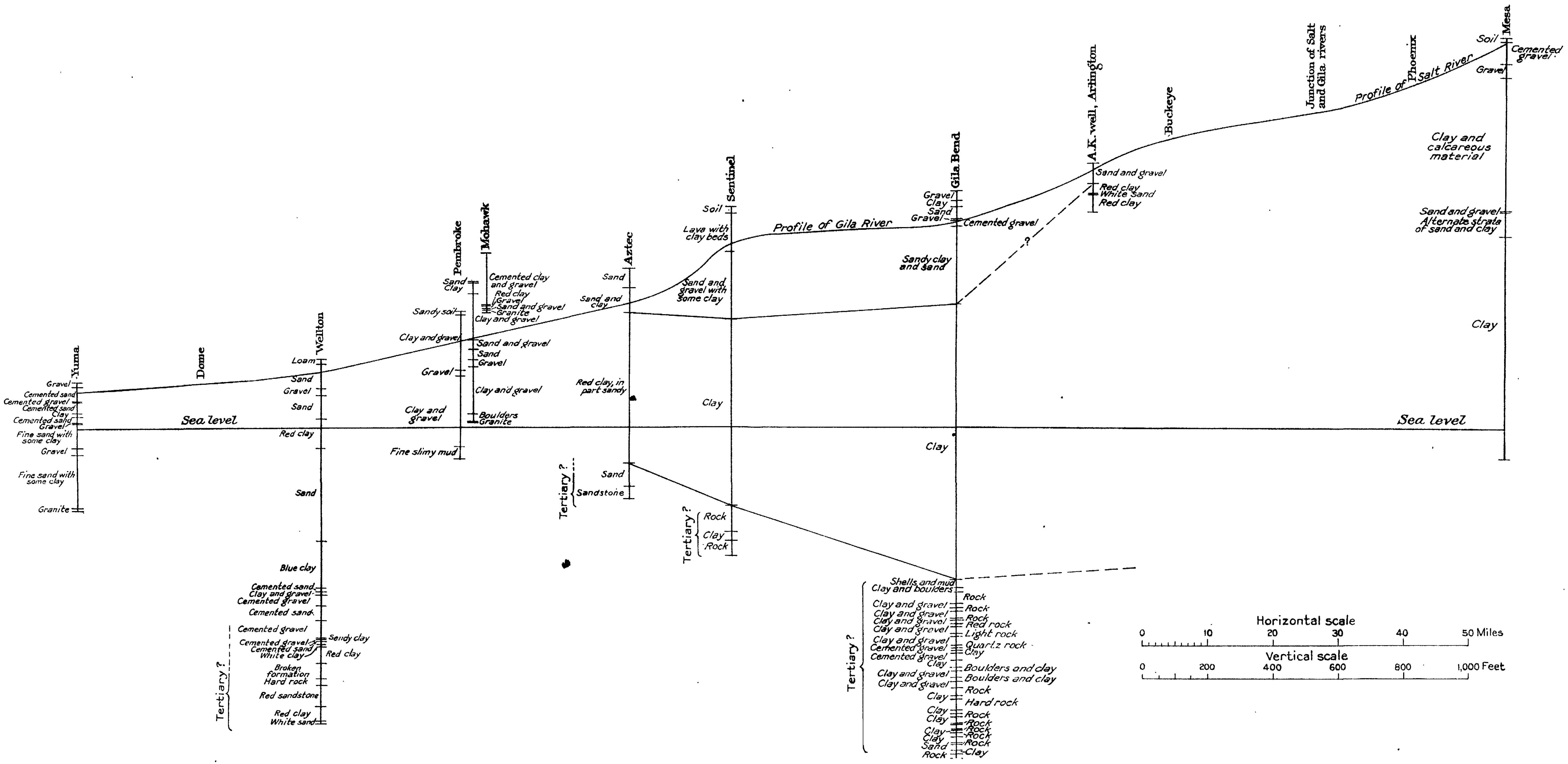
Well records show that the alluvium in the vicinity of Buckeye, north of the river, is more than 250 feet deep. Probably the maximum depth is much more than this, perhaps several times as much. The river itself, however, does not flow over deep alluvium. Outcrops of granitic bedrock project through the alluvium at numerous places close to the river in the district irrigated by the Gila Water & Land Co. At Liberty such outcrops are said to occur on both sides of the river. It is probable that the course of the river has shifted to the south in recent geologic time and thus become superimposed on a bedrock shelf extending out from the Sierra Estrella and the Buckeye Hills. (See the diagrammatic section in Pl. XI, 1.)

The river in Buckeye Valley wanders over a sandy flood plain between cut banks 5 to 15 feet high. The flood plain varies in width but is a mile or more wide in most places. The water meanders in shifting channels and does not cover more than a small part of its flood plain except during unusually great floods. During the drier seasons there is no flow in the river near Buckeye, the water being restricted to pools in the otherwise dry channels. As is indicated in the section (Pl. XI, 1), unconsolidated sand and silt deposited by the river in recent geologic time have a considerable lateral extent beyond the banks that confine the stream except during large floods. Part of this material is deposited during the erratic and powerful floods for which Gila River is noted, but much of it antedates the present cycle of erosion, having been laid down before the existing banks of the river were cut.

Between the river and the Buckeye Hills, on the south, is an irregular and poorly defined gravel terrace. This marks the boundary between the fine-grained recent deposits and the coarser older alluvium, described on page 26. No such terrace exists on the north side of the stream, where the boundary between the two formations is not marked by any prominent topographic break. The Buckeye canal is approximately on or near this boundary. South of the canal are soft silt and sand. North of it gravel and caliche appear in the soil and increase gradually in amount at greater distances from Gila River. No outcrops of the older portion of the Quaternary alluvium are known either in or near Buckeye Valley. It is probable that deposits of this age are buried under the alluvium of intermediate age in the deeper portions of the valley. The material penetrated by some of the wells of the Southwest Cotton Co. north of Avondale may be old. (See pp. 85–88.)



DIAGRAMMATIC CROSS SECTIONS AT VARIOUS PLACES ON THE LOWER GILA RIVER



GRAPHIC LOGS OF DEEP WELLS ALONG LOWER PORTIONS OF GILA AND SALT RIVERS PLOTTED IN THEIR RELATIVE POSITIONS WITH RESPECT TO APPROXIMATE PROFILES OF THESE STREAMS.

ARLINGTON VALLEY.

A small valley bounded by the Buckeye Hills, Palo Verde Hills, and Gila Bend Mountains is known as Arlington Valley. The ground lying below the pronounced terrace on the right side of the river is in part irrigated from the Arlington canal and yields good crops of forage plants, but no attempt has yet been made to farm above the terrace near Arlington. Although much of the land is gravel covered, some of it, perhaps most of it, may some day be put under cultivation when changing conditions justify the expenditures necessary to supply it with water. Such wells as have been drilled in this general locality to supply water for cattle have not yielded very large quantities of water.

Gila River makes a turn of nearly 90° in Arlington Valley. The character of its channel in the valley itself is similar to that in Buckeye Valley. At both ends the channel is restricted by rock walls. At the northeast end of the valley Powers Butte is on the left bank of the river, and Arlington Mesa is but a short distance north of the right bank. (See Pl. XI, 2.) At the south end the southwestern extremity of the Buckeye Hills is on the left bank, and a hill sometimes referred to as Woolsey Butte is on the right bank. (See Pl. XI, 3.) At both these localities the present channel of the river is but a short distance above bedrock. At the northeast end the Tertiary lava and sandstone of Powers Butte form the left bank and extend under the river for at least a portion of its width. At the other end of the valley the headgate of the Enterprise canal is founded on rock, and this undoubtedly extends across the stream at no great depth below the surface. It is reported[53] that during periods of maximum scour bedrock appears in midstream. This rock is almost certainly similar to that of the hills on both sides, which are composed of lava, sandstone, and conglomerate of Tertiary age. In the central portion of the valley no outcrops of rock are known near the channel of Gila River. Probably the river here flows over a considerable thickness of alluvium, but as only shallow wells have been sunk near the river little information is available from that source. The A. K. well, in sec. 32, T. 1 S., R. 5. W., is 150 feet deep and bottomed in red clay. This well is only a mile west of the river. (See p. 84.)

On the left side of the river no terraces above the cut bank of the flood plain exist at either end of Arlington Valley, and none were observed at any other place. On the right side of the river well-defined but somewhat discontinuous terraces were found, including a gravel terrace bordering Arlington Mesa, a low basalt mesa at the northeast end of the valley, and several discontinuous terraces and

[53] Personal communication from Mr. Millett.

eroded portions of terraces between the lava eminence north of Arlington and the mesa west of the Gillespie dam. The material composing these terraces is probably of intermediate age. Many of the pebbles are composed of Tertiary lava and are probably derived from the neighboring mountains.

VICINITY OF ARLINGTON MESA.

Hassayampa River empties into Gila River a short distance east of Arlington Mesa. The terrace that borders this stream on the west swings sharply toward the channel a short distance north of the mesa and trends southeast, gradually dying out along the edge of the basalt. It appears likely that the lava antedates the formation of the terrace. In Hassayampa Plain there is a gently sloping gravel-covered ridge. Between Arlington Mesa and the basalt butte northwest of Arlington is a depression floored with fine silt, in places coated with a white alkaline or saline deposit. The depression is bounded on the east by the abrupt wall of Arlington Mesa. On the north and northeast is the gravel ridge referred to above. On the northwest is a distinct but irregular terrace, which fingers out at one place in a ridge extending several hundred feet into the depression. West of the depression is the basalt butte, with a terrace about 10 or 15 feet high at its base, which connects with that on the northwest. The depression is closed on the southwest and south by a hummocky ridge of silt and sand extending southeastward from the butte on the west. There is an opening in this ridge on the southeast through which the depression is drained by means of several small irregular washes.

GILLESPIE DAM SITE.

The Enterprise canal was originally constructed in 1886 as a part of the Peoria canal system. In 1906 it was taken over by the owners of the Enterprise ranch, who cleaned it out and regraded it. Each year they built earth and brush dams across the Gila at the old Peoria dam site to divert water into their canal. Such dams are of course easily washed out by even a small flood, but they are easily, quickly, and economically built or repaired. A concrete dam called the Gillespie dam has since been constructed here by the Gila Water Co.

This dam site is one of the very few places on the lower Gila where there are bedrock abutments on both sides of the stream and bedrock at no great depth all the way across the channel. Here, as elsewhere along its course, the river has scoured out a deep valley and then, in a later cycle, filled this valley with alluvium. No direct evidence is available as to the depth of the fill in this portion of the valley. Wells a short distance north of the dam site show that the fill there is certainly more than 150 feet deep. When the erosion and subsequent filling took place the river in the vicinity of the dam site flowed farther west, probably as much as 2 miles, than it does at present. During the period of volcanic activity, which was widespread in Arizona in early Quaternary time, a mass of basaltic lava flowed down from the Gila Bend Mountains and across the valley of the river until it lapped against the west end of the Buckeye Hills, damming the Gila and producing a temporary lake. There are discontinuous terraces in Arlington Valley, some of which are 4 miles from the present channel of the Gila. These clearly indicate a change of some sort in the drainage. The shores of this lake can not now be traced with certainty, but there is some evidence on the edges of the basalt hills north of Arlington that the lake extended to that place. The west end of the Buckeye Hills is composed of thin beds of lava, probably andesite, interbedded with red sedimentary rocks that range from sandy shale to conglomerate with angular pebbles as much as 6 inches long. The age of these strata is probably Tertiary. The geologic section shown in Plate XI, 3, will aid in making the relations at the dam site clear. Plate XIII is made from a photograph of the ground through which this section is drawn.

The river cut a new channel through the most western of the Buckeye Hills. It is possible that there is a fault or break in the strata at this point. Such a structural weakness might materially aid the river in its work of cutting a way around the lava dam that had trapped it. Eventually this channel became sufficiently deep to drain the lake.

OLD COURSE OF GILA RIVER.

It is probable that when Gila River was dammed by the lava flow at the Peoria dam site a large part of the water escaped westward through the pass now utilized by the old road through the Gila Bend Mountains. During this period the river did not make the long swing to the south around these mountains as it does now and as it did before the lava blocked it. Such a hypothesis seems to offer the only probable explanation of the remarkable terraces 20 to 50 feet high and a quarter of a mile to 1 mile apart along the wash that issues from the pass containing the old road on the southwest side of the mountains. The present wash is entirely inadequate to have cut such terraces. This wash does not head, as would be expected, in the mountains, but extends through them and heads in a partly inclosed valley on the northeast side. The divide between the water flowing northeast to the Gila near Arlington and that flowing southwest to the Gila west of Gila Bend is in this small valley, which may be called Webb Valley, after the well of that name in it.

VICINITY OF ENTERPRISE RANCH.

The country on both sides of Gila River in the vicinity of the Enterprise ranch was examined with some care. There is a marked difference in the character of the opposite sides of the valley at this place. (See diagrammatic cross section, Pl. XI, 4.) The cut banks that border the present flood plain of the river are higher than the average. At the point at which it was crossed during this examination the western bank is 2 or 3 feet high and the eastern bank 10 or 15 feet and even more. These relative heights of the two banks are reversed at places near by. On the east side the valley floor slopes gently and continuously up to the mountains, with no terrace above the cut bank just mentioned. On the west side several breaks in the slope occur. The first is a fairly continuous and well defined terrace, 1½ miles from the river. About an equal distance west of this is another series of breaks, which do not form a continuous terrace, but the gravel-covered spurs projecting out from the borders of the mountains are abruptly truncated. The benches thus formed are about 500 feet on the average from the outer border of the mountains. At this border there is another and even less continuous set of benches, cut in rock instead of in valley fill. These benches are not in perfect alinement with one another, and they show considerable differences in altitude within short distances, suggesting that some or all of them are the result of recent minor faulting, or have been disturbed by such faulting subsequent to their formation. The irregularities noted do not, however, seem to be sufficient to preclude the production of the benches by unequal cutting of projecting spurs or alluvial fans by the river.

The cross section on Plate XI (No. 4) shows in a general way what is known in regard to the geology of this portion of the valley of Gila River. The only data available in regard to underground conditions are those afforded by the logs of the two wells at the Enterprise ranch. These are given in the table below. The deeper well was abandoned because the water found was too saline. The water in the other well is not good but can be used for drinking. The driller is reported to have been firmly convinced that the abandoned well bottomed in solid granite and not merely in a granite boulder. This is entirely possible, there being ample room on either side of the Enterprise ranch for the deep alluvium-filled valley known to exist elsewhere along the course of the Gila. That such a filled valley exists here is very probable, but the evidence is insufficient to indicate its location.

Logs of wells at Enterprise ranch.

Well in NW. ¼ NW. ¼ SE. ¼ sec. 24, T. 3 S, R. 5 W.

	Thickness.	Depth.
	Feet.	*Feet.*
Sand and gravel	16	16
Caliche	33	49
Sand and gravel	½	49½
Quicksand	15½	65

Well in SW. ¼ SW. ¼ SE. ¼ sec. 24, T. 3 S., R. 5 W.

Sand and gravel	16	16
Caliche	64	80
Granite in bottom.		

GILA BEND.

Near Gila Bend the river passes around the southern extremity of the Gila Bend Mountains, making a turn of more than 90°. At one place in this bend the stream cuts through an outlying hill which, unlike the main mass of the Gila Bend Mountains in this

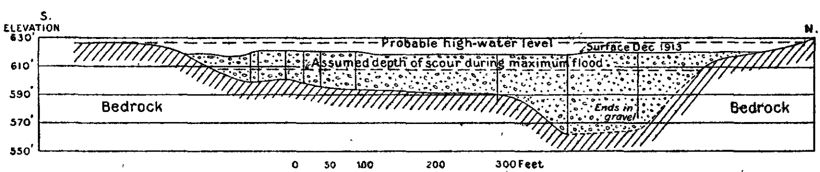


FIGURE 14.—Cross section of Gila River at Gila Bend, showing test holes.

vicinity, is composed of bedded rocks consisting in part, at least, of basalt, probably of Tertiary age. Borings made during an investigation by the Indian Office in connection with a proposed dam at this place show that bedrock is less than 160 feet below the surface at any place in the channel. (See Fig. 14.) The deep wells drilled by the Southern Pacific Co. at Gila Bend show that the alluvium at that place is hundreds of feet thick. These relations are shown in the cross section (Pl. XI, 5), and the geologic map (Pl. VI). (For a further discussion of the railroad wells at Gila Bend see pp. 79–80, 82–84.)

The river between Gila Bend and the north end of the Painted Rock Mountains was not examined during this investigation. The township plats show terraces bordering the river on both sides. These are in places over 6 miles apart. They are doubtless portions of the principal set of terraces which border the river throughout most of the distance from its mouth at Yuma at least as far east as Buckeye. Between the terraces are the flood-plain silt and sand. Portions of this bottom land are cultivated by Papago Indians.

There have been several attempts at the installation of more extensive irrigation systems by white men, but none have yet been successful. (See pp. 100–101.) The land south of the terrace is silty and sandy with but little gravel except near the border of the Painted Rock Mountains. Unsuccessful attempts have also been made to irrigate this area. On the north side the Gila Bend Mountains are close to the river, and much of the land is probably covered with gravel.

Gila River passes between the northern tip of the Painted Rock Mountains and the south end of a spur of the Gila Bend Mountains in a gorge or canyon which, as seen from a distance, appears to be rather narrow. This is one of the few places on the lower portion of the river's course where bedrock crops out close to the river on both sides. In 1882 an unsuccessful attempt was made to dam the Gila in this vicinity. (See p. 100.)

POINT OF ROCKS.

Gila River for some distance on both sides of the place known as Point of Rocks is flanked by black walls of basalt, in places over 100 feet high. These walls are only about 500 feet apart at Point of Rocks. Several unsuccessful attempts have been made to dam the river at this place. (See p. 100.) The lava on both sides furnishes firm support for the end of a dam, but unfortunately it rests on unconsolidated gravel so that an adequate foundation for a dam is lacking. The presence of the alluvial material beneath the basalt is known from well records at Sentinel and from the general geology of the region. The railroad wells at Sentinel show that there the alluvium is at least 780 feet thick, of which, however, the lower 580 feet is clay. The hollows of the lava surface are filled with coarse sand, mixed near the river with small amounts of fine gravel. These deposits are less than a foot thick over much of the basalt plain, but in some depressions they are several feet thick. The gravel on the lava may indicate that at some time in the past the stream overflowed onto this surface. The lava is of Pleistocene age and is later than some of the river deposits. Its extrusion probably resulted in a damming of the Gila. Some of the water of the stream may have flowed over the surface of the lava, depositing gravel and sand, before a new channel was cut sufficiently deep to confine it.

Between the steep lava walls are sand and silt such as make up the flood plain of the Gila throughout the lower portion of its course. The water flows in channels 30 to 100 feet or more wide between low banks. Between Agua Caliente and Palomas no lava exists on the right bank of the stream. Here floods have made great inroads into the soft silt and sand, forming precipitous banks, in places over 30 feet high. The height of these banks, so much greater than that of the usual cut bank in the flood plain, is due to the fact that here the river is acting against a portion of the old terrace. The old road between Agua Caliente and Palomas has been eroded away in several places and the washes emptying into the river have been deepened to such an extent that it is difficult to cross them with automobiles. As a consequence, while the old road with detours around the eroded portions is still used by some, a new road for automobiles well to the north of the affected area has become necessary. A lateral shift of the bank of about a mile in only a few years is reported to have taken place in the vicinity of Agua Caliente.

PALOMAS TO YUMA.

The character of the river throughout the last 85 miles or so of its course varies only in detail. For most of this distance there is a well-defined terrace on each side. It is composed of gravel and sand and has an average height of perhaps 30 or 40 feet. Above the terraces gravel-floored plains extend to the mountains. Below them is the flood plain of the river, 1 to 5 miles wide. The flood plain is a desolate expanse of silt and sand dotted with thickets of mesquite and near the present channel clumps of arrow weed. Irrigation with river water has been attempted at many places, but with little success. The water flows in channels between banks 3 to 10 feet high, except where the stream has swung against and cut into one of the old terraces above mentioned. In such places the bank may be as much as 50 feet high.

FOSSILS.

About a quarter of a mile north of Ligurta siding on the Southern Pacific Railroad Kirk Bryan, of the United States Geological Survey, found on October 31, 1917, fossil bones lying on and partly buried in the gravel and sand of the terrace that borders Gila River. The locality is that marked Fossil Point on Plate IV. The fossils were examined by J. W. Gidley, of the United States National Museum, who reports as follows:

> The collection consists for the most part of indeterminable bone fragments, but two fragments are recognizable. One is a portion of a phalanx of a horse, *Equus* sp., and the other is the basal portion of the antler of a deer, probably belonging to the genus *Odocoileus*. These do not determine the age more closely than that they are Pleistocene, though the presence of horse remains suggests one of the older phases of the Pleistocene.

This terrace is a portion of the principal set of terraces bordering the lower Gila and composed of alluvium of intermediate age.

SUMMARY.

Gila River below Salt River is a winding stream subject to considerable and rapid changes in volume. It flows through a series of valleys deeply filled with alluvium between short rugged mountain ranges in a desert region. The flood plain is bounded throughout most of this portion of the river's course by a single well-defined set of terraces. In places no terrace now exists on one or both sides of the stream, either because conditions were not favorable for terrace formation at these places, or because the terrace has been removed by erosion subsequent to its formation. The latter is the more probable explanation for most of these places. Other terraces besides the principal set can be found here and there, as in the vicinity of the Enterprise ranch, but these are discontinuous and of small extent. Between the principal terraces is the flood plain, which is in most places from 1 mile to several miles wide. Incised into the flood plain are channels 1 foot to 10 feet or more deep and a few feet to a mile wide. The position, size, and number of the channels change with every flood. The flood plain is composed of sand and silt. The sides of the valleys above the principal terraces are covered for the most part with coarse sand and gravel mixed to a greater or less extent with silt.

The water of the river is muddy at all times. During floods it transports great quantities of mud. Although the force of some of the floods is sufficient to tear dams from their foundations, damage bridges, and erode considerable areas of land, the river is in general a depositional stream. It receives greater loads of sediment than it can transport, and the channels are silting up.

INTERPRETATION OF WELL LOGS.

The deep wells put down by the Southern Pacific Co. and others are of considerable assistance in studying the geologic and physiographic history of Gila River. They furnish the only definite information obtainable as to conditions in the lower portions of the thick sedimentary deposits that fill the old valley of that stream. There are some discrepancies between the logs of wells located close together at some of the stations on the Southern Pacific Railroad, although the logs of these wells furnished by the railroad company give evidence of having been carefully kept and appear to be in general reliable. These discrepancies can in part be accounted for by the varied nature of the material penetrated. Considerable lateral variation within a distance of only a few yards is to be expected in the deposits of such a stream as the Gila. Some of the inconsistencies in the logs can be accounted for only by differences in the judgment and methods of the drillers and inaccuracies in the records. Some of them are not as great as they seem at first glance. There is little uniformity in the nomenclature employed by drillers. Two equally reliable and experienced men may call the same stratum by different names. It is often impossible in drilling to determine at precisely what point a significant change in the formation occurs, and this fact also leads to many apparent inconsistencies in well logs.

In Plate XII the logs of the principal wells near Gila River between its mouth and Salt River are plotted. The deep well at Mesa, near Salt River, is also shown. In making this plate the approximate profiles of Gila and Salt rivers were plotted according to the best available data. The graphic logs of the wells are spaced according to their distances apart as measured along the rivers and in the correct position vertically with reference to sea level. Where two or more wells have been drilled close together composite logs are given, and the portions of each log which appeared to be most detailed or most probably accurate were used in making the composite. The complete logs of all the deep wells are given on pages 80–84, 88.

In the absence of detailed surveys it must be recognized that the profiles given are only approximate. It is believed, however, that no errors large enough to affect the accuracy of the general relations exist. The character of the profile of Gila River and of the small portion of Salt River shown is that which would be expected. The gradient is steepest in the upper portions and gradually decreases nearer the mouth. The two places where the profile is convex upward are easily accounted for. At Buckeye the Gila is known to flow over granite with but a thin alluvial cover. The greater resistance to corrasion of this hard rock compared to that of the unconsolidated alluvium which floors most of the rest of the stream has resulted in a lower gradient being established at this locality. At Point of Rocks, near Sentinel, where the other convexity in the river profile occurs, the stream has had to cut through a thickness of more than 100 feet of basalt, which has retarded its progress. Below the basalt is alluvium, but the thickness of the deposit at this point is not known. As the Gila Bend Mountains extend almost to the river channel on the north, it seems probable that the alluvium here is not very thick.

WELLS OF SOUTHERN PACIFIC CO.

The logs of the three railroad wells at Yuma are reasonably consistent. The wells penetrated sand and clay with very little gravel. The deepest one encountered granite at a depth of 385 feet, or about 240 feet below sea level. The material above the granite is probably all river-laid sediment deposited largely by Colorado River but possibly in part by Gila River. This evidence indicates depression of the land in Pleistocene time, for Gila River could not deposit sediment so far below sea level.

The three shallow wells at Wellton penetrated sediments, in large part coarse gravels. This indicates either that the river at the time these sediments were deposited had a much greater transporting power than at present, or, more probably, that the lower formations in the wells are side-wash material and not river sediments. The latter hypothesis is supported by the location of the wells with respect to the present topography. The amount of gravel reported in the deep well at Wellton is less than that reported at corresponding depths in the shallow wells. This may be due to an actual variation in the formations, or it may be the result of inaccuracy in keeping the record of the upper part of the deep well. Two rather thick bodies of clay are recorded in the log of this well. The upper one is red clay, 90 feet thick, reached at a depth of 185 feet, and the lower one is blue clay, 145 feet thick, reached at a depth of 560 feet. These beds are separated by 285 feet of sand. They evidently indicate much quieter conditions of deposition than those which prevailed while the gravel and sand above and below them were being laid down. Below the blue clay the formations are cemented to a greater or less degree. As amount of consolidation is in general a rough measure of the age of a deposit, these lower strata may belong to a somewhat older series than those above them. At a depth of 938 feet "hard rock" is reported lying below 45 feet of "broken formation." It is possible that at this point the well reached bedrock belonging to the series of sedimentary rocks of probable Tertiary age which crops out at Antelope Hill and Baker Peaks. The consolidated alluvium supposed to be Pleistocene and the Tertiary sedimentary rocks in this region are so similar that it is impossible to distinguish the two with certainty in well records. It is probable, however, that at Wellton the Pleistocene alluvium is less than 1,000 feet thick. As indicated in the section on geologic history, this may include beds of upper Tertiary age.

The wells at Pembroke and Mohawk and the one between these two stations penetrated clay and gravel with some sand, and the latter two wells reached bedrock. The material penetrated appears to be ordinary valley fill and to have no special significance.

At Aztec the railroad has two wells. The log of well No. 2 is more detailed than that of well No. 1, but the two are in general similar. There are several points of resemblance between these logs and that of the deep well at Wellton. The upper strata are sand and clay; next there is a considerable thickness of clay containing some sand; next partly consolidated sand and gravel; and in the bottom of the wells rock of apparently sedimentary origin. The gravel that occurs in the upper part of the Wellton well is absent at Aztec, and the clay is much thicker. Otherwise the two sections are similar. No outcrops of Tertiary rock are known in the vicinity of Aztec, but it is entirely possible that such rocks exist buried under the alluvium and that the rock found in the bottom of the wells is of that age.

The logs of the four railroad wells at Sentinel are not very consistent in detail but they agree in general. They show 20 feet of soil, followed by basalt with some interbedded clay; then sand, clay, and a little gravel, followed by more than 550 feet of clay with a little sand, and finally sand, gravel, and clay, partly consolidated, some of which is called "rock" in the logs. It might equally well be alluvium of the older group or Tertiary rock, so far as the evidence available shows.

At Gila Bend (Gila railroad station) there are seven wells belonging to the railroad company. Three of these are more than 1,700 feet deep, being thus by far the deepest wells in this region. The logs of two of these agree almost exactly and were probably made by the same man. The log of the third differs only in detail. These three are at the roundhouse. The other four are shallower and older and are at the pump house, a short distance west of the roundhouse. Their logs agree reasonably closely with those of the roundhouse wells. The roundhouse wells penetrated 90 feet of sand and gravel with a little clay, then sandy clay, followed by more than 850 feet of clay with, according to one log, some sand and mud, and finally more than 600 feet of thin alternating beds of clay and gravel, with minor amounts of sand. Several of the beds in the last 650 feet are called "rock" in the logs, and all of them are probably more or less consolidated. One of the logs mentions "shells and mud" between depths of 1,100 and 1,125 feet. If the "shells" are the fossil remains of organisms they may indicate conditions markedly different from any known to have existed in this region. It is probable, however, that they are not really shells. One of the other logs gives "shale and mud" at this depth, and another, that of well No. 6, gives "hard clay."

It is possible that part or all of the formations below the clay are of Tertiary age, but this can not be proved, and it is equally possible that they are of early Pleistocene or late Tertiary age. In either case, it is clear that at least three important groups of events are recorded by the strata penetrated by these wells. These are (1) sedimentation under rapidly varying conditions, producing the thin beds in the lower parts of the wells; (2) deposition in quiet water;

(3) deposition of the beds above the clay under conditions approximating those of the present day.

Two of the logs show "clay and malapai" between depths of 1,125 and 1,140 feet. "Malapai" (a corruption of the Spanish "malpaís," badland) is a local name for the basaltic lava. Possibly, therefore, volcanic rock exists at this depth. Another and at least equally probable explanation of the record is that the "malapai" noted consists of boulders of lava or some similar rock that have been transported by water from some distant outcrop to the place where they are now found.

Logs of wells of Southern Pacific Co. in lower Gila region.

Yuma well No. 1 (finished Jan. 29, 1917).

	Thickness.	Depth.		Thickness.	Depth.
	Feet.	*Feet.*		*Feet.*	*Feet.*
Dry gravel	10	10	Cemented sand	19	121
Cemented dry sand; water stands at 55 feet	58	68	Water gravel	4	125
Cemented gravel	2	70	Fine sand with some clay	76	201
Cemented sand	22	92	Water gravel, broken rock	20	221
River clay	10	102	Fine sand with clay	25	246

Yuma well No. 2 (finished Apr. 22, 1917).

Sand and gravel	16	16	Clayey sand	21	126
Cemented sand; water stands at 65 feet	55	71	Water gravel	5	131
Gravel	1	72	Clayey sand	59	190
Cemented sand	23	95	Cemented sand	15	205
River clay	10	105	Gravel and broken rock	21	226
			Cemented sand	26	252

Yuma test well (finished Jan. 6, 1917).

Dry gravel	10	10	Cemented sand	19	121
Cemented dry sand; water stands at 55 feet	58	68	Water gravel	4	125
Cemented gravel	2	70	Fine sand with some clay	76	201
Cemented sand	22	92	Water gravel, broken rock	19	221
River clay	10	102	Fine sand with clay	164	385
			Solid rock (granite)	11	396

Old Wellton well No. 1 (finished March, 1892).

Sediment	14	14	Coarse gravel	20	78
Dry sand	27	41	Sand and fine gravel	3	81
Red hardpan	2	43	Coarse gravel	17	98
Dry sand; water stands at 48 feet	6	49	Quicksand and gravel	3	101
Water-bearing sand	9	58	Coarse gravel	17	118

Wellton well No. 1 (finished Jan. 20, 1918).

Soil	18	18	Silt	3	51
Sand	21	39	Adobe or clay; water stands at 51 feet 8 inches	14	65
Coarse gravel	2	41	Coarse gravel	72	137
Soil	1	42	Quicksand	3	140
Sand	6	48			

Logs of wells of Southern Pacific Co. in lower Gila region—Continued.

Wellton well No. 2 (finished Mar. 2, 1918).

	Thickness.	Depth.		Thickness.	Depth.
	Feet.	*Feet.*		*Feet.*	*Feet.*
Soil	17	17	Gravel	22	89
Sand	23	40	Cement boulders	10	99
Clay	4	44	Gravel	7	106
Sand	2	46	Cement boulders	7	113
Clay	1	47	Gravel	[illegible]	115
Gravel; water stands at 49 feet	3	50	Cement gravel	4	119
Clay	1	51	Gravel	1½	120½
Sand	2	53	Cement boulders	½	124
Hard clay	14	67	Loose gravel	5	129
			Cement	37	136

Wellton well No. 3 (finished June 16, 1904).

Loam	15	15	Cement gravel	55	860
Sand; water rises to 58-foot level	75	90	Sandy shale	5	865
Gravel	20	110	Cement gravel	7	872
Sand	75	185	Sandstone	8	880
Red clay	90	275	White clay	5	885
Sand	285	560	Red clay	53	938
Blue clay	145	705	Broken formation	45	983
Sandstone	10	715	Hard rock	17	1,000
Clay and gravel	10	725	Red sandstone	58	1,066
Cement gravel	35	760	Red clay	44	1,110
Sandstone	45	805	White sand	10	1,120

Well 2 miles east of Pembroke (finished September, 1918).

Dry loose sand	3	3	Heaving sand	15	240
Clay	37	40	Water gravel	20	260
Clay and gravel; water stands at 175 feet	150	190	Clay and gravel	148	408
Sand and gravel, water bearing	35	225	Boulders, water bearing	25	433
			Solid rock	5	438

Pembroke well.

Sandy soil	8	8	Water gravel	18	200
Clay and gravel; water stands here	174	182	Clay and gravel	218	418
			Fine, slimy sand with water	37	455

Mohawk well (finished Aug. 3, 1899).

Cemented clay and gravel	160	160	Sand and gravel	6	176
Red clay	3	163	Granite	7½	183½
Gravel	7	170			

Aztec well No. 1 (finished April, 1918).

Sandy soil	25	25	Hard sand	5	145
Cement	2	27	Red clay	455	600
Running sand	35	62	Coarse water sand	22	622
Clay; water stands at 79 feet	20	82	Very hard sand	28	650
Sand	28	110	Very coarse water sand	6	656
Clay	13	123	Hard sand	10	666
Water gravel	2	125	Black rock of sand nature	44	710
Clay	15	140			

Logs of wells of Southern Pacific Co. in lower Gila region—Continued.

Aztec well No. 2 (finished June, 1918).

	Thickness.	Depth.		Thickness.	Depth.
	Feet.	*Feet.*		*Feet.*	*Feet.*
Coarse sand	38	38	Red clay	19	194
Cement sand	2	40	Clay	68	262
Caving sand	17	57	Water gravel	2	264
Sand and clay; water stands at 79 feet	45	102	Clay	13	277
Cement	2	104	Sandy clay	163	440
Sand and clay	26	130	Clay	40	480
Water sand	2	132	Sandy clay	40	520
Red clay	3	135	Red clay	110	630
Sand and clay	22	157	Water sand and gravel	5	635
Water sand	3	160	Cement	5	640
Clay	11	171	Decomposed granite	12	652
Cement	½	171½	Fine sand	2	654
Sandy clay	3½	175	Sand and gravel	21	675
			Sandrock	35	710

Sentinel well No. 1 (finished November, 1882).

Clay	20	20	Sand	250	600
Lava	80	100	Clay	400	1,000
Sand; water (water level 185 feet)	250	350	Sand and gravel	129	1,129

Sentinel well No. 2 (finished April, 1897).

Loam	25	25	Sand; water struck at 242 feet	62	255
Loose rock	9	34	Sand and clay	33	288
Lava	41	75	Sand	38	326
Loose lava and clay	10	85	Clay	587	913
Solid lava	50	135	Soft rock	49	962
Sand and gravel; water rises to 190 feet	58	193			

Sentinel well No. 3 (finished Nov. 10, 1904).

Loam	20	20	Clay and sand	40	650
Lava	16	36	Clay	5	655
Solid rock	40	76	Sand	5	660
Clay	30	106	Clay	55	715
Lava	35	141	Sand	45	760
Sand and gravel	29	170	Clay	173	933
Sand; water struck at 246 feet, rises to 205-foot level	180	350	Rock	69	1,002
Red clay	260	610	Clay	28	1,030
			Rock	52	1,082

Sentinel well No. 4 (finished Jan. 1, 1917).

Soil	20	20	Heavy clay	74	304
Yellow clay	22	42	Sand and clay	36	340
Lava	2	44	Boulders and sand	10	350
Malapai boulders	26	70	Clay	565	915
Solid rock	15	85	Rock	25	940
Clay and boulders	5	90	Clay	40	980
Lava	16	106	Gravel	15	995
Malapai, boulders, and clay	34	140	Rock	11	1,006
Malapai	36	176	Porous rock carrying water	8	1,014
Clay; water rises to 180 feet	44	220	Clay	6	1,020
Sand and gravel	10	230	Rock	10	1,030

Gila well No. 2 (finished August, 1895).

Cemented gravel	20	20	Sand and clay	28	1,178
Indurated clay	20	40	Lava and clay	57	1,235
Cemented gravel	20	60	Hard rock	15	1,250
Coarse gravel and sand	40	100	Clay and rock	44	1,294
Clay; surface of water at 140 feet	68	168	Tough red clay	32	1,326
Quicksand	112	280	Clay	29	1,355
Sand and clay	195	475	Rock and clay	13	1,368
Clay	290	765	Hard rock and clay	4	1,372
Dry clay	215	980	Clay	8	1,380
Clay	170	1,150	Bottom of well	6	1,386

Logs of wells of Southern Pacific Co. in lower Gila region—Continued.

Gila well No. 3 (finished Jan. 20, 1906).

	Thickness.	Depth.		Thickness.	Depth.
	Feet.	*Feet.*		*Feet.*	*Feet.*
Gravel and soil	15	15	Heaving sand	6	170
Clay	25	40	Clay	10	180
Cement gravel	52	92	Sand	20	200
Clay; struck water	46	138	Sandrock	5	205
Water sand	18	156	Gravel and water	4	209
Sandrock	8	164			

Gila well No. 4 (finished Feb. 3, 1906).

Gravel and soil	15	15	Sand	24	162
Clay	25	40	Heaving sand and clay	21	183
Cement gravel	52	92	Sand, clay, and gravel	13½	196½
Clay; struck water at 138 feet	46	138	Clay	13½	210

Gila well No. 5 (finished Feb. 22, 1906).

Clay	17	17	Cement sand and clay	31	111
Sand and clay	39	56	Clay and quicksand; struck water at 138 feet	99	210
Sand and cemented sand	24	80			

Gila well No. 6 (finished Jan. 25, 1917).

Sand and gravel	25	25	Clay and gravel	24	1,355
Clay and boulders	20	45	Light rock	6	1,361
Fine sand	20	65	Clay and gravel	32	1,393
Fine gravel	15	80	Quartz rock	5	1,398
Coarse gravel, cemented in streaks	12	92	Cement gravel	18	1,416
Clay	53	145	Clay	11	1,427
Fine sand, water bearing	30	175	Cement gravel	18	1,445
Sandy clay	50	225	Clay	20	1,465
Fine sand, water bearing	10	235	Boulders in clay	9	1,474
Sandy clay	235	470	Clay and gravel	21	1,495
Clay and hot mud	410	880	Boulders and clay	15	1,510
Cemented clay	20	900	Clay and gravel	20	1,530
Coarse sand with a little water	5	905	Rock	25	1,555
Hard clay	215	1,120	Clay	13	1,568
Hard clay and rock	50	1,170	Hard rock	33	1,601
Hard shell; water struck at 1,175 feet	5	1,175	Clay	11	1,612
Water-bearing sand	10	1,185	Rock	9	1,621
Sandrock	25	1,210	Clay	19	1,640
Rock	49	1,259	Rock	7	1,647
Clay with gravel	12	1,271	Clay	17	1,664
Rock	13	1,284	Rock	9	1,673
Clay and gravel	23	1,307	Clay	8	1,681
Rock	5	1,312	Rock	13	1,694
Clay and gravel	10	1,322	Clay	14	1,708
Red rock	9	1,331	Rock	6	1,714
			Sand carrying water	18	1,732
			Clay	8	1,740
			Rock	6	1,746

Gila well No. 7 (finished Jan. 14, 1917).

Dry gravel	30	30	Clay and gravel	23	1,307
Clay	20	50	Rock	5	1,312
Sand	20	70	Clay and gravel	10	1,322
Dry gravel	4	74	Red rock	9	1,331
Cemented gravel	16	90	Clay and gravel	24	1,355
Sandy clay; water stands at 115 feet	150	240	Light rock	6	1,361
Clay; air inlet at 450 feet	860	1,100	Clay and gravel	32	1,393
Shale and mud	25	1,125	Quartz rock	5	1,398
Clay and malapai	15	1,140	Cement gravel	18	1,416
Rock; water struck at 1,175 feet	35	1,175	Clay	11	1,427
			Cement gravel	18	1,445
Fine sand	1	1,176	Clay	20	1,465
Rock	83	1,259	Boulders in clay	9	1,474
Clay with gravel	12	1,271	Clay and gravel	21	1,495
Rock	13	1,284	Boulders and clay	15	1,510
			Clay and gravel	20	1,530

Logs of wells of Southern Pacific Co. in lower Gila region—Continued.

Gila well No. 7 (finished Jan. 14, 1917)—Continued.

	Thickness.	Depth.		Thickness.	Depth.
	Feet.	*Feet.*		*Feet.*	*Feet.*
Rock	25	1,555	Rock	9	1,673
Clay	13	1,568	Clay	8	1,681
Hard rock	33	1,601	Rock	13	1,694
Clay	11	1,612	Clay	14	1,708
Rock	9	1,624	Rock	6	1,714
Clay	19	1,610	Sand carrying water	18	1,732
Rock	7	1,647	Clay	8	1,740
Clay	17	1,664	Rock	6	1,746

Gila well No. 8 (finished Aug. 14, 1918).

Dry gravel	30	30	Cemented gravel	18	1,416
Clay	20	50	Clay	11	1,427
Sand	20	70	Cemented gravel	18	1,445
Dry gravel	4	74	Clay	20	1,465
Cemented gravel	16	90	Boulders in clay	9	1,474
Sandy clay; water stands at 115 feet	150	240	Clay and gravel	21	1,495
			Boulders and clay	15	1,510
Clay	860	1,100	Clay and gravel	20	1,530
Shells and mud	25	1,125	Rock	25	1,555
Clay and malapai	15	1,140	Clay	13	1,568
Rock; water struck at 1,175 feet	35	1,175	Hard rock	33	1,601
			Clay	11	1,612
Fine sand	1	1,176	Rock	9	1,621
Rock	83	1,259	Clay	19	1,640
Clay with gravel	12	1,271	Rock	7	1,647
Rock	13	1,284	Clay	17	1,664
Clay and gravel	23	1,307	Rock	9	1,673
Rock	5	1,312	Clay	8	1,681
Clay and gravel	10	1,322	Rock	13	1,694
Red rock	9	1,331	Clay	14	1,708
Clay and gravel	24	1,355	Rock	6	1,714
Light rock	6	1,361	Sand carrying water	18	1,732
Clay and gravel	32	1,393	Clay	8	1,740
Quartz rock	5	1,398	Rock	12	1,752

WELLS IN ARLINGTON VALLEY.

Most of the wells near Arlington are too shallow to throw much light on ground-water conditions. None are nearly as deep as most of those described above. The A. K. well, in sec. 32, T. 1 S., R. 5 W., near Arlington, is the only one shown on Plate XII. The schoolhouse well in the NW. ¼ sec. 33, T. 1 S., R. 5 W., just north of the A. K. well, is not so deep but penetrates similar material. The logs of these two wells are given below. Mr. John Montgomery,[54] of the Flower Pot Cattle Co., states that the water level in them rose about 12 feet in the 20 years preceding 1918. He also states that all attempts in this locality to sink wells far enough to pass through the second stratum of red clay have failed and have found no water below that in the white sand under the first stratum of red clay.

[54] Personal communication.

Logs of wells in Arlington Valley.

[Furnished by John Montgomery.]

A. K. well.			Well of district school No. 47.		
	Thickness.	Depth.		Thickness.	Depth.
	Feet.	*Feet.*		*Feet.*	*Feet.*
Sand and gravel	60	60	Sand and gravel	60	60
Red clay	30	90	Red clay	30	97
Sand	2	92	White sand	1	98
Red clay	58	150			

WELLS IN BUCKEYE VALLEY.

None of the wells near Palo Verde, Buckeye, or Liberty furnish any important information as to ground water. Those near the river are very shallow. No detailed logs are available of the deeper wells used for irrigation in the valley a mile or two north of the river. They pass through gravel and sand, probably in part river sediments, in part side wash. Side wash and river sediments can not be distinguished in well logs, and even in surface exposures in this region they grade into each other to so great an extent and possess so many characteristics in common that they can be discriminated, if at all, only by detailed field study.

SOUTHWEST COTTON CO.'S WELLS.

The Southwest Cotton Co. has sunk a number of wells near Avondale on the west side of Agua Fria River. None of them are very deep, but the logs have been carefully kept, and the information in them may be of value. The logs are given below. The material penetrated is principally side wash from the White Tank Mountains, but sediments deposited by Agua Fria River may be present in some wells. The large amount of caliche in nearly all the wells is noteworthy. The formation of caliche is a rather slow process, so that its presence in large amounts in a deposit is an indication that the deposit is not very recent in origin. Probably at least the lower strata in these wells belong to the older alluvium. In the log of well No. 33 a stratum of shells in caliche is recorded. If this record is correct, it indicates that conditions markedly different from those of the present existed during the deposition of these strata. Possibly at some time in the past a basin or basins existed in this locality in which water remained long enough to allow shellfish to live. One of the engineers of the company states that in an abandoned test hole of which no record has been kept a stratum of gypsum was encountered. The gypsum and some of the beds called caliche in the logs may be precipitates formed during desiccation in these basins.

Logs of wells of Southwest Cotton Co., Avondale, Ariz.

Well No. 3, W. ½ sec. 12, T. 2 N., R. 1 W.

[Altitude 1,051 feet.]

	Thickness.	Depth.		Thickness.	Depth.
	Feet.	*Feet.*		*Feet.*	*Feet.*
Boulders and gravel	38	38	Cemented gravel and sand	5	127
Fine sand	2	40	Clay and gravel	8	135
Soft caliche	17	57	Loose boulders and gravel	10	145
Boulders and coarse gravel	18	75	Soft cemented gravel, sand, and boulders	12	157
Clay	21	96	Loose boulders, gravel, and sand	11	168
Boulders and coarse gravel and sand	14	110	Hard sand	2	170
Clay and coarse gravel	12	122	Soft cemented gravel and sand	16	186

Well No. 4, W. ½ sec. 12, T. 2 N., R. 1 W.

[Altitude 1,040 feet.]

Soil and sand	8	8	Gravel and boulders	10	130
Gravel and boulders	30	38	Hard sand	20	150
Clay and boulders	4	42	Clay and gravel	18	168
Gravel and boulders	18	60	Cemented gravel and boulders	4	172
Clay and boulders	10	70	Clay and boulders	6	178
Coarse gravel	32	102	Clay and gravel	11	189
Clay and gravel	18	120			

Well No. 5, SE. ¼ sec. 11, T. 2 N., R. 1 W.

[Altitude 1,044 feet.]

Soil	14	14	Clay	20	89
Caliche	3	17	Gravel	4	93
Clay	25	42	Clay	24	117
Caliche	4	46	Caliche	3	120
Clay	4	50	Clay	10	130
Cemented gravel	11	61	Gravel	79	209
Clay	4	65	Clay	10	219
Gravel	4	69			

Well No. 6, SE. ¼ sec. 11, T. 2 N., R. 1 W.

[Altitude 1,044 feet.]

Soil	8	8	Gravel and boulders	45	115
Caliche	8	16	Clay	52	167
Gravel	8	24	Gravel	4	171
Caliche	46	70	Clay	31	202

Well No. 7, NE. ¼ sec. 14, T. 2 N., R. 1 W.

[Altitude 1,047 feet.]

Soil	8	8	Gravel	41	81
Cemented gravel	7	15	Caliche and clay	114	195
Sand	2	17	Clay	4	199
Cemented gravel	7	24	Gravel	5	204
Caliche	16	40	Clay, caliche, and cemented sand	139	343

Well No. 7A, NW. ¼ sec. 7, T. 2 N., R. 1 W.

[Altitude 1,112 feet.]

Soil	7	7	Gravel	55	192
Sand with clay and caliche	27	34	Sand	12	204
Gravel, sand, and clay	26	60	Soft sandstone	24	228
Fine sand	32	92	Coarse sand	42	270
Gravel and boulders	14	106	Sandstone	5	275
Quicksand	6	112	Shaly sandstone	33	308
Gravel	6	118	Sandy clay	4.5	312.5
Soft caliche	19	137			

Logs of wells of Southwest Cotton Co., Avondale, Ariz.—Continued.

Well No. 8, NE. ¼ sec. 14, T. 2 N., R. 1 W.

[Altitude 1,045 feet.]

	Thickness.	Depth.		Thickness.	Depth.
Soil	3	3	Gravel	4	259
Clay	19	22	Clay	9	268
Clay and gravel	6	28	Sand	2	270
Sand and caliche	18	46	Clay	10	280
Gravel	54	100	Hard sand	12	292
Clay and caliche	98	198	Caliche and hard sand	2	294
Clay and gravel	12	210	Not known	9	303
Clay	45	255			

Well No. 9, NE. ¼ sec. 22, T. 2 N., R. 1 W.

[Altitude 1,045 feet.]

Soil	2	2	Gravel	50	102
Clay	38	40	Clay	2	104
Gravel	2	42	Gravel	11	115
Clay and gravel	10	52	Clay	9	124

Well No. 25a, NE. ¼ sec. 25, T. 2 N., R. 1 W.

Sandy soil	17	17	Clay	17	135
Gravel	13	30	Hard sand and boulders	25	160
Sand	8	38	Clay with streaks of sandstone	44	204
Boulders	2	40	Coarse gravel	12	216
Sand	16	56	Sandstone	16	232
Gravel	16	72	Clay and gravel	12	244
Sand	10	82	Coarse gravel	14	258
Clay	18	100	Sandstone	4	262
Sandstone	13	113	Clay	41	303
Clay and sand	5	118	Soft sandstone	5	308

Well No. 28a, S. ½ sec. 28, T. 2 N., R. 1 W.

[Altitude 1,009 feet.]

Soil	3	3	Caliche	52	103
Caliche	21	24	Gravel	134	237
Sand	27	51	Not known	41	278

Well No. 33a, sec. 33, T. 2 N., R. 1 W.

[Altitude 1,010 feet.]

Soil	3	3	Gravel	13	183
Caliche	9	12	Caliche	17	200
Sand and gravel	12	24	Gravel	7	207
Caliche with strata of shells	74	98	Gray clay	17	224
Cemented gravel	9	107	Gravel	50	274
Gravel	17	124	Sandstone	14	288
Caliche	46	170			

Well No. 34b, center of sec. 34, T. 2 N., R. 1 W.

[Altitude 1,000 feet.]

Soil	3	3	Clay	31	92
Hardpan	12	15	Gravel and boulders	62	154
Sand and gravel	10	25	Clay and caliche	12	166
Boulders	1	26	Gravel and caliche	15	181
Gravel and boulders	4	30	Caliche	19	200
Coarse gravel	31	61			

Logs of wells of Southwest Cotton Co., Avondale, Ariz.—Continued.

Well in SE. ¼ sec. 21, T. 2 N., R. 1 W.

[Altitude 1,041 feet.]

	Thickness.	Depth.		Thickness.	Depth.
	Feet.	*Feet.*		*Feet.*	*Feet.*
Soil and caliche	11	11	Cemented sand and gravel	9	74
Gravel	13	24	Gravel and boulders	74	148
Caliche	7	31	Sandstone	5	153
Cemented sand	32	63	Caliche	7	160
Sand and gravel	2	65			

WELLS IN MESA.[55]

The deep well on the Murphy-McQueen ranch, Mesa, is of interest because it extends below sea level and because of the considerable thicknesses of clay it passes through. The log of this well is given below. Several of the other wells in this locality encounter considerable amounts of clay, but none are nearly as deep as the Murphy-McQueen well. The clay must have been originally laid down in quiet water, undisturbed by swift currents. These conditions must have continued uninterrupted for considerable periods to permit the accumulation of such thick beds of clay as are known to exist. The Murphy-McQueen well penetrated 605 feet of "clay and talc" in its lower part and was still in the same material when drilling ceased. The "talc" mentioned can only be some variety of clay, and the presence of any considerable amount of true talc in such a formation is highly improbable.

Log of well of S. J. Murphy, on Murphy-McQueen ranch, Mesa.

	Thickness.	Depth.
	Feet.	*Feet.*
Surface alluvial soil	13	13
Water-bearing cemented gravel and boulders	57	70
Loose, free water gravel, sand, and boulders	42	112
Clay, soft limestone, and chalk rock	408	520
Coarse sand and small gravel; water	6	526
Thin strata of sand and clay; no water	74	600
Clay and talc: no water	605	1,205

PHYSIOGRAPHIC HISTORY OF GILA RIVER.

TERTIARY EVENTS.

In the Tertiary period there was widespread faulting in the lower Gila region, and probably it continued intermittently for a long time. As a result by late Tertiary time the broad features of the present topography had been blocked out. The mountain ranges

[55] Lee, W. T., Underground waters of Salt River valley, Ariz.: U. S. Geol. Survey Water-Supply Paper 136, pp. 13–44, 1905.

were separated by structural valleys, in some of which the surface of the bedrock had sunk far below the summits of the adjoining mountains. The positions and shapes of these valleys determined in large measure the drainage pattern in the region.

In this report the disturbances that produced the structural valleys are considered to mark the end of the Tertiary period, and all the material deposited in the present valleys is therefore assigned to the Pleistocene. The fossil evidence discovered in San Pedro Valley (p. 32) suggests that the older portions of the alluvium may be Pliocene. Sedimentary rocks similar in many respects to the alluvium in the valleys of the present streams are associated with Tertiary lava in the fault blocks in the mountains. Most of these sediments were laid down prior to or in the early part of the Tertiary period. Their character indicates that in all probability the region at that time had a climate and type of topography similar in many ways to those of to-day. Detailed study may eventually make it possible to decipher some of the features of the drainage lines of that time, but the available information is only sufficient to show that they differed markedly from those of to-day.

QUATERNARY EVENTS.

First period of erosion.—The general effect of the movements near the end of Tertiary time appears to have been uplift of the land. This resulted in greatly increased erosion. The valleys already formed were worn deeper by the streams, and doubtless new ones were formed. It is not possible from the evidence at hand to determine to what extent any particular valley is the result of structural depression or of erosion. Probably both processes played a part in the formation of most of the larger valleys. In one way or another deep valleys were evidently formed at this time. Except for minor changes the positions of these valleys correspond with those of the present ones.

First period of alluviation.—In course of time the streams, for some reason not now determinable, became overloaded. They deposited sediment until their valleys became in large part filled with it. The older groups of alluvial deposits in the valleys, most of which are now partly consolidated, were formed at this time.

The thickness of the alluvium thus deposited differed greatly in different localities. It is impossible now to determine the maximum thickness of the formation in the larger valleys. The beds exposed in the lower Gila region have maximum thicknesses of at most a few score feet. The deep wells in Gila Valley pass through many hundred feet of alluvium, but it is impossible from the records to determine with any certainty where to draw the lines between deposits of different ages.

The Gila conglomerate, which may be equivalent in age to part of the older alluvium here, in some parts of the mountain region of Arizona is thousands of feet thick.[56] If such thicknesses of alluvium were laid down in the mountains, it is probable that equal or greater thicknesses were deposited in the lower Gila region.

Much of the alluvium in the Gila Valley is now below sea level, as is proved by the logs of the deep wells. This is graphically shown in Plate XII, in which the logs of deep wells are plotted in their proper relation to sea level. Much of this deeply buried material is clay, but some of it is sand and gravel, apparently differing little or not at all from material that is being laid down in the present stream channels.

Whatever the origin of the formations, it is clear that the river could not have eroded its channel to any such depths below sea level as those at which alluvium has been found in the wells. Therefore subsidence ranging from several hundred to more than 1,000 feet has taken place in the lower valleys of Salt and Gila rivers since alluviation began. The weight of sediment piled up on the tops of the downthrown blocks of the original structural valleys may perhaps have caused subsidence at a rate more or less proportional to the rate of deposition of the sediment. Renewed or continued crustal movement may have resulted in the subsidence. Whatever the cause, the fact seems clearly established. The abundant evidences of the erosion of great quantities of material from the mountain ranges of the region in early Pleistocene time seems to indicate strongly that the general direction of crustal movement in the mountains was upward. In strong contrast to this movement was the subsidence in the river valleys. In the absence of deep wells it is impossible to determine whether there has been corresponding subsidence in the intermontane valleys away from the rivers. The alluvial fill in many of these valleys is deep, but it has not yet been demonstrated that the fill extends below sea level.

Clay.—A striking feature of the logs of the deep wells along Gila River is the presence of great thicknesses of clay. In Plate XII an attempt has been made to correlate the beds penetrated by the several wells. From this it appears that there is a mass of clay in the Gila Valley scores of miles long, with a maximum thickness of at least 860 feet and a possible width of several miles. The width at Gila Bend might be considerable, but in most places it is probably less than 5 miles. As the railroad crosses the Mohawk Mountains between Wellton and Aztec there is a gap in the record of formations in the river valley. It is reasonable to suppose that the clay continues in

[56] Ransome, F. L., The copper deposits of Ray and Miami, Ariz.: U. S. Geol. Survey Prof. Paper 115, p. 74, 1919.

the valley around the north end of the Mohawk Mountains. In that case the clay in the deep well at Wellton is a part of the body found in the wells at Aztec, Sentinel, and Gila Bend. Another and longer stretch for which no information is available is that between Gila Bend and Mesa, because of the lack of deep wells in this portion of the river valley. Clay is found in the A. K. well, near Arlington, and in some others, but none of the wells are deep enough to show whether or not there is a thickness corresponding to that found at Gila Bend, below this stretch, and at Mesa, above it. At Mesa the clay is at least 605 feet thick and may be much thicker. If it belongs to the same body as that in the railroad wells downstream, then this mass of clay is at least 182 miles long. It is worthy of note that much of the clay is at present below sea level.

The formation of any such mass of clay as appears to be present in the valley of Gila River must have occurred under conditions very different from those of the present day. Clay silts are deposited in quiet places in the present stream, but that hundreds of feet of clay, mixed with only minor amounts of sand, could be laid down by a turbulent and variable river like the Gila is not conceivable. It would appear that the clay must have been deposited in some quiet body of water such as a lake. The record of the presence of the clay is not continuous throughout the river valley, and the clay may not be a continuous and uninterrupted body. It may have been formed in a series of lakes, perhaps corresponding to the series of structural valleys that unite to form the long, sinuous valley of the Gila. If all the material in the lower parts of the valleys of Gila and Colorado rivers above solid bedrock were now removed, the sea water would pour in from the Gulf of California and occupy large parts of these valleys. If at some time in the past the lowering of the valley floor proceeded faster than the alluvial filling, the lower end of the valley of the Gila may conceivably have been flooded by ocean water. Under these circumstances a long, narrow estuary would have been formed. There is no evidence of marine life in the formations in the valley so far as known at present, nor is there any record of characteristic marine sediments among the known formations in the valley. The formation of an estuary long enough and winding enough to account for the distribution of the clay beds by the subsidence of a series of fault blocks would be a most unusual and extraordinary occurrence. On the other hand, the formation of lakes in a river valley, either by differential movement of the valley floor or by some other means, is not uncommon. This appears to be the most probable explanation of the known facts.

In this connection the presence of supposed lake beds in the San Carlos Indian Reservation on Gila River should be mentioned.

Schwennesen[57] found beds of sandstone, tuff, limestone, and marly clay with an aggregate estimated thickness of 700 to 800 feet outcropping in the valleys of San Carlos and Gila rivers in this reservation. He believes that these beds were formed in a body of standing water such as a lake. If, as seems probable, these lake beds are essentially contemporaneous with the clay above described, the known area of such deposits is extended up the Gila as far as the east boundary of the San Carlos Reservation.

Second period of erosion.—After the deposition of the older alluvium there was renewed crustal movement. The beds of older alluvium were in many places broken by faults and bent by minor folding. The lake beds in the San Carlos Indian Reservation have suffered minor folding and faulting[58] and are therefore probably older than the period of movement during which the older alluvium was disturbed. Whether they are contemporaneous with the older alluvium or with a part of it is not clear from the available evidence. The deep wells in the lower Gila Valley are so widely spaced and the correlation between formations in them is so uncertain and to some extent impossible that it is not feasible at present to determine whether any of the formations penetrated by these wells are tilted. As there is no fossil evidence and no safe means of lithologic correlation, divisions between the formations in the river valley can not be made.

During this period of crustal disturbance the general movement, at least in the mountains, appears to have been upward. Erosion became active, and a break in sedimentation occurred. Not only were large quantities of the older rocks worn down and removed from the mountains, but much of the alluvium previously deposited in the valleys was swept out of them again. To what extent this change was due to the earth movements and to what extent to climatic or other causes can not be determined from the available evidence. Certainly crustal movement was an important if not the dominant factor in the change.

Second period of alluviation.—The period of movement and erosion above described was followed by a second period of valley filling during which another series of alluvial deposits was laid down. This is the material that floors the greater portion of the present valleys, including that of Gila River. As it is younger than the alluvium previously described and older than the recent deposits it may be referred to as the alluvium of intermediate age. It is unconsolidated or only locally consolidated and gives little

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[57] Schwennesen, A. T., Geology and water resources of the Gila and San Carlos valleys in the San Carlos Indian Reservation, Ariz.: U. S. Geol. Survey Water-Supply Paper 450, pp. 8–10, 1921.

[58] Idem, p. 9.

or no evidence of having been disturbed by crustal movement. Because of the impossibility of distinguishing with certainty in well logs between it and the older alluvium and of the small number of deep wells in the region, its thickness present in the valleys can not be determined. In some places it may be of the order of hundreds of feet. This formation is the only one deposited since the end of Tertiary volcanism in this region in which fossils have been found. (See p. 75.) These fossils seem to show that the formation is of Pleistocene age. Indefinite as this information is, it marks a distinct advance in our knowledge of the geology of the region.

Basalt.—Flows of basalt occur in many places in the lower Gila region interbedded with Pleistocene alluvium. The eruptions appear to have been more violent during the deposition of the older alluvium, but they continued into the period of deposition of the alluvium of intermediate age. These outpourings of lava disarranged the drainage in several places in the region by blocking the stream channels. Evidence of old lava dams now cut through by Gila River is found at Gillespie dam (p. 71) and Point of Rocks (p. 74).

Third period of erosion.—After the deposition of these beds another pause in sedimentation took place. The streams were rejuvenated and once more began to cut. The evidence of this change on the lower Gila River is found in the well-defined terrace that borders the stream on both sides at most places along its course. The amount of erosion was less than that which occurred during the earlier periods. It may be measured by the height of the top of the terrace above the stream plus the thickness of flood-plain deposits laid down since the cutting of the terrace. The maximum thickness of the flood-plain deposits is not known, and the altitude of the terrace has not been measured. From estimates of the two it is believed that their sum probably does not exceed 200 feet anywhere on the lower Gila. The cause of the rejuvenation is not yet definitely determined. It is highly probable that renewed crustal disturbance took place at this time. This movement was probably similar to those which preceded it and resulted in uplift of the mountains of the region. It appears to have been one of the principal causes if not the major cause of stream rejuvenation, although other processes may also have had a notable influence.

Deposition of the flood plain.—Below the terrace formed during the period of erosion just described is a flood plain composed of silt and fine sand, with subordinate amounts of gravel in places, brought by the tributaries from the near-by mountains. The thickness of the flood-plain deposits is not known. Most of the wells sunk in them are shallow, and few logs have been kept. The presence of these deposits shows that there was renewed deposition after the cutting of the principal set of terraces.

Channel in the flood plain.—Gila River when first seen by white men presented a very different aspect from that of to-day. (See pp. 64–67.) It had a well-defined channel with hard banks, on which cottonwoods and other green-leaved plants were growing. The current was swift and deep enough even in comparatively dry portions of the year to make fording difficult, except at a few places, and to float a flat boat of some size. Fish were plentiful enough to be depended on as food throughout the year by a considerable number of Indians. Strangest of all to one who knows the silt-laden waters of the present stream, the water of Gila River is reported to have been clear and sea-green.

It is evident that in the lower portion of its course the Gila at that time had become confined to a definite channel cut in the flood-plain deposits last described, and, at least during most of the year, it was not carrying much if any sediment. The change that brought this about may have been climatic, or it may have been a slight renewal of uplift. Whatever it was, the erosion did not continue for a long time. There is no evidence that a very deep channel was cut, or that any great amount of the soft and recently deposited material of the flood plain was removed.

Present deposition.—At the present time Gila River in the lower portions of its course is depositing rather than eroding. The definite channel described by the pioneer visitors to the region has disappeared. Instead there are shifting channels with crumbling banks of barren silt forming linked patterns on the flood plain, which change with every flood.

The reasons for this change may be in part climatic. It is possible that less rain falls now in an average year than it did when the Jesuit fathers first visited the region. But this is certainly not the only reason. Much of the change has occurred during the period for which rainfall records have been kept. Gila River had a definite channel with hard, verdure-covered banks in 1889 (p. 67), but the rainfall records at Yuma show that no noticeable decrease in the rainfall at that place has occurred since 1869. Long precipitation records are also available for Phoenix, Buckeye, and other places in the region, and these likewise do not show any noticeable decrease in the precipitation. One of the causes, and perhaps the principal cause, of the change has been the interference of man with the work of nature. One phase of this interference has already been mentioned. (See p. 67.) The changes wrought by man in the mountains in the upper part of the drainage area of Gila River have probably been more effective in changing the character of the lower portion of the river than those in the lower Gila region itself. The natural run-off in the mountain areas has been interfered with by dams and other structures. Much of the water that would otherwise flow into the Colorado has been taken out for irrigation at different places in the upper and middle reaches of the Gila. The removal of forest cover in places has left the surface unprotected from the attack of the forces of erosion. As is forcibly pointed out by Olmstead,[59] the amount of erosion in the mountains is now considerable. Such occurrences tend to cause the streams to become overloaded with sediment in the mountains and consequently to deposit part of their load in the lower courses. However, the change in Gila River began before most of the work referred to by Olmstead was done. Therefore, while this work has probably helped to bring about the present conditions on the Gila, it is neither the primary nor the principal cause of the alteration which has taken place. This cause must be sought in some change in climatic conditions, or in earth movements small in amount but sufficient to disturb the equilibrium of the stream, or in a combination of these two. Much more careful and detailed work must be done in this region before definite conclusions can be reached in regard to the last recorded change in the character of the lower Gila River. As this change has so direct and important a bearing on the present and future development of agriculture in the region, it is highly desirable that it be clearly understood and correctly interpreted.

HISTORY OF IRRIGATION ALONG GILA RIVER WEST OF GILA RIVER RESERVATION.[60]

By C. R. Olberg.

Early in the work of the Gila surveys of the United States Indian Service, it was recognized that the diversions west of the Gila River Reservation were not of sufficient importance to warrant a detailed survey or an exhaustive investigation. Accordingly, a reconnassance survey was made of that portion of the valley, beginning at the west line of the reservation and extending down the river to the farthest irrigated lands of the Gila Bend district. (See Fig. 15.) All available historical data were collected in connection with the present diversions, but only general information was sought respecting the many abandoned canals.

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[59] Olmstead, F. H., Flood control of the Gila River in Graham County, Ariz.: 65th Cong., 3d sess., S. Doc. 436, 1919.

[60] This account is taken substantially from Appendix A of "Report on the water supply and the estimated cost of the proposed San Carlos irrigation project on the Gila River, Ariz.," submitted by C. R. Olberg, superintendent of irrigation, through W. M. Reed, chief engineer, U. S. Indian Irrigation Service, Los Angeles, Calif., November 1, 1915. Minor modifications have been made here and there to incorporate later information.

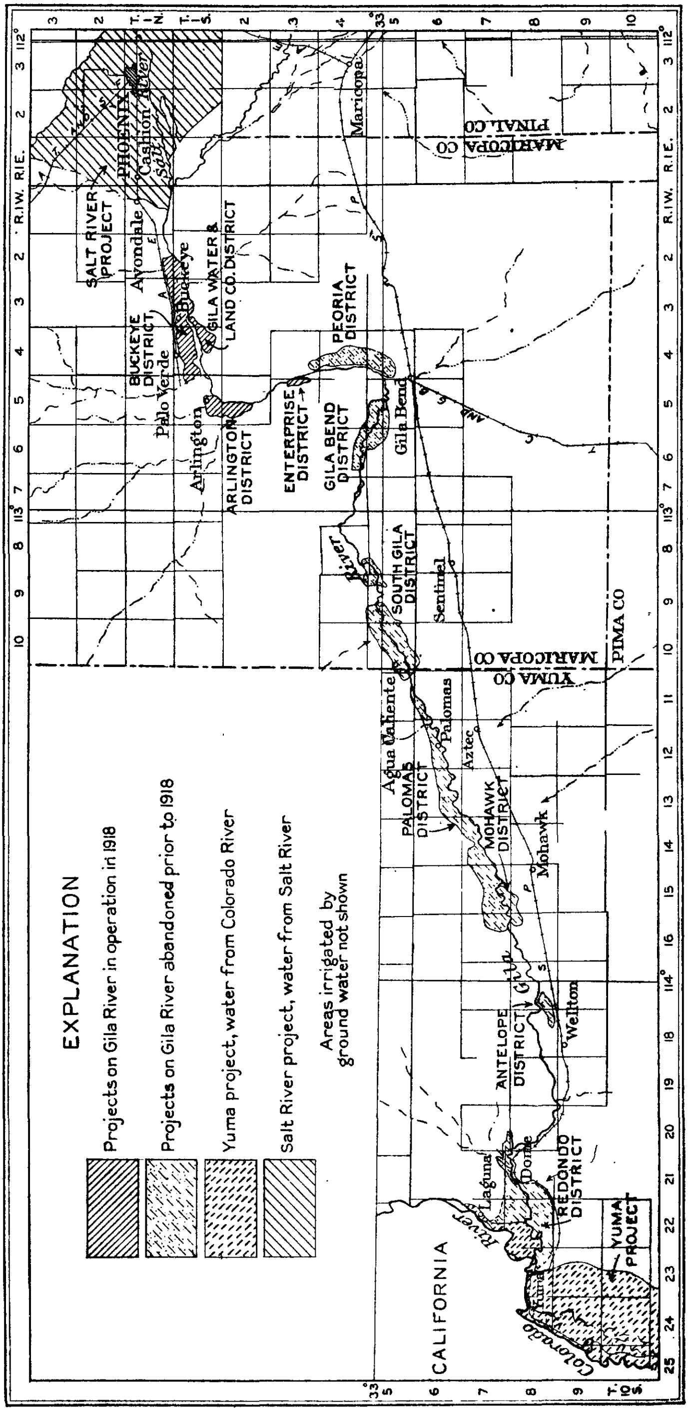

FIGURE 15.—Sketch map of lower Gila River showing past and present irrigated areas of projects utilizing river water.

PREVIOUS IRRIGATION.

The former irrigation by the Indians of this region is mentioned in several of the accounts of early explorations. Emory,[61] for example, states:

> We know that the Maricopas have moved gradually from the Gulf of California to their present position in juxtaposition with the Pimas. They were found as late as 1826 at the mouth of the Gila, and Dr. Anderson, who passed from Sonora to California in 1828, found them, as near as could be reckoned from his notes, about the place we are now camped [Gila Bend].

More or less abundant evidences of old Indian or prehistoric irrigation occur at several places along this portion of the river. The most easily traceable are found just above Gila Bend, in Enterprise Valley, and also just below Gila Bend, near the Painted Rock Mountains.

The earliest irrigation by white settlers in this part of the Gila Valley took place in connection with the establishment of the early overland stage stations. The first stage line was established in 1857 and was operated twice monthly between Fort Yuma and Sacaton, a distance of about 190 miles.[62]

No irrigation of importance, however, took place until the early seventies. Browne, in writing of his travels up the Gila in 1864, gave a very good description of the country but failed to mention any irrigation. Hinton,[63] on the other hand, who wrote on this same territory in 1876, stated that irrigation was being carried on at several of the stage stations and that cultivation was started in the Redondo district, near the junction of Gila and Colorado rivers. He said:

> The owners of the San Ysidro ranch, in this locality, are José M. Redondo and his brother. * * * Mr. Redondo has been trying to irrigate continuously since 1862, but though he spent considerable money he was not successful until this location was selected. The canals on the place are 27 miles long, and work was commenced in 1871, and at least $25,000 was spent before a cent was realized.

The Redondo irrigation district, which later included all the above-mentioned canals, extended 30 miles up the Gila from Yuma. Other comments of Hinton on his trip are as follows:

> Excellent crops of wheat and barley are grown at Mohawk station. * * * A good ranch on the river bottom supplies the station [Antelope Peak] and shows that with industry and water the seeming desert is amazingly fertile. * * *
>
> The first stage station out of Yuma is Gila City. Several ranches are passed, showing that Gila bottom is cultivated.

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[61] Emory, W. H., Notes of a military reconnaissance from Fort Leavenworth, in Missouri, to San Diego, in California: 30th Cong., 1st sess., Ex. Doc. 41, p. 89, 1848.

[62] Browne, J. R., Adventures in the Apache country, p. 292, Harper & Bros., 1869.

[63] Hinton, R. J., Handbook to Arizona, pp. 278–279, 1878.

A pamphlet published in 1892 from data collected in 1889 and prepared by the Citizens Executive Committee of Yuma County contains the following table:

Canals in Yuma County.

Name.	Length (miles).	Capacity (miner's inches).	Estimated cost.	Area reclaimable (acres).
Mohawk	35	11,000	$150,000	40,000
Redondo	5	600	8,000	1,500
Farmers	13	5,000	15,000	10,000
South Gila	22	8,000	45,000	12,000
Purdy	10	9,000	25,000	7,000
Contreras	7	3,000	9,000	2,000
Saunders	10	5,000	25,000	4,000
Araby	8½	3,500	35,000	2,000
Antelope	7	2,000	10,000	2,500
Toltec	3	3,000	15,000	....
	120½	....	....	81,000

The same report contains the following statement in reference to the canals mentioned in it:

In the event of the completion of the above-described canals in accordance with the original plans of the projectors, the total length would reach 241 miles, reclaiming over 267,000 acres of bottom, valley, and mesa land at an estimated cost of $1,318,000.

A summary [64] showing the extent and cost of the new canals farther up the Gila in Maricopa County follows:

Canals in Maricopa County, 1901.

Name.	Year first used.	Length (miles).	Average width (feet).	Capacity (second feet).	Estimated cost.
Buckeye	1886	28	16	300	$80,000
Enterprise	1886	12	14	100	10,000
East Riverside (Gila Bend)	1893	20	17	675	125,000
Lower Gila Bend (Riverside)	1885	20	15	250	25,000
Aztec	1885	14	12	250	6,000
Palomas	1887	22	15	60	10,000
Arlington	1901	15	....	....	12,000

For the last two years no water has been diverted into the Aztec canal. A conflict between the users in times of scarcity and a lack of system in the division of the water has resulted in expensive litigation. The canal was abandoned, with the result that the alfalfa fields and orchards have perished. The ranches still keep up their assessment work on each canal in order to maintain its franchise. The Lower Gila Bend canal has not been in operation for several years but is being repaired, and irrigation will be resumed.

Of the canals in the Yuma County group, none are at present in use. [The Antelope canal, rehabilitated to a certain extent by the

[64] Report of the governor of Arizona to the Secretary of the Interior, 1901, p. 42.

Antelope Valley Canal Co. before 1915 (see pp. 105–106), was abandoned when seen in 1917.—C. P. R.]

In the Maricopa County group three canals—the Enterprise, the Arlington, and the Buckeye—are at present in operation. [The Gila Water & Land Co.'s canal was put into operation in 1917, and the Gillespie dam was constructed in 1921.—C. P. R.] The other irrigation projects were constructed with little regard to the water supply, and consequently, after brief attempts at cultivation, they were gradually abandoned. A few have from time to time been put in shape and used, only to be soon again abandoned. Others, like the Mohawk or the Palomas, have had comparatively longer periods of usefulness or prosperity. The Mohawk and Palomas districts, situated on opposite sides of the river, enjoyed for four or five years prior to 1890 a rapid agricultural development, and it is reported that from 1,000 to 3,000 acres in these districts was under cultivation. Davis[65] in 1897 estimated from the best data then available that 1,000 acres was under cultivation along the Gila in Yuma County, which would include the Mohawk and Antelope districts. Irrigation in this region is referred to in several of the reports of the Territorial governors. In the report for 1901[66] the following statements are made:

> The largest canal taken from the Gila River is the Mohawk, which heads above the town of the same name. It is 23 miles long, cost probably $150,000, and covers between 25,000 and 30,000 acres. For several years previous to 1890 the canal was neglected, and many of the farmers left the valley. In that year it was again put into condition, and the water supply having been plentiful a small acreage was brought under cultivation.
>
> There are large tracts of good land along the banks of the Gila River, aggregating 30,000 acres or more, lying in the Mohawk Valley, but the water supply can not be depended upon, and the rainfall is slight. The history of irrigation in the Gila Valley is full of expensive litigation, due to the continual contests in the courts over prior water rights. A number of canals on the Gila near the headwaters are being enlarged, and new ones are taken out from time to time. As a consequence, the periods of scarcity or of no water in the canals below are more and more prolonged each year.

Intermittent irrigation continued, however, until the disastrous flood of 1905, when the canal headings were so badly washed out that these old districts were abandoned. In 1914 a little overflow irrigation was going on in the Palomas Valley, and about 500 acres in the Mohawk Valley was being rather unsuccessfully irrigated by means of pumps. The canals below the Palomas and Mohawk canals, such as the Redondo and the Araby, evidently went out of commission some time prior to the flood of 1905—that is, before the canals higher up

[65] Davis, A. P., Irrigation near Phoenix, Ariz.: U. S. Geol Survey Water-Supply Paper 2, p. 94, 1897.

[66] Report of the governor of Arizona to the Secretary of the Interior, 1901, p. 50.

on the Gila or in the Mohawk Valley were abandoned. At Sentinel, above the Antelope Valley, are the diversion site and headworks of the South Gila (Sentinel) canal, now owned by the Southwestern Fruit & Irrigation Co. This canal was constructed in the late eighties and is 22 miles long. Davis [67] gives a brief description of it and a section of a proposed dam across Gila River. Several unsuccessful attempts have been made to construct a permanent diversion dam at the canal heading. No land was ever cultivated under this project, and it was only during times of flood that water flowed in the canal. Construction work has been carried on to provide the canal with suitable headworks, and the company intended to construct a high dam at this point for storage. [This irrigation project is now abandoned.—C. P. R.]

Above the Sentinel or South Gila project and about 20 miles northwest of Gila Bend is the old Dendora canal. This canal was excavated in 1882 for a distance of about 7 miles, and a 4-foot rock-fill dam was constructed across the Gila. During the first flood after its construction the dam went out, and no land under the canal was ever cultivated. It was proposed to irrigate about 5,000 acres in the Oatman Flat district by this project. The construction of a storage dam also was contemplated. Efforts to rehabilitate this canal have been made, but without success.

In the vicinity of Gila Bend and just above it there are several large abandoned canals and irrigation projects.

The Citrus canal, which heads within the Gila River Indian Reservation, was built in the early eighties. Like many others, it had but a short life. In a report of Superintendent of Irrigation J. W. Martin, of this Service, dated August 4, 1909, the following reference is made to this canal: "It has been out of use for some years, and the headgates are filled with mud."

The next large abandoned canal above the Citrus is the Lower Gila Bend, constructed in 1885.[68] In 1901 this canal had been out of use for several years, but subsequently a new heading was constructed and the canal was successfully operated until 1908, when its heading was again destroyed by a flood. Since 1908 this canal has been continuously out of service.

The largest of these ill-advised and now abandoned projects is variously known as the East Riverside, Gila Bend, or Peoria canal. The main canal for this project heads at what is known as Woolseys Butte, the present site of the Enterprise canal heading. This project was started in 1891, and it is reported that $1,000,000 was

[67] Davis, A. P., Irrigation near Phoenix, Ariz.: U. S. Geol. Survey Water-Supply Paper 2, pp. 76–77, 1897.

[68] Report of the governor of Arizona to the Secretary of the Interior, 1901, p. 42.

spent in its construction. A brief description of this project is given by Davis.[69]

After a large portion of the dam was washed out for a second time in 1895, and still more of it in 1905, no water is known to have flowed through this canal except in times of extremely high flow, and no successful irrigation has been carried on under this canal since the flood of 1905. During the few years that this ditch was in commission, it is reported, about 1,000 acres was put under cultivation. On a large portion of this land but one crop (grain) was ever grown, but other smaller patches of land were cultivated for several years. Most of the land formerly irrigated under this ditch has since been washed away.

This company, as well as several others having projects below the Gila River Reservation, have made filings and have expressed their intention to construct large dams and store the waters of the Gila, but nothing has been done toward the fulfillment of these proposals.

Other canals of lesser proportions than those discussed above have been constructed on the lower Gila, but all of them, like the larger canals, have been out of commission for at least 10 years. The detailed history of these abandoned canals is not readily available. Little has been written regarding these old ditches, and local information is very meager. However, it is generally known that they were for the most part ill advised and that they were never put to beneficial use. Certain work, such as the occasional cleaning out of a portion of the canal or headworks, has been done on a few of these canals, but this work has been desultory and has been productive of no beneficial results. On the lower Gila there was and to a certain extent there still is a custom among persons owning or interested in a canal to do a certain amount of assessment work on the canal each year and thus hold the " franchise." Owing to the very scanty supply of water available during the dry season (see pp. 106–108), it is quite obvious that irrigation in this section by means of river flood water alone is hardly feasible. The shortage of water undoubtedly accounts for the abandonment and present general disuse of these numerous and expensive canals.

PRESENT IRRIGATION.

Buckeye canal.—At the west line of the Gila River Reservation the Gila is joined by its principal tributary, the Salt. About 3 miles farther west, down the river, the Gila receives the discharge of a smaller tributary, the Agua Fria. This stream, especially near its mouth, is dry the greater part of the year. Just below the mouth of the Agua Fria is the rock and brush diversion dam of the Buckeye

[69] Davis, A. P., op. cit., p. 47.

canal, on the north bank of the Gila in sec. 34, T. 1 N., R. 1. W., Gila and Salt River base and meridian.

This canal is 24 miles long and is intended to irrigate about 20,000 acres of land north of the river. The appropriation of water for this ditch is based on a filing made in 1885. Construction was started the same year, and the first irrigation was done about 1888. Each year thereafter the amount of land irrigated was increased, and at the time of this survey 14,540 acres was under cultivation. [More than 19,000 acres is reported to have been under irrigation in 1917.—C. P. R.] This canal is owned by a mutual company, composed of the farmers under the canal. Not all the water users, however, are stockholders, as some of these farmers buy outright the water they need for their lands. In May, 1914, the stockholders of this company authorized a bond issue of $30,000 to be used for draining, washing, and reclaiming 3,500 acres of alkali lands.

Of the total land under cultivation, about 90 per cent is in alfalfa, and the remainder in grain, sorghum, and pasture. Cattle grazing and feeding is an important industry in this section. At a point half a mile below its heading there is a bridge across the Buckeye canal. The canal at this point is 15 feet wide on the bottom and 25 feet wide on top and has a water depth of 3½ feet. On May 29, 1914, this canal was flowing, by actual measurement, 109 second-feet. This measurement was taken during the low-water season and represents, at least for that year, the minimum flow. The maximum capacity of the canal is 200 second-feet.

Corbett canal.—About 3 miles below the Buckeye canal, but above the Arlington, is a small pumping plant known as the Corbett. This plant pumps directly from the river and at the time of this survey was irrigating about 120 acres, to which the water was conducted through a small ditch. The plant consists of a gas engine and a 14-inch centrifugal pump, which was put in operation about 1910.

Arlington canal.—The next canal diversion down the river from the Buckeye is the Arlington, which is on the same side (north) of Gila River as the Buckeye but about 13 miles farther down. The Buckeye and Arlington districts are in the same general valley, which is practically a westward extension of the larger Salt River valley. Hassayampa River, which joins the Gila about 7½ miles below the Arlington diversion, is generally considered to be the dividing line between these two districts, although the Buckeye water is siphoned across the Hassayampa and irrigates a small area on its west bank.

The Arlington canal is owned by the Arlington Canal Co., a cooperative organization composed of farmers who own the land under the canal. The canal was built in 1889–90 and the notice of water appropriation was filed in July, 1907. This canal, at the time of the survey, was irrigating about 4,800 acres and was intended to irrigate several hundred acres more. In 1913–14 a permanent low-water concrete diversion dam was constructed and considerable work was done on this project. The irrigated land is practically all planted to alfalfa, and cattle feeding is an important industry.

The main canal is about 15 miles long and at a point above the uppermost of its laterals had, at the time of this survey, a bottom width of 10 feet, a top width of 17 feet, and a water depth of 3 feet. A flow of 53 second-feet was measured with a current meter on June 1, 1914. This quantity, according to several farmers in the district, represented practically the minimum flow during the year. The canal has a maximum capacity of about 75 second-feet. The siphon built to carry this canal under Hassayampa River is 300 feet long and has a rectangular section of 4 by 6 feet in the clear.

Joshlin ditch.—The ditch owned by Mr. Joshlin is on the opposite or south side of the river from the Buckeye district and heads half a mile below the point of diversion of the Arlington canal. It was constructed in 1911, and at the time of this survey the land cultivated under it amounted to about 225 acres. This ditch is of small section: the bottom width is 2 or 3 feet, the top width 5 feet, and the depth of water 1 foot. By meter measurement made on June 1, 1914, a flow of only 1.4 second-feet was recorded. Owing to the nearness of this diversion to the intake of the Arlington canal, very little water is available during the dry season. [The Gila Land & Water Co. (see p. 154) started an irrigation project here in 1917.—C. P. R.]

James Bent canal.—The water for the James Bent canal [now abandoned.—C. P. R.] is diverted from the east bank of the Gila at a point 13 miles below the Arlington heading. It served to irrigate about 300 acres near Gila Bend, and the first appropriation was made in 1910. At the time of the survey this ditch was found in a very bad state of repair, and the land covered by it appeared to be reverting rapidly to a state of disuse or abandonment.

The cross section of the ditch in its present condition has a bottom width of 4 feet, a top width of 6 feet, and a possible water depth of 2 feet. On June 1, 1914, the canal was flowing 4½ second-feet, according to meter measurements. Originally the capacity of the ditch was probably 10 or 15 second-feet, although its grade and the consequent velocity are very small. The water supply for this canal appears to be inadequate, particularly as the proprietors of the Enterprise canal, who divert water 2 miles below, claim prior right.

Enterprise canal.—A low mountain ridge entering the valley on the north side of the river terminates the Arlington and Buckeye region. This ridge ends abruptly, terminating at the river's edge in a steep bluff that has been called Woolseys Butte. [Not to be confused with Woolsey Peak, which is about 8 miles southwest.—C. P. R.] The close proximity of the Estrella Mountains [Buckeye Hills on maps in this report], on the east side of the river, to Woolseys Butte forms a relatively narrow channel through which flows the river. This short narrow canyon makes a very favorable diversion site, and in 1915 it was used for that purpose by the Enterprise Canal Co. At an earlier time it was used as the dam site for the Upper Gila Bend project, referred to under the heading "Previous irrigation" (pp. 100–101). The diversion for the Enterprise canal is in sec. 28, T. 2 S., R. 5 W. The greater portion of this canal was constructed during 1885. The original heading was 1½ miles below the present site, and the diversion works used in 1915 were constructed in 1901–2. The canal has a bottom width of 4 feet, a top width of 10½ feet, and a water depth of 2½ feet.

The Enterprise canal was owned by a corporation known as the Enterprise Canal Co. The stockholders were the owners of the land irrigated, and most of them were engaged in cattle raising. At the time of this survey about 700 acres was being irrigated by this canal, and 2,000 acres additional was susceptible of irrigation. During the years of heavy flow in the river other land was cultivated. Nearly all the irrigated land was planted to alfalfa, but some sorghum and grain were also grown.

To the favorable location of the dam apparently is due the excellent supply of return water which was provided. Meter measurement of the flow in this canal, made on May 30, 1914, showed that 25 second-feet was being diverted. This quantity was somewhat in excess of the minimum flow, according to Mr. Montgomery, president of the Enterprise Canal Co., who stated that during the dry season probably not more than 15 second-feet could be depended upon.

Gillespie dam.[70]—The most recent irrigation development of importance in this region is the construction of the Gillespie dam across Gila River, a view of which is shown in Plate XIII. This dam was completed early in 1921. It is on the site of the Enterprise dam and of the old Peoria dam of the Upper Gila Bend project, in sec. 28, T. 2 S., R. 5 W. The present structure is a concrete diversion dam 1,800 feet long, of the multiple-arch type. It is proposed to divert water from Gila River into a canal about 40 miles long recently completed, which is to furnish water for irrigating land below the dam. Most of this land is in the vicinity of Gila Bend. It is stated by

[70] The description of the Gillespie dam is written by C. P. Ross from data derived from the State Land Commission of Arizona in a letter dated Dec. 20, 1921, from a pamphlet issued by the Gila Water Co., owner, and from letters from E. C. La Rue, hydraulic engineer, U. S. Geol. Survey, Apr. 26 and May 15, 1923.

GILLESPIE DAM.

A. A TYPICAL GOOD PLAINS ROAD.

The old road between Agua Caliente and Arlington, in the big wash in the plain west of Woolsey Tank, on the west side of the Gila Bend Mountains. Shows also the terraces bordering the wash.

B. ROAD ACROSS HASSAYAMPA PLAIN.

Showing ruts in silt plain after prolonged drought.

the Gila Water Co., which owns the project, that 100,000 acres of desert land can be brought under cultivation by this means. Early in 1923 a tract of 10,000 acres was being cleared and prepared for cultivation.

Papago canal.—The next canal taking water from the Gila below the Enterprise diversion is the Papago canal, on the Gila Bend Indian Reservation, 19 miles below. The Papago canal was constructed in 1891 by L. S. Anderson. For several years prior to that date the land now under it was irrigated from the Lower Gila Bend (Riverside) canal, which was constructed in 1885 and was abandoned sometime prior to 1900.

A five-sixths interest in the Papago canal was held by Mr. Anderson. The Gila Bend Indians hold the remaining one-sixth interest, and they have irrigated about 82 acres by means of the water thus obtained.

The Papago canal is 8 feet wide on the bottom and 15 feet wide on top; it has a water depth of about 2 feet and a maximum capacity of about 30 second-feet. No meter measurements were made at the time of this survey, because only a small quantity of water was then flowing into the canal.

Several investigations and surveys have been made by the Indian Office with a view of providing additional water for this reservation, but no money has yet been appropriated for the work. The Gila Land & Cattle Co., which owns and cultivates land to the west of the Gila River Reservation, has acquired Mr. Anderson's interest in the canal and at the time of this survey was irrigating 730 acres.

Antelope Valley canal.—Between the Anderson heading at Gila Bend and the mouth of the Gila at Yuma the Antelope Valley canal [not in use in 1918] is the only diversion of importance, but there is at least one of the older or abandoned canals which takes water from the river during extreme high water and is supplemented by pumps during the remainder of the irrigating season. The Antelope Valley canal heads in the SW. ¼ sec. 21, T. 8 S., R. 17 W. This was also the point of diversion of the old Antelope canal which was mentioned in the report of the Citizens' Executive Committee of Yuma County for 1889, previously cited, and it therefore appears that the present project is a rehabilitation of the old canal. The Antelope Valley Canal Co. bases its water rights upon a filing made May 1, 1908, on 5,000 inches of water. Filings for a right of way and reservoir site were made and approved at the Phoenix land office April 15, 1909. The Antelope Valley Canal Co. has applied to the United States Land Office asking that stock in this company be accepted as final proof in desert entries under the canal.

A report favorable to the project was submitted in 1914 by R. G. Mead, field engineer of the Land Office, and a further supplemental report, also favorable, was submitted in April, 1915. From a copy of these two reports kindly furnished by Mr. Mead the following information has been obtained:

The project is intended to irrigate 10,000 acres during five months of the year. Delivery of water began in 1909. The area ready to receive water on November 1, 1914, was 977 acres, and since that date 125 acres additional has been put under cultivation.

The company is a mutual organization composed of landowners under the canal. Until 1913, when a good heading was put in, the Antelope canal was supplied with water by means of a pump, the water being drawn directly from the river. This pumping plant is no longer in use. A number of the farmers under this canal are installing auxiliary pumping plants to supplement the flood-water supply.

AMOUNT OF WATER AVAILABLE FOR IRRIGATION.

With the exception of the gage recently established near Florence in connection with this investigation, the first gaging station on the Gila above the diversion west of the Gila River Reservation is at Kelvin, 90 miles upstream from the west line of the reservation. Between Kelvin and the Buckeye district many diversions take water from the Gila, and at least two tributaries contribute to its flow. The records of this station are therefore of no great value, especially during periods of low water, in determining the available supply below the reservation.

On the river just opposite Sentinel a gaging station has been in operation for several years. This station is approximately in the center of the district under consideration, being just above the Palomas and Mohawk valleys and just below the Gila Bend territory.

Discharge of Gila River at Sentinel, in acre-feet.[a]

	1913	1914
January	(b)	39,600
February	(b)	146,000
March	(b)	22,800
April	(b)	2,810
May	(b)	30
June	(b)	0
July	120	12,700
August	2,350	42,700
September	0	29,900
October	0	45,500
November	4,710	54,400
December	17,000	[c] 39,200
	24,470	435,640

[a] Discharge June-September, 1913, estimated by C. C. Jacob, district engineer, U. S. Geol. Survey, Phoenix, Ariz.; not published. Discharge October, 1913, to August, 1914, from U. S. Geol. Survey Water-Supply Paper 389, p. 162, 1917. Discharge October-December, 1914, from U. S. Geol. Survey Water-Supply Paper 409, p. 161, 1918.
[b] No record available.
[c] December 1-20 only.

For three years a gaging station was maintained on the Gila at Gila City, 14 miles above Yuma, and inasmuch as this station is at what might be called the end of the district under consideration, some idea of the river flow in this district may be had from these observations. They are given below.

Discharge of Gila River at Gila City (Dome), in acre-feet.

	1904 [a]	1905 [b]	1906 [c]
January	0	189,200	136,000
February	0	680,300	168,000
March	0	1,020,000	576,000
April	0	768,200	422,000
May	0	299,700	122,000
June	0	43,140	4,580
July	5,792	4,341	0
August	139,600	0	25,100
September	41,700	2,957	4,280
October	32,800	11,010	0
November	6,486	271,200	0
December	0	375,100	332,000
	226,400	3,665,200	1,790,000

[a] U. S. Geol. Survey Water-Supply Paper 133, p. 206, 1905.
[b] U. S. Geol. Survey Water-Supply Paper 175, p. 166, 1906.
[c] U. S. Geol. Survey Water-Supply Paper 211, p. 125, 1908.

At Yuma the Reclamation Service has made observations of the flow of the Gila since 1903.

Discharge of Gila River at Yuma, in acre-feet.[a]

	1903	1907	1908	1909	1910	1911	1912
January	0	63,500	0	71,900	213,000	60,000	0
February	0	59,400	391,500	175,100	9,200	46,000	0
March	0	289,600	162,600	147,400	500	84,000	121,000
April	30,228	71,500	0	96,000	1,500	0	70,000
May	799	0	0	14,200	0	0	600
June	0	0	0	0	0	0	0
July	0	0	0	21,000	0	34,700	12,500
August	9,200	0	94,700	54,500	0	0	39,700
September	7,319	400	44,200	81,000	0	0	0
October	13,650	93,200	0	0	0	30,200	1,400
November	0	58,000	0	0	0	17,300	0
December	0	13,600	404,000	0	0	0	0
	61,196	648,600	1,097,000	661,200	224,200	266,200	245,200

[a] Discharge for 1903 from U. S. Geol. Survey Water-Supply Paper 100, p. 27, 1904. Discharge for 1907–1912 furnished by U. S. Reclamation Service.

It will be seen from these tables that the annual run-off at these stations ranges from 24,470 acre-feet in 1913 to 3,665,200 acre-feet in 1905. It is also apparent that the river is frequently dry during the time of maximum irrigation drought, and that the dry season is often of considerable duration. It is therefore very questionable whether flood-water irrigation can be successfully practiced on the lower Gila.

The few measurements available include the two highest flood years of recent times, namely, 1905 and 1914. If only these measurements were considered a high average annual run-off would be found, and any conclusions based on these data might therefore be misleading.

Comparisons of the run-off of Gila River at Yuma and Sentinel with the run-off measured farther upstream at Kelvin and San Carlos and also on Salt River indicate that during a period covering seven years prior to 1905 this portion of the valley experienced a very serious drought.

The success of irrigation immediately below the Gila River Indian Reservation and as far down the river as Gila Bend has been due to the return or seepage flow at several points in the river bottom. This return flow is used almost entirely by the most successful of these canals, especially during dry years and the dry season. No measurements of the flow in these different districts covering a considerable period of time have been made, so that the amount of this return flow is not definitely known. Measurements made about June 1, 1914, on the canals above Gila Bend (see p. 103), record a combined flow of 193 second-feet. From conversation with farmers living in this district it was ascertained that these measurements were made at a time of low water supply, so that they represent the minimum flow during the year.

In considering the return flow on the lower Gila, it is important to examine the effects of the extensive irrigation that has taken place in the Salt River valley under the Roosevelt project. Mr. H. L. Hancock, water commissioner of the Buckeye district, states that the return flow at the head of the Buckeye canal has increased at least 100 per cent since the Roosevelt project has been in operation. An increased return flow has also been observed at the headings of other canals as far west as Gila Bend. Inasmuch as practically the entire return flow is diverted from the river at each of the successive canal intakes, it can not be expected that the return flow available to the lower canals would be in proportion to that available to those above. Very little if any return surface flow is available from the river below Gila Bend.

IRRIGATION WITH GROUND WATER IN COLORADO RIVER INDIAN RESERVATION.

By A. L. Harris.

[Note.—In 1915 and 1916 an investigation and test of ground water for irrigation on the Colorado River Indian Reservation was made for the Arizona State land commissioner by A. L. Harris, consulting engineer. The report made by Mr. Harris was kindly furnished by Mr. W. A. Moeur, State land commissioner, and the following statements are abstracted from it.—C. P. R.]

GENERAL FEATURES OF THE AREA.

The arable lands in the Colorado River Indian Reservation belong principally to the so-called flood-plain or bottom lands, composed of the alluvial deposits laid down in the past by Colorado River. These lands amount to about 86,500 acres in the gross, measured south of the north line of T. 7 N., but the area capable of development is considerably less on account of sloughs, alkali spots, sand hills, and sections subject to overflow. There is also an area of 3,000 or 4,000 acres in and about the Parker town site, now in the desert condition, which is arable but for which it will be more expensive to obtain irrigation water.

The bottom lands in general slope gently and evenly toward the river, though they appear nearly flat to the eye. Much of the area is covered with an uneven growth of brush and some moderate-sized trees. Mesquite, cat claw, and small brush prevail on the higher ground; willow, water rushes, arrow weed, and cottonwood grow in the vicinity of water.

Little or no use has ever been made of these lands except to support some range cattle and for cutting a small amount of firewood by the Indians, who live almost entirely at a considerable distance to the north. The lands are similar in character to those of the Palo Verde Valley, across the river in California, where extensive agricultural development has been accomplished both by diverting water from the river and by pumping from wells.

The bottom lands lie somewhat over 300 feet above sea level. The arable mesa lands near Parker are about 75 feet above river level, but the bottom lands are nowhere very much above river level, and during floods considerable areas are overflowed by backwater from the sloughs that communicate with the river. Each overflow deposits a bed of fine red silt but does not generally injure the brush and trees or erode the ground.

FIELD WORK.

The work was carried on with a view not only to collecting data by tests of a scientific nature but also to making demonstrations under practical conditions and on a commercial scale. Locations for test wells were selected at points several miles apart and on areas differing in situation, in order to get representative information (Fig. 16). The wells were made 12 and 16 inches in diameter, which has been considered proper for many wells in this part of the country supplying water for irrigation, and from 75 to 138 feet in depth. Each well had a permanent sheet-metal casing fit for use in an actual development of the land around it. Conditions of pumping development in the similar areas across the river in California were observed, and a considerable number of small borings or drive-point tests were made to determine the depth to ground-water level and quality of water. As shown by these drive-point tests the depth to the water table is generally not less than 8 feet or more than 20 feet. Tests of the quality of water for irrigation were made in nine separate localities, at two-thirds of which the water was found to be fit for irrigation and at one-third not fit unless used in com-

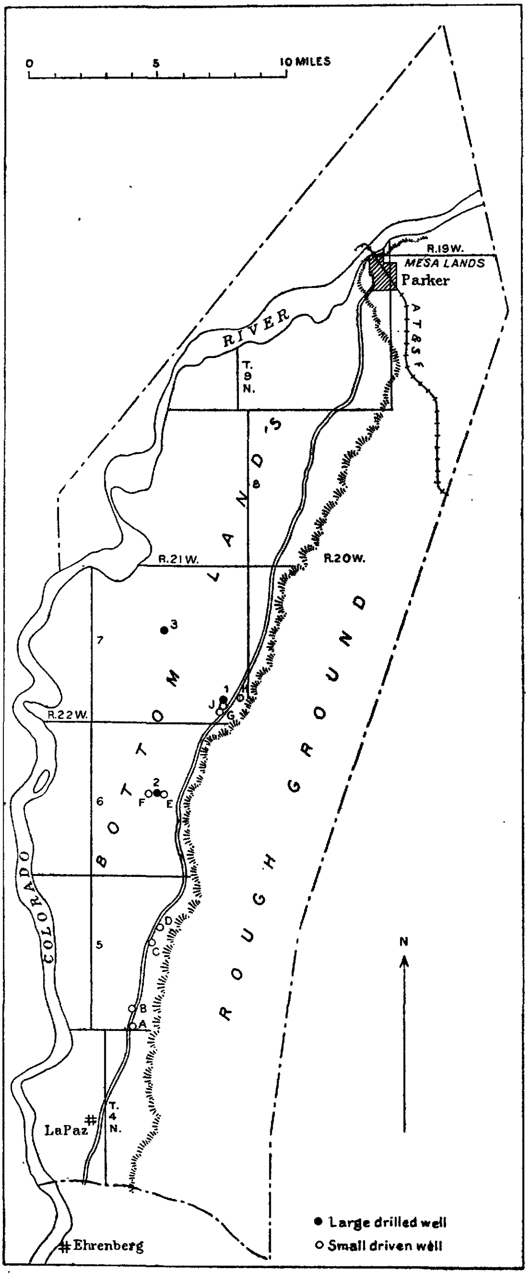

FIGURE 16.—Sketch map of Colorado Indian Reservation showing location of test wells. (From map by Indian Service.)

bination with water of better quality. Where bad water was found, good water usually occurs at other points within a reasonable distance.

WATER-BEARING DEPOSITS AND SOURCE OF WATER.

The logs of the wells show fine silts near the surface, then sands of coarseness increasing with depth, and finally gravels and cobblestones at a depth of about 100 feet. A few clay strata occur below the level of ground water, but generally the materials were found clean and unmixed with fine silt or sediments. A natural separation or grading of the materials by the river's action appears to have taken place. The coarser and heavier parts occur at the lower depths, because the more finely divided matter has been carried in suspension by eddies and currents after the agitation has become too weak to lift or move the material of larger sizes. This natural process has resulted in a good condition of porosity for a given size of grains in the strata through which ground water percolates.

The level of ground water appears to be close to the average river level. This ground water appears to underlie the entire area of bottom lands. It is probably continuous with the waters flowing in the river channel through the interstices between the grains of the sand and gravel. The river is thus the main source of the ground waters. The running waters of the main channel keep the bottom constantly scoured and open to percolation in the sands and gravels, and during the annual flood season the materials under and near the river bottom are powerfully shifted and redisposed, thus greatly increasing the absorption of water into the undisturbed beds beneath the lands on either side. Wherever there is a current sufficient to move coarse materials the fine red silt so characteristic of the Colorado is kept constantly in suspension. It is reasonable to conclude that at some time in the past any given place in the flood plain has been occupied by the river channel and that in the play of forces that constantly bend and crowd the great stream, now one way and then another, first the boulders grinding deep below have been left at rest, then the gravels above them, then the sands, and last the fine silts which have been deposited near the top in comparatively quiet water.

The materials passed through by the wells below the soil consist mostly of siliceous sand and hard rock fragments, well smoothed and rounded by erosion. The soil is from 3 to 10 feet in depth. Alkali in the soil and in the ground water occurs in some parts of the area, but not to a serious extent. The conditions in this respect average about the same as are found in the Yuma, Palo Verde, and Salt River valleys.

CONSTRUCTION OF TEST WELLS.

In putting down the test wells a sheet-metal casing was sunk by weights and the pressure of hydraulic jacks at the same time that the material was removed from inside it by means of a sand bailer. As no other type of well-drilling equipment was readily obtainable this was the only method tried. It is likely that the so-called rotary method of drilling by the use of water under pressure would work well to a depth of 100 feet, or until boulders were struck.

In wells Nos. 2 and 3 the casing was 16 inches in diameter, galvanized and perforated before sinking. The perforations, which averaged about 113 to the running foot, were 1½-inch slits running lengthwise of the casing and opened about one thirty-second of an inch. This casing was designed for taking in the water from the sands at comparatively shallow depths. On account of the lightness of metal necessary to permit such narrow perforations the strain of sinking and of outside pressure will not admit of forcing it to great depths.

In well No. 1 an attempt was made to penetrate to a depth of 200 feet by using 12-inch California "stovepipe" casing of much heavier weight. On account of limitations in the method, accidents, and lack of sufficient funds, a depth of only 134 feet was reached; nevertheless, there is no reasonable doubt that under commercial conditions the desirable water-bearing strata represented by the coarse gravel formations that were found at the bottom of this well and presumably extend to greater depths can be reached by wells at reasonable cost.

The experience gained on this work indicates that good irrigating streams can be obtained from the sands without penetrating below 100 feet, but that the yield could be much increased by sinking deeper.

WATER FOR THE MESA GROUND.

A supply of water for the mesa land lying within and near the town site of Parker could probably best be obtained by pumping at a central plant at the river and near the railroad. This land lies about 75 feet above the river. The soil is lighter and more sandy than that of the bottom lands and would be benefited by the silt carried in river water. Several wells have been sunk on this high ground in which good water-bearing gravels are struck, but the considerable depth required makes their original cost high and largely increases the practical difficulties and cost of pumping from them. In pumping water from the river the effect of drawdown would be eliminated, and the economies of a concentrated plant working on a large scale would be considerable. The need of water in the town of Parker for irrigating lawns, trees, gardens, etc., would seem to justify the cost of delivering it for those purposes. The ground around the town should be suitable for growing citrus fruits and other crops and could be irrigated by pumped water at a cost well within the limits considered practicable in other parts of the Southwest.

SUMMARY OF CONCLUSIONS.

The following general ideas and observations are offered as a result of this examination:

1. In many parts of the bottom lands it is probable that at small expense for embankments and controlling gates enough water for one or two good irrigations can be caught from the overflow and utilized at the time of the annual Colorado River floods in May and June. On numerous areas this overflow occurs as a gently rising backwater laden with rich silt and communicating through the remnants of old river channels to lands safely removed from flood violence. The ancient Indian method of raising quick-growing crops of corn, squashes, and similar crops by utilizing the moisture of the naturally flooded ground, after the manner of the Egyptians, has never been tried in any large or adequate way in this district. The benefit of such an addition to the supply of irrigation water each season would include not only the saving in the expense of pumping but also the continual replenishing of fertile elements in the soil. From the irrigator's standpoint such a combination is almost ideal as providing a solution of the problem of overabundant silts, which is at present serious indeed on projects that obtain all their water by gravity from the Colorado, and at the same time preserving the benefits derived from a suitable proportion of the river water.

2. Tracts where the ground water that can easily be obtained is of only medium quality for irrigation may still be reclaimed by the pumping method if a part of the year's service can be supplied by the overflow or by water pumped from the numerous sloughs in which it stands a part of the time. The sweetening of alkali land can also be effected by washing out and silting it with river water. The location of wells should be selected after testing to avoid bodies of poor water. The testing can be done inexpensively by taking samples with drive point and pump.

3. The roots of some cultivated plants will doubtless extend to the ground water on much of this land. The soil is generally loose, and after the roots of trees and alfalfa have been established by moisture supplied at the surface they will penetrate the 10 or 12 feet necessary to reach the ground water.

4. If the reclamation of this area is started by pump irrigation, the most favorable locations will be chosen first, but as the community fills up levees to protect the tracts now exposed to direct and damaging flood water will be built. The system of pumping for the greater part of the season will also be appropriate on such lands.

5. Experience with gravity systems that take all their water from the river in this vicinity suggests some material advantages in the method of pumping from the ground water; for example, the pumped water contains no seeds of Bermuda grass and other noxious plants, such as are conveyed by the river from other localities; it is fit for domestic and stock consumption, whereas river water is always very turbid; it is always at hand when wanted; and ditch maintenance and seepage losses are reduced to a minimum. Furthermore, when river water is used the disposition and control of the enormous quantities of silt it carries, such as are deposited in the canals and ditches of the Palo Verde Valley and in those of the Indian Service on this reservation, constitute a very difficult problem.

6. Preliminary settlement of the district by pumping irrigators may reasonably be expected to help and not hinder any subsequent movement for large consolidated works, inasmuch as a point of difficulty in many reclamation projects hitherto has been the task of building up a large community of water users who are ready and able to irrigate and cultivate a considerable area. There is a certain flexibility to the individual pumping system which permits a large project to grow in a natural way by the assemblage of small units. With such a community first established on the ground the way is open for a strong association of individuals to further any movement promising general benefits.

7. The "duty of water," or number of acre-feet required per acre each year, will vary according to the kind of crops cultivated, the number of crops per year, and the intelligence of the irrigator. It should probably run 4 or 4½ acre-feet at the place of consumption. It should be remembered that with an individual pump for each ranch no allowance need be made for seepage in long lines of main canals and laterals. Such seepage in a distributing system would probably amount to 25 per cent of the water taken in at the headworks.

RESULTS OF TESTS.

WELL LOGS AND NOTES.

Log of test well No. 1, sec. 36, T. 7 N., R. 21 W.

[Begun September 6, 1915; drilling stopped January 30, 1916. Twelve-inch stovepipe casing; perforated from 100 to 125 feet depth with 8 by ⅜-inch slits, four on a circumference and 8 inches apart.]

	Thickness.	Depth.
	Feet.	*Feet.*
Loam and sand	12	12
Sand (water surface)	4	16
Gravel	4	20
Gravelly sand	3	23
Coarse sand and gravel	5	28
Clay	.5	28.5
Coarse sand and gravel	14.5	43
Coarse and fine sand	17	60
Coarse sand and clay streaks	15	75
Coarse and fine sand	17	92
Gravel and cobble	4	96
Coarse sand	5	101
Gravel and large cobble	23	124
Gravel and cobble	10	134

This well was begun with a 16-inch galvanized riveted casing and sunk about 75 feet. The wet sand settled around the casing a good deal, owing to the bailing of sand being carried below the end of the casing. A downward slip extending from the surface of the ground around the well often occurred suddenly. In one of these slips the 16-inch casing was crippled at about the water surface. A string of 12-inch double California stovepipe casing was then introduced inside the 16-inch casing, and the well was finished with it. While the 12-inch casing was being sunk the ground slipped repeatedly as before and the original 16-inch casing settled with the ground to an unknown depth.

The testing equipment was set up at this well, but it was found that the sand had come into the well from the bottom and through the perforations until they had been entirely covered, so that the pump would merely suck out the water standing in the well to the bottom of the suction pipe, when the suction would be broken. However, the very favorable strata for pumping offer a practical guaranty of a free delivery of water under working conditions, and the physical requirements for constructing a properly cased well hole are certainly no different from those at the other two test wells and no more onerous than those at many other localities in the Southwest where wells of this kind are in use.

The water at well No. 1 was not of a satisfactory quality for irrigation unless used in combination with some other water, but at drive-point test G, less than half a mile away, is water that gave a favorable test.

Log of test well No. 2, sec, 16, T. 6 N., R. 21 W.

[Put down in November, 1915. 16-inch riveted and soldered casing, perforated full length before sinking with $\frac{1}{32}$ by 1½ inch slits, about 118 to the foot.]

	Thickness.	Depth.
	Feet.	*Feet.*
Soil and sand	10	10
Clay	2	12
Sand	2	14
Sand, medium-size grains (water surface)	26	40
Sand, coarser	14	54
Sand and small gravel	6	60
Sand and gravel, some clay	18	78
Small pebbles and a little sand	7	85
Clean gravel	13	98

A continuous pumping test of 48 hours was run on this well February 9–11, 1916. The record was kept by H. E. Buckingham, representing the State, and C. A. Engle, engineer, of the United States Indian Service. A No. 5 special Krogh horizontal centrifugal pump with 21-inch runner installed 2.87 feet above the normal water level was driven from a pulley attached to a Yuba tractor engine, burning distillate, which was run up close to the pit for the purpose and connected by a sloping belt direct to the pump pulley. The pump was set in a pit close to the surface of ground water. The pipe connections were of 10-inch riveted sheet-iron pipe, dipped in hot asphalt. The suction end was 30 feet long, and the discharge pipe, which contained an increasing 5 by 7 inch check valve, was about 22 feet long, with a long-radius elbow. The pump connections were each 5-inch and 3-foot reducer sections connected to the 10-inch pipe. The water was pumped into a weir box in which the discharge was measured. A few of the measurements are given below.

Time.	Draw-down. (feet).	Discharge.	
		Gallons per minute.	Second-feet.
Feb. 9, 2.30 p. m.	24.3	858	1.91
3.00 p. m.	24.3	858	1.91
Feb. 10, 12.30 a. m.	22.9	825	1.84
12.30 p. m.	24.1	825	1.84
Feb. 11, 12.30 a. m.	24.9	825	1.84
12.30 p. m.	24.3	825	1.84
2.30 p. m.	24.9	825	1.84

The drawdown or depth to which the surface of water in the well while being pumped recedes below the general surface of the ground water can be decreased by increasing the number and area of perforations. The well had filled with sand in the bottom to some extent at the time of the test, so that only about 57 feet of perforated casing was exposed for the entrance of water.

Log of test well No. 3, sec. 16, T. 7 N., R. 21 W.

[Put down in December, 1915. 16-inch galvanized riveted casing, perforated full length before sinking with $\frac{1}{32}$ by $1\frac{1}{2}$ inch slits, 113 to the foot. Some larger perforations cut after the well was done.]

	Thickness.	Depth.
	Feet.	*Feet.*
Soil and sand	10	10
Sand, clean and rather fine (water surface)	19	29
Clay	4	33
Sand, medium, growing coarser toward bottom, a few small stones	39	72

About 6 feet of cobbles were put into the well after drilling to hold sand that was coming up in the bottom. Sand afterward rose and reduced the depth to 57 feet.

It was found after the pumping test had been begun that the perforations had been made too small, and this condition, together with the shallow depth, was unfavorable to a large yield of water. Nevertheless when pumped for eight hours each day for a week the well steadily delivered nearly 30 miner's inches, or 337 gallons a minute. The pump was then disconnected and about 75 additional perforations in the casing were made by lowering an instrument into the well. This produced an increase of about 30 per cent in the amount of water pumped, bringing up the discharge to about 40 miner's inches, or 449 gallons a minute. There is no reason to doubt that an increase in the depth and a correction of the defect in perforations would produce as large a yield as that given by well No. 2.

The final test was run for 24 hours continuously on April 9 and 10, 1916. The arrangement of apparatus was similar to that used in the test of well No. 2, the same equipment having been moved to this well. The record was kept by H. E. Buckingham for the State, and F. R. Macpherson, of the United States Indian Service. The center of the pump was 3.33 feet above normal water surface. A few of the measurements are given below.

Time.	Draw-down (feet).	Discharge.	
		Gallons per minute.	Second-feet.
Apr. 9, 3.00 p. m.	24.25	473	1.05
4.00 p. m.	24.82	441	.98
12.00 m.	25.38	441	.98
Apr. 10, 12.00 m.	25.38	441	.98
3.00 p. m.	25.38	441	.98

DRIVE-POINT TESTS.

The localities at which drive-point tests were made and samples of water were taken are indicated on Figure 16. The drive-point method was simply the driving of a pipe with a pointed end, upon which was placed a section of strainer to keep out sand. After this pipe had been driven far enough into the ground to bring the strainer below the level of ground water a pitcher pump was attached to the upper end of the pipe, and the water was pumped up for obtaining samples. A rod was also let down into the pipe for measuring the depth at which the surface of the underground water lay. The depths to water for all the drive-point holes and also at the large wells are given below. The letters correspond to those used on the map.

	Ft.	in.		Ft.	in.
A	11	8	G	11	4
B	7		H	10	
C (higher ground)	28	6	J (well No. 1)	12	
D	18		J'	10	6
E	11		K (well No. 3)	10	1
F	11	6	Well No. 2	14	4

Samples of water from holes A to K, inclusive, were examined by the University of Arizona College of Agriculture and Agricultural Experiment Station. The following table shows the total solids and the classification of the different waters:

Total solids and classification of waters.

Hole.	Total solids (parts per million).	Classification for irrigation.[a]	Hole.	Total solids (parts per million).	Classification for irrigation.[a]
A	[b] 1,142	Fit.	G	462	Fit.
B	1,956	Fit.	H	[c] 936	Unfit.
C	5,000	Unfit.	J	2,814	Unfit unless in combination.
D	4,874	Unfit.			
E	310	Fit.	J'	[b] 796	Fit.
F	[b] 750	Fit.	K	1,152	Fit.

[a] Classification by A. L. Harris.
[b] Alkalinity as Na_2CO_3 (black alkali), 140 parts per million.
[c] Alkalinity as Na_2CO_3 (black alkali), 610 parts per million.

TRAVEL IN THE REGION.

TYPES OF ROADS.

The roads in this region are of several types, which are defined below.

Mountain roads run through mountains of various types and consequently have somewhat varying characteristics. The roadbed is constructed on rock, residual soil, thin alluvium, or caliche. In consequence it is seldom muddy, but it may be rough. These roads usually have steep grades, especially in and out of the gulches, the crossing of which presents the principal difficulty in traveling roads of this type.

Plains roads, which form the greater part of the roads in this region, pass through alluvium-filled valleys or plains. Such roads the traveler comes to know as the typical desert roads. Generally the alluvium makes good, well-drained roads, on which the greatest obstacles to travel are the washes. The difficulties here are heavy sand and very steep descent into and ascent out of the washes. As every rain changes the character of the washes permanent improvements are impossible. Under heavy traffic plains roads may become "chucky," but usually not sufficiently so to cause serious trouble. The adobe flats encountered here and there in desert valleys present more difficulties. They are dusty and chucky in dry weather and muddy in wet weather. Where there is much or long-continued traffic on a plains road, ruts may be worn so deep that "high centers" will be a serious menace to low-hung automobiles. Plate XIV, *A*, shows an example of a good plains road.

River-bottom roads are built along the courses of rivers, principally on the fine-grained sandy clay and loam of the flood plains. Well-graded roads built on such material may be excellent in dry weather, provided there is little traffic. The material is so soft, however, that well-traveled roads in river bottoms soon become very badly cut up. They are dusty in dry weather and may become so muddy in wet weather as to make passage over them very difficult. Parts of river-bottom roads may run on the gravel benches along the river. Here the alluvium is coarser and more compact than it is in the flood plain, and the roads are similar in character to plains roads. It is common to find two parallel roads along a river valley, one following the flood plain, the other the gravel benches. Which road is the better will depend on the season, the weather, and the amount and character of the traffic.

Malpais roads, which pass over mesas capped by lava or "malpais," are in general comparatively good. Steep grades, bad washes, and heavy sand are rare. Depressions in the surface of the lava may become filled with sand, making rather heavy going. Such stretches are usually short and seldom present serious difficulties. Roads of this type may be rough and are hard on tires.

ROAD DIFFICULTIES AND SUGGESTIONS FOR SURMOUNTING THEM.

The roads in southwestern Arizona, with few exceptions, have been but little improved. Here and there may be found stretches of excellent graded road built and maintained by the county or State, which reflect credit on the engineering skill of those in charge. However, the mileage of good roads compared to the total mileage of roads in this part of Arizona is very small. The traveler who uses the roads in this region now and for a number of years to come must expect to encounter long stretches on which little or nothing in the way of improvement has been done. Under such conditions it is inevitable that certain portions of the roads will at times get into such poor shape as to make travel over them rather difficult. The well-traveled roads rarely become dangerous or even really difficult for an automobile in good condition, particularly if the traveler, knowing the impediments he is likely to encounter, goes prepared to cope with them. The following is a brief description of the major road difficulties, together with some suggestions for overcoming them. As most of the traveling in this region is done by automobile, the needs of the motorist have been kept particularly in mind. However, much of what follows applies equally to travel by wagon.

On many of these roads garages at which even simple repairs can be made are separated by 50 or 100 miles, or even greater distances, and consequently the car should be put in as good shape as possible before starting. Enough tools and spare parts should be taken, so that minor repairs can be made on the road. On leaving a supply station there should be ample gasoline in the car to last until the next point at which it can be obtained is reached. Fewer miles per gallon must be expected on unimproved roads than on boulevards, and the gasoline obtainable will not always be of the best quality. Gasoline should be carried in at least one container in addition to the tank in the car in order to have a reserve in case of a leak in the gas line.

A few tools for overcoming road difficulties should be carried. A shovel and ax and perhaps also a pick are likely to prove valuable possessions at times. A rope and tackle or one of the patented devices of this nature might be useful to pull the car out of a hole or up a steep bank. A rope and bucket are often necessary to obtain water from wells. Enough water should be taken to fill the radiator at least once in case of a leak and leave some for drinking. Human consumption is very great in the desert, 2 gallons per man per day being a minimum requirement. It is advisable to carry a little food and bedding, even if main reliance is to be placed on the eating houses and hotels along the way. There is always the possibility of not arriving at the hotel on schedule time. Even with a car in good condition at the start a breakdown may occur on the desert or in the mountains far from any habitation. Without provisions such an occurrence might prove a very serious matter. With them it becomes merely a vexatious delay. At some places food can be purchased, but the traveler must provide his own bedding.

One of the very common impediments to travel in this region is that presented by the dry washes. These are stream courses that are entirely dry except for short periods immediately after exceptionally heavy rains. During times of flood it is impracticable to attempt to ford the streams, and travelers must wait at some town until the flow ceases. Such delays are rare and usually short, even during the rainy season.

A dry wash presents difficulties of two kinds. Its banks may be steep, making descent into and ascent out of the wash abrupt. On a road over which there has been little recent travel it is a wise precaution to look at the wash and its banks before attempting to cross. Time can often be saved by cutting down the banks to a better grade or otherwise improving the road across the wash. It is much easier to cross a wash with the aid of the momentum of the car than it is to get out of the wash after the car has got stuck and been compelled to stop.

A rather frequent difficulty with a Ford automobile in ascending the bank of a wash or other steep pitch is that the gasoline fails to feed from the tank into the carburetor. This difficulty is of course especially liable to occur when the gasoline supply is getting low. Slopes steep enough for trouble of this sort are usually short, and if the car is moving at a fair rate of speed its momentum may be sufficient to carry it over the slope. If the car is stopped at the foot of such a pitch, however, it may be unable to get up under its own power. At such times the motorist will be very thankful if he has had sufficient forethought to bring a shovel to cut down the obstruction to a practicable grade and a rope and tackle or similar device to aid the engine.

Various devices for pumping air into the gasoline tank and thus getting a sufficient increase in pressure to force the gasoline through the carburetor have been tried. So far as known to the writer none of these devices have been perfected for use on the Ford car. One scheme, used on the Geological Survey car in the work north of Gila

River, is to fit the screw cap of the gasoline tank with an ordinary tire valve and pump air in with the tire pump. This helps in an emergency but has three disadvantages. The cushion must be removed during the operation, making it slightly difficult to drive. The screw cap is not perfectly airtight, so it is difficult to get sufficient pressure to do much good, especially in the awkward position in which the pump must be used. This cap can not be left on the tank permanently, as the valve easily clogs with dirt. When this happens, no air enters the tank from above, and the gasoline, of course, does not flow even when the tank is full.

Trouble may also be encountered in crossing the sandy or gravelly bed of a wash. Here, likewise, it is very important to maintain the momentum of the car, if possible. It is not advisable to rush across a wash at high speed, for such a proceeding is always dangerous and might lead to disaster, but the car should be kept moving all the time until the wash is passed. If the traveler has any doubts as to the condition of the road he should examine it before he attempts to cross. If the road is not in good shape he will usually save time and labor by putting it in good shape, so far as possible. On the main traveled routes the banks of washes are usually cut or worn down, and the roads across them are well packed, but even on such routes it is well not to assume that everything is all right but to make sure of it.

In crossing the bed of a wash or following a road along such a bed, or indeed in going over any stretch of soft roadbed, it is absolutely necessary to keep in the tracks made by the wheels of the vehicles that have preceded. A car may run easily in a track packed down by previous automobiles and yet be entirely unable to make any progress in the soft, unpacked sand or gravel on either side. One danger to be constantly guarded against is that of getting off the road in the wake of some car that has started off a few feet and then backed into the road again. One of the Geological Survey parties spent 24 hours in one gravel-bottomed wash in La Posa Plain near Quartzsite because the driver followed such a set of tracks and got off the roadway. The car was finally backed out the way it had come, and the wash was not crossed at that place.

If the roadway in a wash or elsewhere is too soft to afford traction, it can be corduroyed. If planks are available, they are excellent to lay in the tracks for the wheels to run on, but they are usually not to be had. Creosote and similar bushes grow almost everywhere in this region, however, and if cut and laid crosswise of the tracks for a considerable distance in front of the car they will afford traction for the wheels. It is usually not necessary to lay them the whole distance across the soft ground, unless this is very short, as the car ordinarily gathers momentum enough to carry it some distance past the end of the corduroy. It may be necessary, especially in long sandy stretches, to let the air out of the tires until a pressure of only about 25 pounds or so remains in them. This provides a greater bearing surface and is of very great assistance. It is, of course, very injurious to the tires, causing rim cutting, and should not be resorted to unless unavoidable.

The road difficulties met with in sandy places, such as parts of the flood plains of rivers and sand dunes, are similar to those met in the bottoms of sandy washes.

The difficulties encountered with silt in river flood plains and on adobe flats in desert valleys are of two kinds. In wet weather such places are liable to be "seas of mud" and passage over them is difficult, if possible at all. Local advice should be sought and carefully considered before making the attempt. In dry weather, especially if there has been much travel, roads over them are sure to have deep ruts and be "chucky," in some places exceedingly so, but are not likely to present any difficulties to the traveler who does not try to go over them too fast and incautiously. "High centers" should be watched for and avoided if possible. Usually there is a choice of a number of tracks across such places, crossing and recrossing one another but all leading in the same general direction. Care should be taken not to follow a set of these tracks that leads to some place which the traveler has no desire to visit. If the surface is hard and the car is lightly laden, it may be well to make a new track, for by doing so much shaking up from the chuck holes in the old tracks may be avoided. This should be attempted with caution, however, because the surface may not be as hard as it looks, and on leaving the beaten track the car may get stuck, necessitating more or less labor to get it back into the road.

The difficulties encountered on mountain roads are familiar to most experienced motorists. No general advice can be given except to take no needless chances and avoid excessive speed. The car should be kept entirely under control at all times. These roads are in some places so narrow that two cars can not pass. Before starting on such a very narrow stretch, the traveler should look and listen to be sure that no car is on it coming the other way. A meeting where the road is so narrow that it is impossible either to turn around or to pass the other car would cause delay, if nothing more.

In conclusion, it may be said that the roads in southwestern Arizona, though in general unimproved and rough, are for the most part passable and offer no particular danger or great difficulty to the experienced driver who takes proper precautions and sufficient supplies. The reckless, ignorant, or careless driver is likely to find trouble here as elsewhere.

ROUTES OF TRAVEL.

GENERAL OUTLINE.

The main route of travel through the region covered by this guide is the road between Phoenix and Yuma, about 200 miles long. The route between these places by way of Deep Wells is 222 miles long, but this is now seldom used and is not recommended. At Yuma there are connections with main roads leading to Los Angeles and San Diego.[72] The distance to Los Angeles from Yuma is 320 miles by way of San Diego and 294 miles by way of Mecca. The San Diego route is perhaps the more favored. According to recent maps received from the office of the State highway engineer it is planned to construct a permanent graded highway between Phoenix and Yuma, crossing Gila River near the Enterprise ranch, passing through Gila Bend, and following the railroad from that town to Yuma.

Next in importance are the routes between Phoenix and Parker, 162 or 178 miles long, according to the exact course taken. At Parker these routes connect with roads leading to San Bernardino and Los Angeles.[73] The distance to Los Angeles from Parker is 132 or 170 miles, according to the route; the longer route is the better.

Roads branching from the Phoenix-Parker routes lead by way of Quartzsite to Ehrenberg Ferry, on the Colorado, and there connect with a main road leading through Blythe and Coachella Valley to Los Angeles.[72] The distance from Phoenix to Ehrenberg is 163 to 193 miles by different routes. The distance from Ehrenberg to Los Angeles is 248 miles.

There are various routes and combinations of routes between Phoenix and Parker. All of them are used by travelers from and to points in California, and each is referred to locally as the "Parker cut-off." From Phoenix the tourist may follow in a general way the line of the Santa Fe, Prescott & Phoenix Railroad through Wickenburg, Wenden, Salome, and Bouse to Parker, or he may leave the railroad at Wenden and go to Parker by way of Cunningham Pass and Butler Well. Other routes lead through Buckeye Valley, past Winters Well, the Palo Verde mine, and Tolladay's Well, through Harrisburg Valley, and thence either through Wenden and Cunningham Pass to Parker or through Salome and Bouse along the railroad to Parker. The choice depends on individual preference and on the condition of the roads at different times. The route by way of Wickenburg and Bouse is more than 15 miles longer than that by way of Buckeye, Winters Well, and Bouse,

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[72] Brown, J. S., The Salton Sea region, Calif.: U. S. Geol. Survey Water-Supply Paper 497, 1923.

[73] Thompson, D. G., Routes to desert watering places in the Mohave Desert region, Calif.: U. S. Geol. Survey Water-Supply Paper 490-B, 1921.

but in the early part of 1918, after a prolonged drought, many travelers were going by way of Wickenburg in order to avoid badly cut-up stretches of road near Winters Well and across the Harquahala Plains. The Wickenburg road was not traveled by the writer during the present investigation. After periods of heavy rains the road by way of Wenden and Cunningham Pass is reported to be better than that along the railroad through Bouse, but this route is not good immediately after a rain storm. Some prefer the road through Cunningham Pass at all seasons.

Some travelers between Arizona and California points use the ferry over Colorado River at Ehrenberg instead of that at Parker. They follow one of the Parker cut-off routes in Arizona either to Vicksburg or to Bouse, which are stations on the Santa Fe, Prescott & Phoenix Railroad, and thence go to Quartzsite and Ehrenberg. The road between Bouse and Quartzsite is 6 miles shorter than the road between Vicksburg and Quartzsite. For travelers between Ehrenberg and places east of Vicksburg the route by way of Bouse from Quartzsite is 14 miles longer than that direct to Vicksburg, but the road is much better, especially in wet weather. The ferry at Ehrenberg is usually not operated from the later part of May to the early part of August because of high water.

There are three main routes between Phoenix and Los Angeles. The portions of these routes in Arizona are those that lead from Phoenix to Yuma, Parker, and Ehrenberg. The choice depends largely on individual preference, the weather, and the condition of the roads at the time of the trip. The Yuma road is somewhat the most popular. Watering places are numerous on it, and the road is easy to follow in most places. The bridge at Yuma obviates the necessity for ferrying across Colorado River. In 1918 there was a bridge over Gila River at Antelope Hill, but it is reported that this bridge has since been washed out and the river must be forded here. (See p. 230.) Many travelers now go by way of Buckeye and Gila Bend instead of by this route. The road along Gila River is usually in bad shape for considerable stretches, and the scenery here is mostly dreary and rather uninteresting. In California about 30 miles of very sandy road is encountered in the sand-hill area east of the Imperial Valley. The Parker cut-off routes are used almost as much as that by way of Yuma. The scenery is, on the whole, rather more attractive, and the distance is but little longer. It is slightly more difficult to keep on the correct road, and reliable watering places are somewhat farther apart. At times some stretches of the roads are in bad shape, but as there are several alternative routes the worst of these can usually be avoided. Local advice should be sought as to which route to follow. The route by way of Ehrenberg is roughly 100 miles shorter than either of the others, but it is not nearly as much used, because of the comparatively long stretches along which no supplies, or very few, can be obtained. In California no supplies of any kind can be procured along the 95-mile stretch west of Blythe. Some portions of the road are rough, and others are very sandy. There is a variety of attractive desert scenery along the Arizona portion of the route.

An important route is the road between Quartzsite and Dome on the main Phoenix-Yuma route. The Harquahala road between Palomas and Salome is another north-south route, but is now seldom used.

From Buckeye, on the Phoenix-Yuma route, a road leads south to Gila Bend, and thence to Ajo, the Papago country, and Mexico.[75] From Gila Bend there is also a road leading westward to Yuma, following in general the course of the Southern Pacific Railroad. From Sentinel, on this road, there is a road across Gila River to Agua Caliente, on the main Phoenix-Yuma route.

PLAN OF LOGS AND DESCRIPTIONS.

In the following pages are given, first, road logs that are intended to furnish accurate information about distances and principal points and are made brief enough to be convenient for the traveler whose time is short, yet sufficiently detailed, it is believed, to enable him without other guide to reach his destination safely. Logs of principal roads are given in both directions. Distances are stated in miles and tenths as measured by the Geological Survey party in traveling the road. All the signs mentioned in the logs are believed to be reliable. As the condition of many of the roads may have changed since the material for this book was collected, the traveler should, if possible, obtain local information as to a road before starting on a trip. Some information obtained recently by correspondence is given on pages 229–230.

The logs are followed by more detailed descriptions of many of the routes and special features of the region.

[75] Bryan, Kirk, Routes to desert watering places in the Papago country, Ariz.: U. S. Geol. Survey Water-Supply Paper 490–D, pp. 389–391, 1922.

ROAD LOGS.

PHOENIX-YUMA ROUTE.

PHOENIX TO YUMA BY MAIN ROAD (199 MILES).

[See pp. 130-132 for log in opposite direction.]

0.0 **Phoenix.** Arizona Eastern Railroad station. Go north on Central Avenue to Washington Street. Turn west. Go past courthouse (0.4 mile) and continue west.

1.5 Capitol Building. Turn south on Seventeenth Avenue.

1.6 Jefferson Street. Turn west on Jefferson Street. Pavement ends here; good dirt road for 14 miles to Agua Fria River.

1.9 Nineteenth Avenue. Turn south on Nineteenth Avenue. Cross, first, the Santa Fe, Prescott & Phoenix Railway, then the Arizona Eastern Railroad.

2.4 Buckeye road. Turn west on Buckeye road. Continue west.

13.8 **Cashion.** Water and supplies. Water is piped from Cashion ranch and is warm and somewhat mineralized. Continue west.

15.4 Abrupt turn to right and then to left on to concrete roadway across part of Agua Fria River. Continue west at end of concrete roadway, fording stream (usually easy to ford).

16.2 **Coldwater.** Water and supplies. Water from well here is cold and good. Continue west. Road somewhat rough.

22.2 Turn south (left) at end of fenced land on good plains road, avoiding road straight ahead (west).

22.4 Turn west (right).

22.9 **Fork.** Right-hand road is plains road to Buckeye, avoiding Liberty. Left-hand road is graded dirt road leading to Buckeye by way of Liberty. Take left-hand road.

25.0 Cross Arizona Eastern Railroad and continue south.

25.1 Cross Buckeye Canal and continue south.

26.6 Turn due west (right).

28.3 **Liberty.** Water and supplies. Continue west.

33.0 Buckeye Canal. Road that forked at mile 22.9 comes in from northeast, across the canal. Turn due south (left).

33.6 Turn due west (right).

34.2 **Buckeye.** Water, supplies, lodging, and auto repairs. Continue west.

34.5 **Crossroads.** Road south (left) leads across Gila River to Gila Bend, about 36 miles distant. Geological Survey sign. For Palo Verde, Yuma, and Parker continue straight ahead (west).

36.5 Turn south (left).

37.5 Turn west (right).

39.5 Turn south (left).

40.0 Turn west (right).

41.0 Crossroads at **Palo Verde.** Water and supplies. Continue straight ahead (west).

43.7 Ford Hassayampa River. Usually very little water in river.

43.9 Fork. Geological Survey sign. Road west leads to Bouse, Wenden, Parker, and Ehrenberg. (See pp. 133-139.) It is an alternate route to Los Angeles. For Yuma turn south (left) along base of lava cliff. Go south about 2 miles, then bend to right and go west around lava cliff. Road poor around cliff. Continue west.

47.5 **Arlington.** Store. Water and supplies. Take enough water to last until Agua Caliente is reached, as watering places in mountains are unreliable. Continue west nearly a mile, then bend south. Alternate road from Arlington store goes south 1 mile, then west 1 mile. A road back of Arlington store leads northwest to Winters Wells.

49.3 Crossroads. Geological Survey sign. Alternate road from Arlington comes in on east. Road south goes to Enterprise ranch and leads to old road across Gila Bend Mountains. (See p. 129.) Enterprise ranch is about 15 miles from Arlington. Turn west (right) for new road across Gila Bend Mountains. Continue west up bluff past a house (mile 49.9). After climbing bluff, road is fairly good.

54.8 Fork in mesquite thicket of Centennial Wash. Geological Survey sign. Road northwest (right) connects with abandoned Harquahala freight road, now used only to reach some of the wells of the Flower Pot Cattle Co. Continue straight ahead.

62.1 **Surprise Well.** Good water when windmill is pumping.

64.8 **Dixie mine.** Good **water** in well on north side of road when mine is being worked and well is attended to.

67.6 Fork. Faint road straight ahead goes to Clantons Well and beyond. (See p. 151.) It is used only by cattlemen. Turn south (left). Continue south and southwest over good, winding mountain road.

71.0 Road makes steep descent and then crosses **Fourth-of-July Wash. Water can be obtained by digging a foot or two** in sand in this wash, 200 to 300 yards downstream from road, except after long dry season.

72.2 **Willow Tanks.** Geological Survey sign. Two natural tanks, 50 yards upstream from road, also one in a small branch gully that joins main wash about 200 yards downstream from road. Wooden platform on north bank of main wash short distance downstream from point where gully containing one tank enters the wash. Tanks generally contain water, except after long dry season. Water is good if clean but usually fit for stock or automobile only. Continue west.

75.8 **Yellow Medicine Tank.** Geological Survey sign. Small rock tank 75 yards south of sign in gully. Water good if clean but usually fit for stock or automobile only. Dries up in long dry seasons. **Yellow Medicine Well** is on east side of Yellow Medicine Wash, about a mile south of the tank. It contains permanent water, but it is poorly protected and the water usually becomes contaminated. From sign near Yellow Medicine Tank continue west over good graded State road with steep grades and many turns.

78.7 Cross big wash where graded road ends.

78.9 Fork. Geological Survey sign. Branch road to left is old road now open only about half a mile to wash near **State Well.** This well contains permanent water but is unprotected from contamination, and there are no facilities for getting water. Rope and bucket required.

97.3 Geological Survey sign. Branch road on right comes from homestead of G. T. Morris. This is 0.7 mile from the fork. There are two wells here, but neither is used, and the water is reported to be undrinkable. Mr. Morris keeps a supply of somewhat salty but drinkable **water** at his house.

97.7 Geological Survey sign. Road coming in on east (left) is old road from Arlington. (See pp. 129–130.) Continue southwest, soon turning nearly due west.

98.0 **Agua Caliente.** A road leads south to Sentinel. Agua Caliente has hot springs, water, supplies, hotel, and garage with gasoline, and a few other supplies. Continue westward through Agua Caliente.

99.4 Fork. Geological Survey sign. Avoid left-hand road (straight ahead), which is old road to Palomas. Turn northwest (right). Continue northwest about 3 miles, then turn southwest, avoiding faint roads forking off on right. One of these roads leads to **Frank Baragan's well,** 1¼ miles north of the main road. (See Pl. III.) This well has windmill with windlass and buckets and good water.

110.8 Junction with north-south road. Geological Survey sign. Road coming in on north (left) comes from Harquahala and Salome. (See pp. 150–151.) Turn south.

112.6 Geological Survey sign. Old road from Agua Caliente comes in on left.

113.4 **Palomas.** Water, supplies, meals, gasoline, post office, and camp ground. Road south leads to Aztec (7 miles), a station on the Southern Pacific. Turn southwest (right) on outskirts of village.

117.4 Fork. Geological Survey sign. Road north (right) is old road to Yuma by way of Deep Well and Castle Dome; now no water or habitation for 55.5 miles from this fork. This old road joins the road from Quartzsite to Dome at Geological Survey sign at mile 39.4 going south. (See p. 146.) To continue on main road to Norton and Yuma turn south (left), then southwest along the flood plain of Gila River. The particular road used varies from time to time and with the seasons. Follow most used tracks or get local advice. Road full of holes in dry weather and muddy in wet weather. Avoid branch roads leading off to ranches along the route. **Water** obtainable at several of these ranches in emergency. At mile 125.8 is a reverse fork leading to Farra's ranch, three-fourths of a mile south of the main road, where there is a well that yields fairly good water. Continue to Norton.

135.2 **Norton.** Old buildings, post office. Somewhat salty but drinkable water. No other supplies. Road leading due north goes to Deep Wells and beyond. It is little traveled. Road south leads to Mohawk (7 miles), a station on the Southern Pacific Railroad. Continue west.

136.3 **Hicks ranch.** Well with salty but drinkable water. Supply small, so that owner prefers that it be used only in emergency. Continue west and southwest.

142.0 Deserted schoolhouse.

146.3 Ranch building with windmill. Continue west about 3 miles. Turn south. Road goes over silty flood plain, full of holes in dry weather, very muddy in wet weather. Last 2 miles before reaching bridge is graded road but in poor condition.

152.5 Cross Gila River on Antelope Bridge (concrete). Water is usually obtainable in river bed, but it is not of good quality for human use. After crossing bridge turn to right and run southwest, avoiding branch roads to ranches. Road has chuck holes and is very dusty in dry weather and muddy in wet weather.

161.4 **Wellton.** Water, gasoline, supplies, post office, hotel, and railroad station. A road leads south to Tinajas Altas.[76] Turn to right and go west. This road is undergoing improvement west of the town, and new roads to homesteads are being made. It lies in a flood plain of Gila River, between the river on the north and the Southern Pacific Railroad on the south, so it is impossible to get far off it. First part of road to Dome has chuck holes and dust in dry weather and mud in wet weather. For 8 miles east of Dome there is good graded road.

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[76] See Water-Supply Paper 490-D.

178.9 **Dome.** Water, gasoline, supplies, post office, and railroad station. Continue west on good graded road.

185.6 Blaisdell, railroad station. Road south to Fortuna mine. Continue west on poor sandy river-bottom road to outskirts of Yuma, then 1 mile on asphalt pavement to Yuma depot (mile 198.9).

198.9 **Yuma.** Depot.

PHOENIX TO YUMA BY OLD ROAD ACROSS GILA BEND MOUNTAINS (202 MILES.)

[See pp. 132–133 for log in opposite direction.]

On the route from Phoenix to Yuma there are two optional roads between Arlington and Agua Caliente through the Gila Bend Mountains, known as the old and new roads. The new road, which lies north of the old, is about 3 miles longer. Water is obtainable on it at more frequent intervals, and it is the one usually traveled by automobilists. For these reasons it is the safer of the two. The old road, being shorter and having less steep grades, is sometimes used by parties traveling with stock. It has more sand than the new one but fewer curves. (See Pl. XIV, *A*.)

For road from Phoenix to Arlington, see log, pp. 126–127.

47.5 **Arlington** store. Water and supplies. Continue west nearly a mile, then bend south. Alternate road from Arlington store goes south 1 mile, then west 1 mile.

49.3 Crossroads. Geological Survey sign. Road from east (left) is alternate road from Arlington. Road west (right) is new road across Gila Bend Mountains. (See p. 127.) To follow the old road across the mountains or to go to Enterprise ranch continue straight ahead (south).

51.0 Fork. Geological Survey sign. Road straight ahead goes to Enterprise ranch, about 10 miles from this point. For Agua Caliente and Yuma turn west (right) and go over fair plains road, crossing Arlington Canal and leaving irrigated district at mile 52.4.

58.0 Fork. Wooden sign. Road to left leads to Webb mine, about a mile south. Continue straight ahead past faint road to right, leading to **Van Hagen windmill,** 0.3 mile north of main road. This well is unreliable for water supply.

59.4 Geological Survey sign. **Webb Well** is 150 yards to the right of road. **Good water.** Continue over good mountain road.

63.8 Fork. Road on left goes to **Woolsey Tank** (Pl. XVII, *B*), 100 yards away, and to camp ground. **Water for stock in natural tank, for men in shaft of Perhaps mine.**

63.9 Geological Survey sign. Another road on left leading to Woolsey Tank. Continue west over fairly good mountain road.

68.2 Road leaves mountains. Continue over good plains road.

73.8 Fork. Geological Survey sign. Road on left is an old road now washed out and impassable. Turn west (right) and continue over rather poor valley road.

75.4 Faint road to left leads 0.7 mile south to **apiary,** where there is a driven well that yields water of poor quality, which may be used for drinking in an emergency. The well is equipped with a pump, but it may be necessary to prime the pump.

77.7 Geological Survey sign. Road coming in on left was once a part of the main road but is now washed out and impassable at one place. Near this old road, 1.8 miles from the main road, is a cattlemen's camp, with a driven well that yields salty water. Continue on main road, passing south of lava buttes and skirting them on fair valley road to mile 83.9; then cross low lava mesa on good road to mile 86.8; then pass over fair river-bottom road.

94.0 Small ranch where **salty water** could be obtained in an emergency.

94.6 Geological Survey sign. Road coming in on north is the new road across the Gila Bend Mountains. Set speedometer to mile 97.7 and use log of main Yuma-Phoenix road. (See p. 127.)

YUMA TO PHOENIX BY MAIN ROAD (199 MILES).

[See pp. 126–129 for log in opposite direction.]

0.0 From **Yuma depot** go east for 1½ miles on asphalt to outskirts of Yuma. Then continue east on poor sandy river-bottom road to Blaisdell.

13.3 Blaisdell railroad station. Road south from here to Fortuna mine. Continue east along good graded road.

20.0 **Dome.** Water, gasoline, oil, supplies, post office, and railroad station. Continue east past railroad station; a good graded road extends for 8 miles east of Dome; beyond that point the road has chuck holes and dust in dry weather and mud in wet weather, growing worse toward Wellton. This road is undergoing improvement west of Wellton, and new roads to homesteads are being made. It lies in a flood plain of Gila River between the river on the north and the Southern Pacific Railroad on the south, so it is impossible to get far off it. Continue east.

37.5 **Wellton.** Water, gasoline, oil, supplies, post office, hotel, and Southern Pacific station. Turn north and northeast, continuing to Gila River across Antelope Bridge, avoiding branch roads to ranches. Road has chuck holes and is very dusty in dry weather and muddy in wet weather.

46.4 Cross Antelope Bridge (concrete) over Gila River. **Water** usually obtainable in river bed, but it is not of good quality for human use. Continue north for 2 miles on graded road that is in poor shape. Turn east, passing ranch building with windmill (mile 52.6). Continue northeast and east, passing deserted school (mile 56.9) to Hicks ranch. Road goes over silt of flood plain, full of chuck holes in dry weather and very muddy in wet weather.

62.6 **Hicks ranch.** Well with salty but drinkable water. Supply small, so that owner prefers that it be used only in emergency. Continue east from the ranch.

63.7 **Norton.** Ranch buildings, old store, and post office. Salty but drinkable water, but no supplies obtainable. Road due north from Norton goes to Deep Wells and beyond; little traveled. Road south to Mohawk (7 miles), a station on the Southern Pacific. From Norton start northeast, then turn east past the schoolhouse, avoiding road which continues to north (left). The present route continues east and northeast along the flood plain of Gila River. Avoid branch roads leading off to ranches along the route. **Water** obtainable at several of these ranches in emergency. Continue to fork. The exact road used varies from time to time and with the seasons. Follow most-used tracks or get local advice. Road full of chuck holes in dry weather and muddy in wet weather.

73.1 Fork. Keep straight ahead on main road. Road on right goes three-fourths of a mile to **Farra's ranch,** where there is a well that yields fairly good water.

81.5 Fork. Geological Survey sign. Continue northeast, avoiding road to north (left), which is old road to Yuma by way of Deep Well and Castle Dome; now no water or habitation for 55.5 miles from this fork.

85.5 **Palomas.** Water, gasoline, oil, supplies, meals, post office, and camp grounds. Continue north through Palomas, avoiding road forking to right, Geological Survey sign (mile 86.3), which is old road from Palomas to Agua Caliente.

88.1 **Fork.** Geological Survey sign. Turn to right, avoiding fork on left, which is road to Harquahala and Salome. Continue northeast, avoiding faint road forking to left at mile 95.1, which goes to **Frank Baragan's well** (1¼ miles). Well has windmill, windlass and buckets, and good water.

99.5 Fork. Geological Survey sign. Continue northeast, avoiding road forking to right, which is old road from Palomas.

100.9 **Agua Caliente.** Hot springs, water, gasoline, oil, supplies, hotel, and garage, but no automobile repairs except very minor ones. Continue north through Agua Caliente, passing road to south at mile 100.9.

101.2 Fork. Geological Survey sign. Continue north, avoiding road to east (right), which is old road to Arlington.

101.6 Fork. Geological Survey sign. Continue north, avoiding road forking to left to homestead of G. T. Morris (0.7 mile). There are two wells here, but neither is used, and the water is reported to be undrinkable. Mr. Morris keeps a supply of somewhat salty but drinkable **water** at his house.

120.0 Fork. Geological Survey sign. Continue straight ahead, avoiding road forking to right, an old road now open only to bank of wash near **State Well** (0.5 mile); permanent water but unprotected from contamination; no facilities for getting it; rope and bucket must be provided.

120.2 Cross wash. Graded road starts here. Continue east on graded State road (steep grades, many turns, good road) to Geological Survey sign, near **Yellow Medicine Tank.** About a mile south of the tank is **Yellow Medicine Well,** on the east side of Yellow Medicine Wash. Permanent water, but well is poorly protected, consequently water is usually contaminated.

123.1 **Yellow Medicine Tank.** Small rock tank in gully 75 yards south of Geological Survey sign. Water good if clean, usually fit for stock or automobile only. Dries up in long dry spells. Continue east past the sign.

126.7 **Willow Tanks.** Unreliable. Geological Survey sign. Water in two natural tanks 50 yards upstream from road, except after long dry season, also in **another tank** in a small side gully south of main wash about 200 yards downstream from road; wooden platform on north bank of main wash short distance downstream from point where gully containing the tank enters the wash. Water in all three tanks good if clean, usually fit for stock or automobile only. Continue northeast and east past Geological Survey sign at Willow Tanks.

127.9 Fourth of July Wash. **Water** can be obtained by digging in sand of this wash 200 to 300 yards downstream from road, except after long, dry season. Cross Fourth of July Wash. Here road makes steep ascent. Continue northeast and north over good winding mountain road.

131.3 Turn east (right); faint road to left goes to Clantons Well and beyond. Used only by cattlemen.

134.1 **Dixie mine.** Good water in well on north side of road when mine is working and well attended to. Continue east.

136.8 **Surprise Well.** Good water when windmill is pumping. Continue past Surprise Well on fair to good plains road.

144.0 Fork. Continue straight ahead. Road to northwest (left) connects with abandoned Harquahala freight road, now used only to reach some of the wells of the Flower Pot Cattle Co. Continue east past house at mile 149.0, descending bluff.

149.4 Fork. Geological Survey sign. Turn north. Road straight ahead is alternate road to Arlington. (Road to south goes to Enterprise ranch; old road across Gila Bend Mountains turns west from it 2 miles south of this fork. For log of this road, see p. 129.) Continue north and east past two green bungalows to Arlington store (mile 151.4), supplies and water. Alternate road goes south 1 mile and west 1 mile from Arlington store. Continue east past Arlington store. Go east around lava cliff on river bottom road which is poor around cliff; then go north to fork.

155.0 Fork. Geological Survey sign. Turn east (road west is Parker cut-off, alternate route to Los Angeles by way of Parker and Bouse or Wenden). Continue east, crossing Hassayampa River (mile 155.2); usually very little water. (Road east by way of Liberty as far as Buckeye Canal is graded and usually in fair repair.)
157.9 **Palo Verde.** Supplies and water. Continue east through Palo Verde.
158.9 Turn north.
159.4 Turn east for 2 miles.
161.4 Turn north.
162.4 Turn east and continue through crossroads (mile 164.4). Geological Survey sign. Road to south here leads across Gila River to Gila Bend.
164.7 **Buckeye.** Supplies, food, lodging, auto repairs, and water. Continue east.
165.3 Turn north.
165.9 Turn east. Branch road on left (northeast) leads across desert, joining main road at mile 176.0.
170.6 **Liberty.** Supplies and water. Continue east.
172.3 Go north, crossing Buckeye Canal (mile 173.9) and Arizona Eastern Railroad (mile 173.8).
176.0 Turn east. Road coming in from west is alternate route across desert from mile 165.9.
176.5 Turn north.
176.7 Turn east. Road on this stretch usually chucky in part.
182.7 **Coldwater store.** Supplies and water. Continue east, ford west branch of Agua Fria River (usually an easy ford), cross east branch on concrete roadway, turn to right, make abrupt turn to left, and turn just east of Agua Fria River.
185.1 **Cashion.** Supplies and water. Go east for about 13 miles (good dirt road).
196.5 Fork. Turn north, crossing first the Arizona Eastern Railroad tracks, then the Santa Fe, Prescott & Phoenix Railway tracks. Pavement begins at Nineteenth Avenue.
197.0 Turn on Nineteenth Avenue.
197.3 Go east on Jefferson Street.
197.4 Go north on Seventeenth Street to Washington Street. Go east on Washington Street past the Capitol Building and the courthouse (mile 198.5). Turn south on Central Avenue to the Arizona Eastern Railroad station.
198.9 **Phoenix.** Arizona Eastern Railroad station.

YUMA TO PHOENIX BY OLD ROAD ACROSS GILA BEND MOUNTAINS (202 MILES).

[See p. 129 in regard to this road. For road from Yuma to Agua Caliente see log on p. 130.]

100.9 **Agua Caliente.** Hot springs, water, supplies, hotel, and garage, with gasoline and a few other supplies. Continue east, later turning northeast.
101.2 Fork. Geological Survey sign. Follow right-hand road, avoiding road to left, which is new road across Gila Bend Mountains. (See mile 101.2 of log on p. 131.)
102.2 Small ranch where **salty water** could be obtained in an emergency. Fair valley road to mile 109.8.
109.8 Low lava mesa. Good mesa road to mile 112.7, then on fair river bottom road, skirting base of buttes.
118.5 Fork. Geological Survey sign. Turn to left, avoiding road to right, which is abandoned portion of this road, now washed out and impassable at one place. Near this old road 1.8 miles from the fork at mile 118.5 is a cow punchers' camp. Driven well, **salty water.** Continue north and northeast on fair to poor river bottom road. At mile 121.3 faint road on right leads south 0.7 mile to **apiary and driven well** with water of poor quality, which can be used for drinking in an emergency. The well is equipped with a pump, but this may need to be primed.

122.4 Old road comes in on right (south). Geological Survey sign. Turn northeast (left), avoiding old road on right, now washed out and impassable. Go on good plains road to mountains (mile 128.0), then on fairly good mountain road.

132.3 Fork. Geological Survey sign. Road to right goes to **Woolsey Tank,** 75 yards to camp ground, water for stock in **natural tank,** for men in **shaft of Perhaps mine.** Continue on main road, passing another road to Woolsey Tank, then on good mountain road.

136.8 **Webb Well.** Geological Survey sign. Well is 150 yards to left of road; good water. Continue, passing faint road on left (mile 137.7) to Van Hagen windmill, 0.3 mile to north; this is unreliable.

138.2 Continue straight ahead, avoiding road on right to Webb mine, on fair to good plains road, crossing Arlington canal and entering irrigated district at mile 144.2.

145.2 Junction with north-south road. Geological Survey sign. Turn north (left). Road to south (right) goes to Enterprise ranch.

146.9 Crossroads. Geological Survey sign. Road on left is the new road across the Gila Bend Mountains. Reset speedometer to 149.2 and continue north, using log of main Phoenix-Yuma road from this point. (See p. 131.)

ROUTE BETWEEN PHOENIX AND PARKER BY WAY OF BUCKEYE AND SALOME OR WENDEN.

PHOENIX TO SALOME BY WAY OF BUCKEYE AND PALO VERDE (104 MILES).

[See pp. 138–139 for log in opposite direction.]

For log of road from Phoenix to Palo Verde see Phoenix-Yuma log, page 126.

41.0 Crossroads at **Palo Verde.** Continue west.

43.7 Ford Hassayampa River. Usually very little water in river.

43.9 Fork. Geological Survey sign. Avoid road to south, which is Yuma road. (See pp. 126–129.) Continue west and northwest over rocky road around basalt hill. Avoid faint branch roads going north on north side of this hill.

45.1 Fork. Geological Survey sign. Turn northwest (right). Road straight ahead is an alternate route to Winters Wells but is seldom used. If main road is in bad shape it may be advisable to use this alternate. In the next 8 miles main road is chucky, with high centers in dry weather and very mudddy in wet weather.

53.2 Geological Survey sign. Road coming in on left goes to Arlington and also joins with the road straight ahead from mile 45.1, forming alternate route from Palo Verde to Winters Wells. Continue straight ahead along north side of Palo Verde Hills.

56.1 **Winters Wells.** Geological Survey sign. **Water.** No other supplies. Cattleman's camp.

56.2 Fork. Geological Survey sign. Continue straight ahead over fair to poor plains road, avoiding road on left.

62.5 Geological Survey Sign at **Palo Verde mine. Water** but no other supplies. Caretaker lives here. Continue over good plains road, avoiding branch road on right about 1 mile farther west.

68.0 **Big Horn Well.** Geological Survey sign. **Water** but no facilities for obtain-it. The road all the way from this well to Salome is a fair to good plains road.

71.7 **Burned Place Well.** Geological Survey sign. **Water** at faucet. Continue about 20 miles to Geological Survey sign, where road comes in on right. Thence about 1 mile farther to another Geological Survey sign.

93.1 Geological Survey sign. Road forks. Road on right is poor road to Wenden. Continue straight ahead for either Salome or Wenden. About 3 miles farther along main road there is another Geological Survey sign where a road comes in on left, crossing Centennial Wash.

97.0 **Tolladays Well. Water.** Usually someone living here.

97.1 Fork. Geological Survey sign. Take right-hand road.

99.0 (approximate). Geological Survey sign. Continue straight ahead, avoiding fork to right.

101.4 Fork. Geological Survey sign. Road on north (right) leads to Wenden, 4.0 miles distant, and is an alternate route to Parker. (See pp. 135–136.) Left-hand road at mile 101.4 leads northwest to Salome. Avoid faint roads south (left).

104.1 Railroad crossing. Geological Survey sign. Turn to right across railroad for Salome. If bound for Parker or Ehrenberg turn to left along railroad without crossing. (For log of remainder of route to Parker see pp. 134–135; to Ehrenberg, pp. 142–145.)

104.4 **Salome depot. Water,** gasoline, supplies, hotel, and post office.

TOLLADAYS WELL TO WENDEN (9 MILES).

[See p. 138 for log in opposite direction.]

This log is for the use of travelers going to Wenden or to Parker by way of Cunningham Pass. From Phoenix to Tolladays Well use log on pages 133–134.

0.0 **Tolladays Well.** Go west.

0.1 Fork. Geological Survey sign. Bear right on main road. Road on left goes to ranch.

2.0 Fork. Geological Survey sign. Keep straight ahead on main road. Road to right is abandoned road to Wenden.

4.4 Fork. Geological Survey sign. Turn to right. Road on left leads to Salome.

7.7 **Petes Well,** water. Continue north into Wenden, passing Geological Survey signs at reverse forks at miles 8.7 and 9.0.

9.2 Crossroads in Wenden. Geological Survey sign. Wenden railroad station is 0.1 mile to the east (right). If bound for Parker continue straight ahead at crossroads as indicated by the sign. **Water,** gasoline, and other automobile repairs, garage, stores, and hotels in Wenden.

SALOME TO PARKER (58 MILES).

[See pp. 136–137 for log in opposite direction.]

0.0 **Salome** railroad station. Go southwest across railroad.

0.3 Crossroads. Geological Survey sign. Turn to right along railroad. Road on south leads from Palomas, on southeast from Palo Verde and Phoenix, and on east from Phoenix, Wickenburg, and Wenden. Continue along railroad on good plains road to border of Granite Wash Hills.

3.8 Go southwest through Granite Wash Pass on good mountain road.

6.2 Emerge from hills and continue westward over good plains road near railroad.

10.6 **Vicksburg** railroad station. Water, groceries, and post office, but no automobile supplies. Continue westward as directed by Geological Survey sign over winding but good plains road along railroad, passing railroad well at McVay; usually no water obtainable.

30.7 **Bouse** railroad station. Water, gasoline, supplies, automobile repairs, hotels, and post office. Road north across railroad leads along Arizona & Swansea Railroad to Swansea. (See p. 142.) Leaving Bouse for Parker, turn south as directed by Geological Survey sign. Follow most traveled road south and west through town. In Bouse two roads leading south (left) to Quartzsite branch off the road to Parker. (See pp. 143–144.) These forks are marked by Geological Survey signs. After leaving Bouse follow graded dirt road near railroad. Roads leading to mines leave main road at miles 33.7, 34.4, and 35.2 but are not confusing. The road between Bouse and Parker was repaired and partly changed in winter of 1918. As these changes are not known, the exact log can not be given, but there is little danger of losing the way. In December, 1917, there was a good road, graded in part, from Bouse to mile 45.5, and this was being extended. The unimproved stretch between miles 45.5 and 50.4 was poor, with numerous sharp pitches and some sand.

50.4 Road swings west away from railroad on fair desert road.

51.6 Enter gully and continue down its sandy bed.

53.3 Turn north (right) out of gully and continue over fair sandy road.

58.0 Geological Survey sign at street corner. Turn east (right).

58.2 **Parker** railroad station. Water, gasoline, supplies, garages, hotels in town. Travelers bound for California turn north (left) at street corner opposite railroad station (Geological Survey sign) and continue to ferry over Colorado River. The exact location of this changes with the river. Follow ferryman's signs. Distance about 1¾ miles. Charges $2 per automobile (December, 1917). (For roads in California see Water-Supply Paper 490–B.) From Parker there is also a road down the river to Ehrenberg Ferry (see p. 145) and one east through Cunningham Pass to Wenden (see pp. 137–138).

WENDEN TO PARKER BY WAY OF BUTLER WELL (57 MILES).

[See pp. 137–138 for log in opposite direction.]

0.0 **Wenden** railroad station. Go southwest to railroad crossing.

0.1 Railroad crossing. Geological Survey sign. Go north across railroad.

0.3 Fork. Geological Survey sign on wooden post. Continue north, avoiding road to east (right) and also road just beyond it going west (left). Go straight ahead on fair to good plains road, poor when wet, to fork.

0.7 Fork. Geological Survey sign on wooden post. Continue straight ahead, avoiding road to left here and another faint one at mile 1.6.

4.2 Fork. Geological Survey sign. Continue north and northeast, avoiding road to northwest (left). The ascent of Harcuvar Mountains through Cunningham Pass commences soon after passing this signpost. Road across mountains is good.

8.2 Fork. Wooden sign marked "The Black Reef." Continue straight ahead, avoiding road on left to mine.

8.9 Fork. Wooden sign marked "Wenden, 9 mi. The Desert Mining and Development Co." Continue straight ahead, avoiding road on left leading to mine. Beyond this fork 0.2 mile is another road leading to same mine. On right of road, 100 yards away, near this fork, is a covered **well with good water** but no facilities for getting it. It is 62 feet to water, which can be obtained with a rope and bucket. Continue to summit.

9.5 Summit of Cunningham Pass. Just beyond the summit a mine road forks to left, marked by Geological Survey sign. Continue on main road down slope.

10.0 Fork. Continue on main road. Road on left leads to a mine.

10.1 Fork. Geological Survey sign. Right-hand road goes to Alamo, 30 miles north. Take left fork.

10.5 Fork. Geological Survey sign. Take right-hand road.

11.4 Fork. Geological Survey sign on wooden post; also wooden sign marked "Black Giant mine." Take left fork, avoiding road on right, which leads to the mine.

15.9 Fork. Geological Survey sign; also metal sign, without post, marked "Parker 42 mi. [pointing along left-hand road], Renada ranch 6 mi. [pointing along right-hand road]." Renada ranch has a well and water supply. For Butler Well and Parker take left fork and continue over fair plains road.

21.1 **Butler Well.** Geological Survey sign at crossroads. Road on right goes to **Renada ranch** (4.9 miles). Road to left goes down valley to **Graham Well.** Middle road, passing on left side of Butler Well, leads to Parker. Road for next 4 miles is good plains road, then good for 6 miles through spur of Buckskin Mountains.

22.2 Continue on main road, avoiding faint road on right.

24.4 Geological Survey sign. Continue straight ahead, avoiding road that comes in on right.

30.4 Fork. Geological Survey sign. Road to right goes to Midway and Swansea. Take left-hand road.

31.0 Fork at railroad. Geological Survey sign. Road on right along railroad goes to **Midway (water tank)**, about a mile distant, and to Swansea. For Parker turn to left along railroad.

31.2 Fork. Geological Survey sign. Road straight ahead along railroad goes to Bouse. For Parker turn to right and cross railroad.

31.6 Geological Survey sign. Road coming in on left joins road to Bouse along railroad at a Geological Survey sign, 0.3 mile south of point where Parker road crosses railroad. Parker road goes northwest 3 miles, then swings west, and goes through pass in small spur of Buckskin Mountains. Some sand in pass. Road from pass nearly to Osbornes Well is fair plains road. Avoid faint roads crossing or branching from it.

42.9 Fork. Geological Survey sign. Road on right leads to Osbornes Well, 1 mile distant. **Water** and shelter. Road straight ahead is main road to Parker.

43.9 Geological Survey sign. Road on right comes from Osbornes Well, 0.4 mile distant. Turn to left and continue on main road to Parker. The road is fairly good for 7 miles, then very sandy for 6 miles.

57.2 **Parker** railroad station. Water, hotels, stores, and garages. Ferry over Colorado River; charge, $2 per automobile (in 1917).

PARKER TO SALOME (58 MILES).

[See pp. 134–135 for log in opposite direction.]

0.0 **Parker** railroad station. Go west.

0.2 Geological Survey sign at corner. Turn south (left) and continue over fair sandy road.

4.9 Turn east (left) and go up sandy bed of gully.

6.6 Leave gully and continue over fair plains road to railroad.

7.8 Road reaches railroad and runs southward along it. From this point follow main traveled road along railroad to Bouse. Road was repaired and partly changed in winter of 1918. As these changes are not known the exact log can not be given, but there is little danger of losing the way. Roads leading to mines leave the main one at miles 23.0, 23.8, and 24.5 but are not confusing. In December, 1917, there was a good road, graded in part, from mile 12.7 to Bouse, and this was being extended. The unimproved stretch between miles 7.8 and 12.7 was poor with numerous sharp pitches and some sand.

27.5 **Bouse** railroad station. Water, gasoline, supplies, automobile repairs, hotels, and post office. In the town of Bouse two roads leading south (right) to Quartzsite are passed. These forks are marked by Geological Survey signs. Leaving Bouse for Salome turn to right, keeping on west side of railroad as directed by Geological Survey sign at street corner opposite and south of railroad station. Continue along railroad over winding but good plains road to Vicksburg, passing railroad well at McVay; usually no water obtainable.

47.6 **Vicksburg** railroad station. Water, groceries, and post office, but no automobile supplies. Continue eastward as directed by Geological Survey sign over good plains road near railroad to border of Granite Wash Hills.
52.0 Go northeast through Granite Wash Pass over good mountain road.
54.4 Emerge from hills and continue over good plains road.
57.9 Crossroads. Geological Survey sign. Road north goes across railroad into **Salome.** Water, gasoline, supplies, hotel, post office, and railroad station. Road straight ahead along railroad goes to Wenden and Wickenburg and thence to Phoenix or Prescott. (See pp. 141–142.) Road southeast goes to Palo Verde, Buckeye, and Phoenix. (See pp. 138–139.) Road south goes to Harquahala and Palomas.

PARKER TO WENDEN (57 MILES).

[See pp. 135–136 for log in opposite direction.]

0.0 **Parker,** Santa Fe, Prescott & Phoenix Railway depot, garages, hotels, stores, water in town. Cross railroad track south of station and go east. Continue on the main road, avoiding any faint roads branching off from it. Road is very sandy for 6 miles from Parker, then fair to good plains road for 8 miles.
13.3 Fork. Geological Survey sign. Turn to right, avoiding road on left to **Osbornes Well** (0.4 mile). Water, shelter, no other supplies to reverse fork. Geological Survey sign. Road from fork near Osbornes Well is fair to good plains road. Continue straight ahead.
14.3 Fork. Geological Survey sign. Road forking back to left is fairly good road to Osbornes Well (1 mile). Continue to pass in small spur of Buckskin Mountains. Go through pass (some sand in pass). Road here swings east, then goes southeast 3 miles to fork, Geological Survey sign. Continue straight ahead to Arizona & Swansea Railroad, avoiding road forking to right. Latter joins road to Bouse along railroad at fork (Geological Survey sign) 0.3 mile south of point where Parker road crosses railroad. Cross this railroad to fork.
26.0 Fork. Geological Survey sign. Turn to left along railroad. Road on right goes to Bouse. Road for next 6 miles is good mountain road through spur of Buckskin Mountains, then good plains road for 4 miles.
26.2 Fork. Geological Survey sign. Turn to right. Road on left along railroad goes to **Midway (water tank)**, about a mile distant, and to **Swansea.**
26.8 Fork. Geological Survey sign. Continue straight ahead, avoiding road on left to Midway and Swansea.
32.8 Fork. Geological Survey sign. Avoid fork to left. Continue on main road.
35.0 Fork. Continue on main road, avoiding faint road on left.
36.1 **Butler Well** at crossroads. Geological Survey sign. Road on right goes down valley to Graham Well. Road on left goes to **Renada ranch** (4.9 miles). From Butler Well good plains road to point near fork.
41.3 Fork. Geological Survey sign and metal sign without post marked "Parker 42 miles, Renada ranch 6 miles [pointing along road forking back to left]." Road enters mountains shortly before reaching fork. Continue.
45.8 Fork. Geological Survey sign (wooden post) and wooden sign marked "Black Giant mine." Take right fork, avoiding road on left to mine.
46.5 Fork. Geological Survey sign. Turn to left, avoiding road on right.
47.1 Fork. Geological Survey sign. Take right fork; left fork goes to Alamo (30 miles).
47.2 Fork. Continue on main road, avoiding road on right to mine. Continue on main road up slope, avoiding mine road forking to right, marked by Geological Survey sign just before reaching summit.
47.7 Summit of Cunningham Pass. Continue on main road down slope. Road across mountains is good mountain road.

48.1 Fork. On left of road 100 yards away is covered **well,** good **water,** but no facilities for getting it. It is 62 feet to water, which can be obtained with a rope and bucket. From fork continue south.

48.3 Fork. Wooden sign marked "Wenden 9 mi., The Desert Mining and Development Co." Continue straight ahead, avoiding road on right to mine.

49.0 Fork. Wooden sign marked "The Black Reef." Continue southwest and south, avoiding road to northwest (right).

53.0 Fork. Geological Survey sign. Continue south and southwest, avoiding road to northwest (right) and another faint one farther south at mile 55.6. From this point to Wenden is fair to good plains road.

56.5 Fork. Geological Survey sign (wooden post). Continue south, avoiding road on right. Geological Survey sign.

56.9 Fork. Geological Survey sign (wooden post). Continue south on main road.

57.1 Railroad crossing. Geological Survey sign at crossroads on south side of railroad. Go east to Santa Fe, Prescott & Phoenix Railway station.

57.2 **Wenden,** Santa Fe, Prescott & Phoenix Railway station.

WENDEN TO TOLLADAYS WELL (9 MILES).

[See p. 134 for log in opposite direction.]

This log is for the use of travelers going to Phoenix by way of Cunningham Pass and Wenden. From Parker to Wenden use log on pages 137–138. From Tolladays Well to Phoenix use log on pages 138–139.

0.0 **Wenden** railroad station. Go west.

0.1 Crossroads. Geological Survey sign. Turn south.

0.3 Fork. Geological Survey sign. Turn to right. Road on left is poor road to Tolladays Well.

0.6 Fork. Geological Survey sign. Turn to right on main road.

1.6 **Petes Well,** water. Continue south.

4.9 Fork. Geological Survey sign. Turn to left. Road on right leads to Salome. Continue, passing Geological Survey signs at reverse forks at miles 7.3 and 9.2.

9.3 **Tolladays Well,** water.

SALOME TO PHOENIX BY WAY OF PALO VERDE AND BUCKEYE (104 MILES).

[See pp. 133–134 for log in opposite direction.]

0.0 **Salome** railroad station. Go southwest across railroad. The road all the way from Salome to Palo Verde mine is a fair to good plains road.

0.3 Crossroads. Geological Survey sign. Turn southeast (left) as indicated by sign. Road coming in on west along railroad leads from Parker (see p. 137); that along railroad on east leads to Wenden, Wickenburg, and Phoenix (see pp. 141–142), and that on south leads to Harquahala and Palomas (see pp. 150–151).

3.0 Fork. Geological Survey sign. Road coming in on left is from Wenden and is alternative route from Parker. Continue, passing Geological Survey signs at reverse forks at miles 5.4 and 7.3.

7.4 **Tolladays Well,** water, usually someone living here. Continue straight ahead.

7.7 Fork. Geological Survey sign. Continue straight ahead, avoiding road to right, which leads to cattle watering places in Harquahala Plain, used only by cattlemen.

11.3 Fork. Geological Survey sign. Road coming in on left is poor alternate road from Wenden. Continue straight ahead.

12.1 Fork. Geological Survey sign. Bear to right. Road on left goes to mine.

32.7 **Burned Place Well.** Geological Survey sign. Water, faucet is provided.

36.4 **Big Horn Well.** Geological Survey sign. Water but no facilities for obtaining it.

41.9 **Palo Verde mine.** Geological Survey sign. Water but no other supplies. Caretaker lives here. Continue straight ahead over fair to poor plains road.

48.2 Fork. Geological Survey sign. Continue on main road, avoiding road on right.

48.3 **Winters Wells.** Geological Survey sign. Water but no other supplies, cattleman's camp.

51.2 Fork. Geological Survey sign. Road on right leads to Arlington and also joins with a road which rejoins the main road to Palo Verde at mile 59.3, forming alternate route. When the main road is in bad shape it is sometimes advisable to use this alternate. For 8 miles from this fork the main road is chucky, with high centers in dry weather and very muddy in wet weather.

59.3 Geological Survey sign. Road coming in on right is alternate mentioned above. Continue over rocky road around basalt hill. Avoid faint branch roads going north on north side of this hill.

60.5 Fork. Geological Survey sign. Turn east (left), avoiding road to south, which is Yuma road. (See p. 127.)

60.7 Ford Hassayampa River. Usually very little water in river.

63.4 Crossroads at **Palo Verde.** For log of road from Palo Verde to Phoenix see Yuma to Phoenix log (p. 132).

ROUTE BETWEEN PHOENIX AND WENDEN OR SALOME BY WAY OF WICKENBURG.

PHOENIX TO WICKENBURG (62 MILES).

[See pp. 141–142 for log in opposite direction.]

0.0 **Phoenix.** Santa Fe, Prescott & Phoenix Railway station. Go north on Central Avenue to Van Buren Street.

0.5 Turn west (left) on Van Buren Street to Five Points.

1.0 Five Points. Turn northwest (right) on Grand Avenue (electric-car track). Continue northwest.

2.3 State Fair Grounds on right. End of electric-car track.

2.4 Railroad crossing and end of asphalt road. Cross railroad and then follow it.

3.8 Clarks station.

4.8 Alhambra station.

6.5 Kane siding.

8.7 Fair Hope Farm. Macadam road ends.

9.3 **Glendale** station. Water, gasoline, and supplies. Continue northwest along railroad, through town, avoiding roads crossing main one at miles 9.8, 10.2, and 10.8.

12.2 Railroad crossing. Cross railroad and canal and continue northwest along railroad.

13.6 **Peoria, water,** gasoline, and supplies. Continue northwest, passing Goodrich sign at crossroad just beyond station.

14.9 Crossroads.

15.4 New River. Cross on concrete dip.

15.6 Avoid branch road on right.

16.5 Crossroads. Transformer house. Marinette station.

16.8 Fork. Goodrich sign. Continue straight ahead, avoiding road on right.

17.6 Fork. Continue straight ahead, avoiding road on left.

18.0 Agua Fria River. Cross river, poor ford, quicksand in flood time. Continue northwest along railroad.

18.4 Fork at railroad water tank. Continue straight ahead, avoiding road on left.

19.7 Crossroads.

20.0 Ennis station.

20.1 Continue straight ahead, avoiding road on left.
21.8 Avoid road on left. Continue along railroad.
24.3 **Beardsley** siding. Section house. Road forks just beyond station. Continue straight ahead, avoiding road on left.
27.3 Hoover. Ranch buildings, abandoned well, no water. Continue along railroad.
33.4 New graded road starts.
35.9 Nada siding. Continue along railroad.
43.3 Cross railroad to **Hot Springs Junction.** **Water for sale** from railroad tank; also supplies and hotel. Continue northeast, leaving railroad and avoiding road on left, which leads to Wickenburg along railroad but is a poor road.
45.4 Avoid old road forking off on left.
46.1 Fork. Take left-hand road, avoiding road on right, which leads to Castle Hot Springs, 21.5 miles from this point.
46.8 Old road comes in on right.
49.9 Fork at **Santo Domingo Wash.** **Water in sand** approximately 300 yards downstream from road at all seasons. Runs on surface in rainy season. Take right-hand road.
50.2 Fork. Road on right goes to **Tub Springs,** 1.2 miles from this point, and rejoins road 0.8 mile farther on. Water in sand of Tub Springs Wash above and below road at all seasons, runs on surface in rainy season. Take left fork.
51.8 Road coming in on right leads to Tub Springs, 0.8 mile away. Continue northward on main road.
55.1 Road coming in on right leads to mining camps. Continue straight ahead.
57.1 Fork. Turn southwest (left).
61.5 Cross bridge over Hassayampa River and continue to Wickenburg.
61.8 **Wickenburg** post office. Water and supplies.

WICKENBURG TO WENDEN AND SALOME (58 MILES).

[See p. 141 for log in opposite direction.]

Most of this portion of the Parker cut-off was not traveled during the present investigation. The logs southwest and northeast are in large part adapted from that given in Arizona Good Roads Association Illustrated Road Maps and Tour Book, by Harry Locke, 1913.

0.0 **Wickenburg** post office. Go west along railroad.
0.1 Railroad crossing. Turn right across railroad.
0.3 Fork. Keep straight ahead, avoiding road on left.
0.6 House and **windmill.**
1.5 Another road from Wickenburg comes in on right. Continue straight ahead.
2.0 Fork. Tin sign. Road to left leads to Vulture mine, which is 11.7 miles from this point. Take right fork. Pass through northern part of Vulture Mountains.
10.3 Fork. Take left fork.
17.9 Road reaches railroad and continues along it.
21.2 Forepaugh. Continue along railroad, avoiding crossroads and forks leading off.
27.3 Road passes **windmill.**
29.1 **Aguila.** **Railroad water supply.** Continue along south side of railroad, avoiding crossroads and forks leading off.
52.6 **Wenden.** Water, gasoline, supplies, post office, and hotels. Road south from Wenden leads to Tolladays Well, Palo Verde, and Phoenix. (See pp. 138–139.) Road north leads to Parker through Cunningham Pass (see pp. 135–136), also to Alamo. Geological Survey sign at crossroads. Continue along south side of railroad over new graded county road.

58.0 Railroad crossing. Geological Survey sign. Turn right across railroad for **Salome** depot (mile 58.3), or continue along south side of railroad for Vicksburg and Parker. (See pp. 134–135.) Salome has water, gasoline, supplies, post office, and hotel. Road south from Salome leads to Harquahala and Palomas. (See pp. 150–151.) Road southeast leads to Tolladays Well, Palo Verde, and Phoenix. (See pp. 138–139.)

SALOME AND WENDEN TO WICKENBURG (58 MILES).

[See pp. 140–141 for log in opposite direction.]

0.0 **Salome** depot. Go west to railroad crossing and cross to south side.

0.3 Crossroads on south side of railroad. Geological Survey sign. Turn to left and continue on new graded county road along railroad.

5.7 **Wenden.** Geological Survey sign. **Water,** gasoline, supplies, post office, and hotels. Road south from Wenden leads to Tolladays Well, Palo Verde, and Phoenix. (See pp. 138–139.) Road north leads to Parker through Cunningham Pass (see pp. 135–136), also to Alamo. Geological Survey sign at crossroads. Continue along south side of railroad, avoiding crossroads and forks leading off.

29.2 **Aguila. Railroad water supply.** Continue along railroad, avoiding crossroads and forks leading off.

31.0 Road passes a **windmill.**

37.1 Forepaugh. Continue along railroad.

40.4 Turn southeast (right) away from railroad.

48.0 Road comes in on left. Continue southeast and later east, passing through northern part of the Vulture Mountains.

56.3 Tin sign. Road coming in on right leads to Vulture mine, which is 11.7 miles from this point. Continue northeast.

56.8 Fork. Both roads go to Wickenburg. Take right-hand road.

57.7 Road passes house and windmill.

58.0 Fork. Keep straight ahead, avoiding road on right.

58.2 Railroad crossing. Cross to east side.

58.3 **Wickenburg** post office. **Water** and other supplies.

WICKENBURG TO PHOENIX (62 MILES).

[See pp. 139–140 for log in opposite direction.]

0.0 **Wickenburg** post office. Go east across Hassayampa River bridge (0.3 mile), then north.

4.7 Fork. Goodrich sign. Turn east, avoiding road to north (left) on good mountain road.

6.7 Fork. Goodrich and two other signs. Take right-hand road, avoiding road on left to mining camps.

10.0 Fork. Road to left (wooden sign) goes to Tub Springs (0.8 mile), then rejoins main road 1.2 miles farther east. **Water in sand of Tub Springs Wash** at all seasons; runs on surface in rainy season. Continue on right fork (main road).

11.6 Fork. Road forking back on left goes to Tub Springs (1.2 miles), then rejoins main road 0.8 mile farther west. Continue straight ahead.

11.9 **Santo Domingo Wash.** Goodrich sign. Water in sand approximately 300 yards downstream from road at all seasons. Runs on surface in rainy season. Continue, avoiding old road on left (mile 15.0).

15.7 Fork. Turn south, avoiding road on north (left) to Castle Hot Springs (mile 21.5). Continue south to Santa Fe, Prescott & Phoenix Railway crossing at Hot Springs Junction (Goodrich sign), avoiding old road on right (mile 16.4) and road on left a short distance north of railroad. **Hot Springs Junction** is town of 14 houses, water for sale from railroad tank, supplies, hotel. Cross railroad and turn southeast (left) along railroad on graded road.

25.9 Pass Nada siding and continue. New graded road ceases at mile 28.4.

34.5 Pass Hoover, ranch buildings, abandoned well, no water, and continue.

37.5 Fork. Goodrich sign. Continue straight ahead, avoiding road on right and passing **Beardsley** siding, section house, just beyond fork, and a road to right (mile 40.0).

41.7 Fork. Goodrich sign. Continue straight ahead, avoiding road on right, passing Ennie siding (mile 41.8), and crossing road (mile 42.1).

43.4 Fork at water tank, wooden sign. Continue straight ahead, avoiding road on right.

43.8 Cross Agua Fria River, poor ford, quicksand in flood time. Continue southeast along railroad.

44.2 Fork. Continue straight ahead, avoiding road on right.

45.0 Fork. Goodrich sign. Continue straight ahead, avoiding road on left, cross road at transformer house, **Marinette station** (mile 45.3), cross New River on concrete dip (mile 46.4), cross another road (mile 46.9), and another one. Goodrich sign, just before reaching Peoria station.

48.2 **Pass Peoria station.** Water, gasoline, and supplies in town. Continue to railroad crossing. Sign on each side of railroad.

49.6 Cross canal and railroad and continue southeast along railroad, crossing roads at miles 51.0, 51.6, and 52.0, passing through town of **Glendale**. Water, gasoline, supplies, and hotels in town.

52.5 Pass Glendale station and continue past Fair Hope Farm. Macadam road starts here (mile 53.1). Pass Kane siding (mile 55.3), Alhambra station (mile 67.0), cross railroad, follow asphalt street (Grand Avenue) (mile 59.4), pass State Fair Grounds, and follow electric-car track (mile 59.5) to Five Points.

60.8 Turn east at Five Points on Van Buren Street to Central Avenue.

61.3 Turn south on Central Avenue.

61.8 **Phoenix.** Santa Fe, Prescott & Phoenix Railway station.

BOUSE-SWANSEA ROUTE.

The road from Bouse to Swansea runs northward along the Arizona & Swansea Railroad. At 12 miles from Bouse it crosses the Wenden-Parker road and continues along the railroad 10 miles to Swansea, a mining town which operates the only smelter in this section of the country. The first 12 miles from Bouse is a good desert road that keeps close to the railroad and crosses it four times. At 12 miles north of Bouse the road enters the mountains. The last 10 miles to Swansea was not traveled during the present survey. The road is reported to be a good mountain road. At Midway there is a water tank which is usually kept filled by the railroad company.

VICKSBURG-QUARTZSITE ROUTE.

VICKSBURG TO QUARTZSITE (30 MILES).

[See p. 143 for log in opposite direction.]

0.0 **Vicksburg** depot. Geological Survey sign. Go south and southwest over good plains road.

4.9 **Desert Well.** Water. Geological Survey sign short distance west of well. Bear to right, avoiding roads leading off to left, some of them to Twentymile Well, which is several miles southwest of this point and has emergency water supply. Cross adobe flat, which is miry in wet weather.

10.9 Geological Survey sign. Road coming in on left goes to Twentymile Well. Continue westward among hills and through valley, then ascend Plomosa Mountains over steep and very rough road.

19.7 Guadalupe mine, near summit. Abandoned; no water or other supplies. Descend mountains over a fair mountain road to the plain and continue westward.

24.4 Geological Survey sign. Road coming in on north (right) leads to Bouse. Continue straight ahead.

24.9 Geological Survey sign. Road coming in on south leads to Plomosa mine. Continue straight ahead over good desert road.

29.8 **Tysons Well. Water.** Continue straight ahead to Quartzsite.

30.0 **Quartzsite** post office. Water. From this place roads lead west to Ehrenberg and south to Dome and Yuma.

QUARTZSITE TO VICKSBURG (30 MILES).

[See pp. 142–143 for log in opposite direction.]

0.0 **Quartzsite.** Go east, passing Geological Survey sign near post office. Take left fork a short distance past this sign to Tysons Well. Geological Survey sign.

0.2 Continue to fork. Geological Survey sign. Good plains road to mountains.

5.1 Fork. Continue straight ahead, avoiding road on south (right) to fork. Geological Survey sign.

5.6 Continue straight ahead, avoiding road on north (left). Ascend Plomosa Mountains, fair mountain road, passing Guadalupe mine (abandoned; no water supplies) near summit.

10.3 Descend mountains, very rough mountain road, cross inclosed valley, and pass through hills to fork. Geological Survey sign. Road east (right) at fork goes to Twentymile Well (2.6 miles), where water could be obtained in an emergency. A road runs from Twentymile Well to Desert Well (4 miles), but it has high centers and chuck holes. Automobilists should use caution if they travel over it.

19.1 Fork. Geological Survey sign. Continue, passing **Desert Well** (mile 25.1). Water. Geological Survey sign. Road as far as Desert Well over adobe flats; look out for high centers, bad in wet weather. Road from Desert Well to Vicksburg is good plains road.

30.0 **Vicksburg.** Southern Pacific Railroad station and post office. Geological Survey sign. Road west to Parker, east to Wickenburg and Phoenix.

BOUSE-QUARTZITE ROUTE.

BOUSE TO QUARTZSITE (24 MILES).

[See p. 144 for log in opposite direction.]

0.0 **Bouse** railroad station. Cross railroad and go south, passing Geological Survey sign at corner of street.

0.2 Fork at which there is another Geological Survey sign. Road on right goes to Parker. Take road on left (west of south). The road from Bouse to Plomosa Mountains, 10 miles distant, is a good plains road, except for short stretch of silt just out of Bouse.

0.9 Fork. Geological Survey sign. Road on left goes to a mining camp, 10 miles away. Take road on right.

1.7 Road coming in on right is an alternate road from Bouse. Continue ahead.

7.2 Fork. Geological Survey sign. Road on left goes to Daly mines. Take right-hand road.

8.7 Fork. Geological Survey sign. Take left-hand road to Plomosa Mountains and across them.

12.4 Fork on west side of mountains. Geological Survey sign. Road on left goes to Plomosa mine. Take right-hand road. The road from this fork to Quartzsite is a good plains road.

23.8 Forks on outskirts of Quartzsite. Bear to right, avoiding road on left. Continue on main street to post office.

24.2 **Quartzsite** post office. Water, groceries, and hotel, but no automobile supplies. From the post office roads lead east to Vicksburg (see p. 143); west to Ehrenberg, Blythe, and Los Angeles (see pp. 144–145); south to Dome and Yuma (see pp. 146–148); and southeast to New Water Pass.

QUARTZSITE TO BOUSE (24 MILES).

[See pp. 143–144 for log in opposite direction.]

0.0 **Quartzsite.** Post office, water, groceries, hotel. No automobile supplies in town. Continue past post office on main street to fork at outskirts of Quartzsite. Road for 12 miles from this fork is good plains road.

0.4 Fork. Go to left, avoiding road on right.

11.8 Fork. Geological Survey sign. Continue straight ahead through Plomosa Mountains on good mountain road. Road coming in on right is from Plomosa mine.

15.5 Continue straight ahead. Road from the Plomosa Mountains to Bouse is good desert road except for a short stretch of silt just south of Bouse.

17.0 Fork. Geological Survey sign. Take right-hand road. Road coming in on left is from Daly mines.

22.5 Fork. Go straight ahead, avoiding road on left, which is alternate to Bouse.

23.3 Fork. Geological Survey sign. Take road on left. Road on right goes to a mining camp (10 miles).

24.0 Fork. Geological Survey sign. Take road on right. Road on left goes to Parker. (See log, p. 135.) Go north, passing Geological Survey sign at corner of street. Cross railroad to station. If bound east, turn east at sign.

24.2 Santa Fe, Prescott & Phoenix Railway station at **Bouse.** Road northwest through town leads to Swansea.

QUARTZSITE-EHRENBERG ROUTE.

QUARTZSITE TO EHRENBERG (19 MILES).

[See p. 145 for log in opposite direction.]

0.0 **Quartzsite** post office. Road for 12 miles from Quartzsite is fairly good but rough mountain road. From the post office go west, then southwest around a hill.

2.6 Fork. Geological Survey sign. Left fork goes to some mining camps. Follow right fork and continue west.

3.6 Fork. Geological Survey sign. Right fork goes to Keiser camp, 1 mile distant. Follow left fork and continue over winding road through Dome Rock Mountains.

9.1 **Gonzales Wells.** Water of fair quality. Continue along canyon.

10.2 Avoid road on right.

11.4 Fork. Avoid tracks on right, down the wash, which go to La Paz gold mine. Take road on left, emerging from mountains. There is good plains road for 5 miles after leaving the mountains. Road then descends to Colorado River flood plain and turns southwest.

12.6 Geological Survey sign. Avoid road coming in on right. Continue straight ahead.

16.6 Geological Survey sign. Road coming in on right goes to La Paz and to Parker, 43 miles distant. Continue over sandy river-bottom road southwestward to Ehrenberg Ferry.

18.8 **Ehrenberg Ferry.** Wooden shack, no supplies. Wooden ferry boat with cable across Colorado River; current furnishes motive power. Charges are $3 per automobile, $2 per wagon, and 25 cents per foot passenger (1917). The California side of the river is flooded at high water, caused by melting snow, and hence the ferry is usually not operated during the later part of May and during June, July, and a part of August. No well, but river water can be used if necessary.

EHRENBERG TO QUARTZSITE (19 MILES).

[See pp. 144–145 for log in opposite direction.]

0.0 **Ehrenberg Ferry.** Wooden shack, no supplies. Wooden ferry boat with cable across Colorado River; current furnishes motive power. Charges are $3 per automobile, $2 per wagon, and 25 cents per foot passenger (1917). The California side of the river here is flooded at high water, caused by melting snows, so that ferry is usually out of commission during the later part of May and during June, July, and part of August. Continue on sandy river-bottom road.

2.2 Fork. Geological Survey sign. Turn north (right), avoiding road forking at left (which goes to **La Paz** and **Parker,** 43 miles along Colorado River).

6.2 Fork. Geological Survey sign. Avoid road forking to left. Continue east.

7.4 Fork. Geological Survey sign. Take road on right, avoiding tracks leading back to left down wash, which go to La Paz gold mine. Continue, entering Dome Rock Mountains. Road from this point to Quartzsite is fairly good but rough mountain road.

8.6 Fork. Continue, avoiding road on left along canyon.

9.7 **Gonzales Wells.** Water of fair quality is obtainable. Continue on winding road through Dome Rock Mountains.

15.2 Fork. Geological Survey sign. Take right fork. Road forking back goes to Keiser camp (1 mile).

16.2 Fork. Geological Survey sign. Take left fork. Right fork goes to some mining camps. Go northeast, then east.

18.8 **Quartzsite** post office.

EHRENBERG-PARKER ROUTE.

A poor but passable road lies between Ehrenberg and Parker. From Ehrenberg it is the same as the road to Quartzsite for 2.2 miles, where a fork with Geological Survey sign is reached. At this fork take left-hand road, leading northward along edge of valley, past the abandoned town of La Paz. In December, 1917, the La Paz Gold Mining Co. started to drill wells a short distance east of La Paz.

Between La Paz and Parker there are several possible roads along the river. Water can be obtained from the river or from sloughs. Generally the water from these sloughs is fit for stock and can be used by man if it is boiled. Shallow wells on the Indian reservation yield salty water, none of which is probably drinkable.

QUARTZSITE-DOME ROUTE.

QUARTZSITE TO DOME BY MAIN ROAD (73 MILES).

[See pp. 148–149 for log in opposite direction.]

Only the new county road across La Posa Plain has been marked by the United States Geological Survey. The log of this road is given here. For log of old road see pages 147–148. This new road is much better for a stranger to follow because of the numerous confusing forks along the old one. The latter is considered better by many local people because, having been more traveled, it is harder.

0.0 **Quartzsite** post office. Go east to Geological Survey sign, then turn south, as indicated on sign, and continue to crossroads.

0.9 Crossroads. Geological Survey sign. Road on left (southeast) goes to New Water Pass, where there is a water supply. Road coming in on left (northeast) is from Tysons Well, on outskirts of Quartzsite. For Dome bear to the right. Fair to good plains road for 30 miles from this point to Castle Dome Mountains.

2.9 Fork. Geological Survey sign. Road on right is the old road. (See pp. 147–148.) Take left fork.

13.6 Crossroads. Geological Survey sign. The crossroad comes from the old road and **Sand Tanks** (about 1.5 miles northwest) on the right and leads eastward to New Water Pass. **Water** may be obtained at Sand Tanks by digging in a wash. Continue straight ahead. About 2 miles beyond this point the old road comes in on right.

26.2 Fork. Geological Survey sign. Avoid faint road forking back to right, and also a similar road just before reaching the sign. These roads go past the so-called Clark well, an abandoned dry hole at the side of the valley, and thence lead to Cibola on the Colorado. Road to Dome continues southward. The old road (winding) and the new road (straight) are close together and cross each other in several places. Follow the most traveled road.

28.7 Turn southeast (left) and enter pass in Castle Dome Mountains. Go through pass on good mountain road and emerge into small valley hemmed in by mountains.

30.9 Turn to right on leaving the pass.

32.0 Fork. Geological Survey sign. Right fork is a fairly good road to **Horse Tanks,** 1.8 miles from this point. These are a series of natural rock tanks extending up a canyon. Not difficult to find. Water for stock or automobile always obtainable, and usually some of the tanks have water clean enough for human consumption. Travelers desiring to go to tanks turn off at mile 32.0 and rejoin main route at 32.5. (See Pl. II.) Left fork is main road. Continue on main road unless water is needed.

32.5 Fork. Geological Survey sign. Road on right leads to Horse Tanks, 2 miles from this point. Continue straight ahead.

32.6 Fork. Geological Survey sign. Avoid fork on left, which is old road to Deep Well. Continue on right-hand road. It passes out of the small valley through a pass in low hills and then turns to the right and skirts the mountains. It is a good plains road.

39.4 Fork. Geological Survey sign. Avoid road coming in on left, which leads to Deep Well and Palomas. The road to Dome enters the Castle Dome Mountains and is in them for the next 4.7 miles. This part of the road is rough and has steep grades but is entirely passable for automobiles in good condition.

41.5 Geological Survey sign which indicates direction to **McPherson Tanks.** These are natural rock tanks, 1.5 miles up a canyon from the road. Water obtainable at all seasons, usually clean and good. It would be possible to drive a wagon up the wash near to these tanks, but an automobile could not get far from the main road. Continue on main road, steep down grades, to border of mountains. Then follow along edge of mountains to Geological Survey sign.

44.1 Geological Survey sign indicationg direction to **Ladder Tanks.** These are natural rock tanks half a mile up a canyon from the road. Water obtainable at all seasons, usually clean and good. It would be possible to drive a wagon up the wash nearly to these tanks, but an automobile could not get far from the main road. Main road continues southward near edge of mountains.

47.9 **Castle Dome.** Old mining camp, usually someone living here. Water but no other supplies. Water can usually be obtained from tank at mine shaft or from pipe at houses, if this is in repair. Continue, passing schoolhouse. Several Goodrich signs at points where mine roads branch off show main road. Road from Castle Dome to Gila River (23.2 miles) is excellent desert road.

48.9 Fork. Geological Survey sign. Take right fork. Road on left goes to mining camp.

49.6 Geological Survey sign. A branch road on the left leads back to same camp. Continue on main traveled road southwestward, away from the mountains, avoiding faint roads that branch off. There are Goodrich signs at some of these forks.

67.2 Fork. Geological Survey sign. Road coming in on left goes to Thumb Butte mine, 15.2 miles distant, and points beyond. It was at one time an alternate route to Phoenix but is now not used. Water is obtainable in prospect holes at Thumb Butte mine. Road to Dome continues southward.

68.4 Fork. Either road leads to Dome. Left one avoids steep pitch coming out of wash and is therefore somewhat preferable. Mileage given is on left-hand road. The other is 0.3 mile shorter.

69.7 Alternative road comes in on right.

71.2 Point where road descends from terrace to flood plains of Gila River. Old buildings, corrals, and a well containing water that is undrinkable, with windmill that is out of order. From this point cross river flood plain to Dome, on the south bank. There are several roads. Take the most traveled one. This crossing is sandy but usually not very difficult except when river is high. At such times a Mexican is usually at hand to push cars across the stream on a flat boat. When the river is actually in flood this crossing is impassable.

73.3 **Dome** post office. Water, gasoline, oil, supplies, hotel, and railroad station. The water is somewhat salty but drinkable. Road west leads to Yuma (p. 129). Road east leads to Phoenix (pp. 130–132).

QUARTZSITE TO DOME BY OLD ROAD ACROSS LA POSA PLAIN (73 MILES).

[See p. 150 for log in opposite direction.]

Many local people prefer this road to the new county road, because they are more used to it and also because the old road, having been more traveled, is harder. The distance is practically the same. The numerous roads branching off the old road make it rather easy for a stranger to lose his way. No signposts have been erected by the Geological Survey. Strangers are recommended to use the new road.

0.0 **Quartzsite** post office. Go east to Geological Survey sign, then turn south as indicated on sign and continue to crossroads.

0.9 Crossroads. Geological Survey sign. Road on left (southeast) goes to New Water Pass, where there is a water supply. Road coming in on left (northeast) is from Tysons Well, on outskirts of Quartzsite. For Dome bear to the right.

2.9 Fork. Geological Survey sign. Road on left is new road. Road on right is old one. Take road on right.

3.6 Fork. Take left-hand road.

3.9 Abandoned well. No facilities, but **water could be obtained with a rope in emergency.** Depth to water is 36 feet. Continue southward.

5.5 Fork. Road on right goes to **Kuhn's windmill,** 0.6 mile distant. Water usually obtainable when windmill is pumping. Was sucking air when visited in November, 1917. There is a wash which may be difficult to cross just before reaching windmill. To continue on old road to Dome take left fork at mile 5.5.

11.4 Fork. Road on left joins the new road from Quartzsite to Dome. It has several branches, all leading in the same general direction. The distance from this fork to the Geological Survey sign, at the crossroads at mile 13.6 on the new road (see p. 146), is a little over 2 miles. Travelers bound for Dome should use main log of Quartzsite-Dome road from this sign, or, if it should be missed, from the next sign, which is at mile 26.2. Road on right at the forks on the old road at mile 11.4 is the road to Cibola. It continues to a big wash, 0.8 mile farther on, where water is obtainable by digging a foot or two in the sand of the wash. This place is known as **Sand Tanks.** It is possible to reach the Quartzsite-Dome road from the Sand Tanks by striking off to the east (left) across the desert, following old roads in part but picking one's own way for most of the distance over the desert surface, which makes a good road. Distance is 1.8 miles. If one takes this course he will strike the main Quartzsite-Dome road about a quarter of a mile south of the Geological Survey sign at mile 13.6. If bound for Dome turn to the right on the main road and continue southward, using log of Quartzsite-Dome road. (See p. 146.) Just beyond the wash where the water is available (Sand Tanks) the road forks. The left-hand road goes to Cibola, and the right is an abandoned road to Ehrenberg.

DOME TO QUARTZSITE BY MAIN ROAD (73 MILES).

[See pp. 146-147 for log in opposite direction.]

0.0 **Dome** post office. Water, gasoline, oil, supplies (including feed for horses), hotel, and Southern Pacific Railroad station. Cross the Gila River flood plain on one of the several roads. Take the most traveled one. This crossing is sandy but usually not very difficult except when river is high. At such times a Mexican is at hand to push cars across the stream on a flatboat. When the river is actually in flood this crossing is impassable. This road reaches a point on the northern bank of the flood plain of Gila River where there are old buildings, corrals, and a well with windmill. Windmill is out of order, and water in well is undrinkable.

2.1 At windmill ascend terrace and continue north.

3.6 At fork the road to left is left-hand road to next fork. Either road leads to Quartzsite. Right one avoids a steep pitch into a wash and is therefore somewhat preferable, especially going south. Mileage given is on righthand road. The other is three-tenths of a mile shorter.

4.9 At fork the road coming in on left is left-hand road from last fork.

6.1 Fork. Geological Survey sign. Avoid road forking to right. This goes to Thumb Butte mine (15.2 miles) and beyond. It was at one time an alternate route to Phoenix but is not now used. **Water** is obtainable in prospect holes at **Thumb Butte mine.** Continue on main traveled road, avoiding faint roads branching off. There are Goodrich signs at some of these forks.

23.7 Fork. Geological Survey sign. Continue on left-hand road, avoiding road on right to mining camp.

24.4 **Fork.** Geological Survey sign. Take road on left. Road on right goes to mining camp. Several Goodrich signs beyond fork at points where mine roads branch off show main road.

25.4 **Castle Dome,** old mining camp, usually someone living here. Water but no other supplies obtainable. Water can usually be obtained from tank at mine shaft, or from pipe at houses, if this is in repair. Follow along edge of mountains.

29.2 Geological Survey sign indicates direction to **Ladder Tanks.** These are natural rock tanks up a canyon half a mile off road. Water obtainable at all seasons, usually clean and good. It would be possible to drive a wagon up the wash near to these tanks, but an automobile could not get far off the main road. From this sign the road goes through Castle Dome Mountains for 4.7 miles. It is rough and has steep grades but is entirely passable for cars in good condition. Continue from border of mountains up steep grades.

31.8 Geological Survey sign here indicates direction to **McPherson Tanks.** These are natural rock tanks up a canyon 1.5 miles off road. Water obtainable at all seasons, usually clean and good. It would be possible to drive a wagon up the wash near to these tanks, but an automobile could not get far off the main road. Continue straight ahead.

33.9 Fork. Avoid road forking off on right, which goes to Deep Well (no water) and Palomas. From this point the road skirts the mountains (good plains road) and then enters inclosed valley through pass in low hills.

40.7 Fork. Geological Survey sign. Avoid fork on right, which is old road to Deep Well.

40.8 Fork. Geological Survey sign. Continue straight ahead. Road on left leads to **Horse Tanks** (2 miles). Northbound travelers use this to go to the tanks and the one farther west to rejoin the main road. Southbound travelers desiring to go to tanks turn off at mile 41.3 and go to tanks, and use this road to return to main road. Horse Tanks are a series of natural rock tanks extending up a canyon. No difficulty in finding them. Water for stock or automobile always obtainable. Usually some of the tanks have water clean enough for human consumption.

41.3 Geological Survey sign. Road coming in on left is from Horse Tanks.

42.4 Turn to left and go through pass on good mountain road to turn on west side of Castle Dome Mountains. Fair to good plains road for 30 miles from Castle Dome Mountains to Quartzsite.

44.6 Turn north.

47.1 Fork. Geological Survey sign. Avoid faint road forking on left, and also similar road after passing the sign. These go past abandoned dry well at side of valley to Cibola. Along this portion of route the old road (winding) and the new road (straight) are close together and cross each other in several places. Follow most traveled road.

59.7 Crossroads. Geological Survey sign. Continue straight ahead. Road to left is old road to Quartzsite (see log, p. 150). Road on right leads to New Water Pass.

69.7 Reverse fork. Geological Survey sign. Continue straight ahead. Road coming in on left is old road across La Posa Plain.

70.4 Crossroads. Geological Survey sign. Road coming in on right is from New Water Pass. Road on northeast (right) leads to Tysons Well on the outskirts of Quartzsite. If bound for Vicksburg or Bouse, a small distance will be saved by using this road. Geological Survey sign at well. For Quartzsite bear to left.

73.3 **Quartzsite** post office.

DOME TO QUARTZSITE BY OLD ROAD ACROSS LA POSA PLAIN (73 MILES).

[See pp. 147–148 for log in opposite direction.]

The old road across La Posa Plain is preferred to the new county road by some people but is not recommended to strangers. (See p. 147.) Several faint roads which lead to the old road fork to the northwest off the county road in the southern part of La Posa Plain. None is now very distinct. The most distinct at the time of visit was that at which a Geological Survey sign was erected, so the log will be given from this point. From Dome to these crossroads use log of main road (pp. 148–149).

59.7 Crossroads on county road across La Posa Plain. Geological Survey sign. For old road turn to left.

61.7 Road comes in on left from Cibola. Continue north.

67.6 Fork. Road on right goes to **Kuhn's windmill** (0.6 mile). Water obtainable when windmill is pumping; was sucking air when visited in November, 1917. There is a wash which it may be difficult to cross on the windmill road just before reaching windmill. From fork continue north to abandoned well.

69.2 Well, abandoned. No facilities but could get **water** with a rope in emergency. Continue to reverse fork.

69.5 Continue north to reverse fork. Road coming in on right is new road across La Posa Plain from Dome.

70.2 From fork continue north to Quartzsite.

73.1 **Quartzsite** post office.

HARQUAHALA ROUTE.

SALOME TO PALOMAS BY WAY OF HARQUAHALA (65 MILES).

[See p. 151 for log in opposite direction.]

0.0 **Salome** depot (Santa Fe, Prescott & Phoenix Railway). Go west to railroad crossing.

0.3 Cross railroad. Take road going due south (straight ahead). Good desert road. Geological Survey sign here indicates the proper road. Continue past Mesquite Well (0.8 mile), avoiding faint branch roads. Good water at Mesquite Well when windmill is pumping. Pool is dirty.

4.2 Enter Little Harquahala Mountains. Follow main road to Harquahala mine office and post office, avoiding faint roads and trails leading off into mountains. Good mountain road, excellent when in repair.

9.0 **Harquahala** mine office and post office. Water but no supplies. Go past post office down valley, emerging from mountains at mile 10.3. It is not necessary to ascend hill to post office if not desired. Several roads lead through old town at base. Continue east of south across Harquahala Plain. Old road here too deeply worn in places to be used. Follow more recent tracks alongside of it or make new one. No difficulty is likely to be experienced in doing this.

20.4 Cross end of Eagle Tail Mountains through low pass. Cross valley to edge of hills.

28.9 Pass through gap in hills along wash. Road is in bed of wash for greater part of a mile; heavy going. Dead Man's Tank or Road Tank in this wash unreliable; dry when visited.

30.9 Emerge from hills and go southeast on good desert road to fork.

39.2 Turn south (right). Road on east (left) goes to **Clantons Well** (0.6 mile), **water**, and then continues to Arlington (little used). The faint road on northwest goes to a mining camp. Go through gap in hills. Continue south on good plains road.

62.6 Road to east (left) goes to Agua Caliente (mile 12.3) and Phoenix (mile 110.4). (See mile 88.1 of log on p. 130.) Continue straight ahead on fair to poor river-bottom road.

65.3 **Palomas.** Water. From Palomas a road leads southwest to Yuma and another south to Aztec on the Southern Pacific Railroad.

PALOMAS TO SALOME BY WAY OF HARQUAHALA (65 MILES).

[See pp. 150–151 for log in opposite direction.]

0.0 **Palomas** post office. Go north on main Phoenix-Yuma road. About a mile from post office avoid tracks leading east (right). There is a Geological Survey sign here. Continue north over a rather poor road.

2.7 Fork. Geological Survey sign. Go straight ahead. Road on right goes to Agua Caliente (12.3 miles) and Phoenix (110.4 miles) from this point. (See mile 88.1 of log on p. 130.) Take road straight ahead for Harquahala and Salome. Good plains road.

25.0 Pass through gap in hills.

26.1 Fork. Geological Survey sign. Road on right across wash goes to **Clantons Well,** half a mile distant. Water. Thence the road continues to Arlington, but it is little used. Road nearly straight ahead goes to mining camp. To continue to Harquahala take left-hand road. It is a good plains road but is faint in some places.

34.4 Gap in hills on right of steep-sided butte. Pass through gap along wash. Road is in bed of wash for nearly a mile and is somewhat difficult for automobiles. Dead Mans Tank, or Road Tank, is in this wash but is unreliable as a watering place. Continue on good plains road toward west end of Eagle Tail Mountains.

44.9 Low pass across end of Eagle Tail Mountains. Go through the gap, then straight across the desert toward the Little Harquahala Mountains. The road here is too deeply worn in places to be used. Follow more recent tracks along side of it or make new tracks. The desert surface makes good natural road.

55.0 Enter Little Harquahala Mountains along wash.

56.3 **Harquahala mine** office, post office, and **water,** but no other supplies. It is possible to continue to Salome without going quite to post office. From the post office go north downhill and continue down the valley. The road from Harquahala to Salome is good; excellent when in repair.

61.1 Road leaves mountains.

64.5 **Mesquite Well.** If windmill is pumping good water is available; that in pond is dirty. Avoid faint branch roads and trails which lead off the main road at several points.

65.0 Railroad crossing. Geological Survey sign. Cross the railroad.

65.3 **Salome** depot. Water, gasoline, supplies, hotel, and post office

ROUTES TO ALAMO SPRING.

It is probably not possible to reach Alamo Spring by automobile, but several roads extend close to it. The old road, still in fairly good condition, through Middle Well and Deep Well to Kofa can be easily traveled by automobile. From Kofa there are trails across the S. H. Mountains to Alamo Spring.

Another route is from Quartzsite through New Water Pass to Alamo Spring. Automobiles can reach New Water Pass where there is a water supply. Prospectors frequently make their headquarters here and travel east toward Alamo Spring with burros. Several trails are reported.

Cattlemen enter the Alamo Spring country from the east by taking the new road from Arlington through Gila Bend Mountains to a fork 20.1 miles from Arlington. Here they take the right-hand road to Clantons Well, a distance of roughly 20 miles. From Clantons Well they have made a road for about 28 miles farther to Hoodoo Wells. These wells are not very far from Alamo Spring.

Another possible route extends across the Ranegras Plains from Vicksburg in a direction a little east of south. There is reported to be no well-defined road, but several trails lead in this general direction. No automobile is known to have gone the whole distance, roughly 30 miles, from Vicksburg to Alamo Spring, but certainly most of the trip could be made in a car and possibly all of it. With animals this route presents no difficulties except the lack of water.

DETAILED DESCRIPTIONS.

In the following pages most of the routes for which logs are given above are described in greater detail. A cross reference to the log is given at the head of each description.

PHOENIX TO YUMA.

[For log see pp. 126–132, and for data on numerous recent changes see pp. 229–230.]

Phoenix.—Phoenix is the capital of Arizona and the county seat of Maricopa County. In 1910 its population was 11,134; in 1920, 29,053. It is a progressive and prosperous city, the commercial center of the rich Salt River valley. Almost all the important roads in Arizona pass through Phoenix, as do all the so-called national highways that cross the State except the one that passes through Holbrook, Flagstaff, and Kingman, farther north.

Phoenix was founded in 1868.[77] In 1871 it had a population of 75, of whom 1 was a woman. In 1877 about 500 people lived there, half of them Mexicans. In 1871 the county of Maricopa was established. In 1879 the Southern Pacific Railroad, which was being built eastward, reached Maricopa, and this greatly increased the amount of freight passing through Phoenix. In the early days the town, in common with all its contemporaries, was rough and crimes were frequent. In 1879 vigilantes were organized, and the town reformed. On July 4, 1887, the Maricopa & Phoenix Railway was completed, giving Phoenix railroad connection with the transcontinental line of the Southern Pacific Railroad. In 1889 the town, now grown to a small city, was made the Territorial capital, and in 1912 it became the State capital. March 12, 1895, the line of the Santa Fe, Prescott & Phoenix Railroad reached the city, furnishing connection with the Atchison, Topeka & Santa Fe Railway at Ash Fork. The Arizona Eastern Railroad has branches extending both east and west of the city.

Salt River project.—The prosperous farms that cover the Salt River valley in the neighborhood of Phoenix present a striking and pleasing contrast to the dry and desolate desert and the mountain country which surround this area. Almost all of this farming country is supplied with the essential irrigating water by the Salt River project of the United States Reclamation Service.[78] Reconnaissance work on this project was started in 1902. The Roosevelt dam was completed February 5, 1911, and the whole project was completed June 30, 1917. The Service is prepared to furnish a permanent supply of water to 192,077 acres, and during periods in which the reservoir is full it can give a temporary supply to an additional 20,889 acres. In 1917 815.5 miles of canals were in operation. The gross cost of constructing the project was $14,440,874.47. The value of the irrigated crops in the season of 1916 was $8,435,719, that for 1918 was $18,188,800, and that for 1919

[77] Report of the governor of Arizona, 1899, pp. 192–196.

[78] U. S. Reclamation Service Sixteenth Ann. Rept., pp. 45–59, 1917.

was $23,768,682, according to the reports of the Reclamation Service. Many kinds of crops can be raised here, including alfalfa, barley, cotton (mostly long staple), corn, fodder crops, wheat, olives, and numerous other varieties of fruit. The very profitable crop long-staple cotton can not be raised successfully anywhere in the United States except in the arid regions of the Southwest, where it thrives. The area planted in cotton, mostly long staple, in 1917 under this project was about 25,000 acres.

The following quotation from the report of the Reclamation Service cited above will give a good idea of the general features of this project:

The irrigation plant of the Salt River project provides for the storage of water in the reservoir created by the building of the Roosevelt dam, which is situated at the confluence of Tonto Creek and Salt River, about 70 miles northeast of Phoenix, Ariz. This stored water is carried down Salt River to a point about 4 miles below the mouth of the Verde River, where together with such water as may be discharged by the Verde it is diverted to the North and South Side canal systems by the Granite Reef diversion dam. The water supply for the canals on the north side of the river is further augmented by the water diverted by the Joint Head diversion dam.

There have been completed and put into operation nine pumping plants with an approximate capacity each of 10 second-feet. A pumping plant located at the junction of the Western canal and the Kyrene branch pumps water through a 54-inch pressure pipe 5,930 feet long to an elevation of 40 feet and waters approximately 7,500 acres of land. The United States claims all waste, seepage, unappropriated springs, and percolating water arising within the project and proposes to use such water in connection therewith.

The canal and lateral system at present comprises 815.5 miles and on completion of the project provides for the delivery of water to each 160-acre tract of irrigable land.

A power plant located at Roosevelt generates power from stored water in the reservoir and from water delivered from the power canal, heading at a diversion dam in Salt River 19 miles above the storage dam. Three other power plants have been constructed by the water users' association and have become a part of the project, viz, the South Consolidated, the Arizona Falls, and the Cross Cut. A portion of the power developed will be used for pumping water for irrigation and the remainder for industrial purposes.

The principal features are the intake dam and power canal, the Roosevelt dam, Granite Reef dam, Joint Head dam, the main canals of the distributing system and the greater part of the lateral system, and the power system, comprising four power plants, transformer house, transmission lines, switching station, and four substations. Some work remains to be done on the sluicing tunnel through the Roosevelt dam, and rather extensive repairs are now needed on the intake dam and Granite Reef dam.

The maximum observed output during the year was 12,900 kilowatts. The gross income from the sale of power for the year was $491,812.51.

Phoenix to Coldwater.—For the first 30 miles out of Phoenix the route usually followed is the "Buckeye road." From Phoenix to Cashion this is a graded dirt road, usually kept in fairly good condition. It passes through a prosperous farming country, part of the Salt River project. Cotton is the principal crop grown, but several stock farms are passed. Plate XV, *B*, shows a typical field of long-staple cotton.

At Cashion, a siding and station on the Arizona Eastern Railroad, Buckeye Line, there is a store at which gasoline, oil, and some general supplies can be purchased; also a meat market, an eating house, and a garage. Water is piped here from the Cashion ranch; it is likely to be warm, tastes of the pipe, and is somewhat mineralized.

From Cashion the dirt road continues straight west for 1½ miles, swings to the right across the railroad, then to the left on a concrete roadway across the eastern channel of Agua Fria River. This is the eastern approach of a bridge that is to be built across the river. The work of bridging the river was not complete in 1917 and it was necessary to ford the western channel of the stream. This is seldom difficult unless the river is in flood. At Coldwater, on the west bank of the Agua Fria, is a store at which gasoline, oil, groceries, and some other supplies can be purchased, and a well yielding excellent water.

To the northwest are the White Tank Mountains, a striking range rising abruptly from the plain to a maximum altitude of about 5,000 feet. Their bold fronts and rather steep slopes are carved from coarse-grained massive granite, cut by small dikes of pegmatite, diabase, and other igneous rocks. A few of the peaks are capped with lava.

To the south, beyond Gila River, is the Sierra Estrella, with altitudes of 4,000 feet and over. These mountains are composed principally of somewhat gneissoid granite of pre-Cambrian age but also contain Mesozoic intrusives.[79]

The Southwest Cotton Co., a subsidiary of the Goodyear Tire & Rubber Co., owns about 14,000 acres in Tps. 1 and 2 N., Rs. 1 and 2 W., of which 1,700 acres was planted in cotton in 1916. This company has a number of wells which it was testing for use in irrigating its land and expected to put down others. Data on these wells are given in the tables on pages 86–88.

Coldwater to Buckeye.—At Coldwater the railroad swings southwest but the road continues west. The scattered houses of Avondale are passed on the south and the land of the Southwest Cotton Co. on the north. The road from Coldwater west for 9 miles is on soft silt. The traffic is often heavy, and consequently the road usually has stretches of almost continuous chuck holes. About 2½ miles out of Liberty the country irrigated by the Buckeye canal is entered, and the character of the road improves because the loamy soil makes better road material.

Liberty is a pleasant farming village. The population was 150 in 1910 and 425 in 1920. It has a store and post office at which gasoline, oil, groceries, and supplies can be bought and good water obtained. A mile east of the store is an attractive-looking school building, and the village contains two churches.

West of Liberty the road, which is usually in rather good condition, passes for nearly 4 miles through alkali land, where little agriculture is possible. From the far edge of the alkali land the road to Buckeye goes through a prosperous-looking farming district.

Buckeye had a population of 375 in 1910 and 726 in 1920. It had in 1918 a post office, ice plant, moving-picture house, school, telephone exchange, garage at which repairs could be obtained, and several stores, including a meat market. Several wells furnish excellent water. About three-quarters of a mile south of the town is a hotel where meals and lodging may be had. Buckeye is the center of the irrigation project of the same name. The Buckeye canal, which is over 20 miles long, heads on the north bank of the Gila near the mouth of Agua Fria River. It was reported in 1917 to be irrigating more than 19,000 acres. Among the crops grown are cotton, alfalfa, millo maize, and corn.

South of Gila River, opposite Buckeye, a new project has recently been started by the Gila Water & Land Co. in the district served by the old Joshlin ditch. Water is obtained by pumping from Gila River. The plant was installed in 1916 but was damaged by floods. For this and other reasons irrigation on a commercial scale did not begin until March, 1917. At the time of visit (October, 1917) cotton, wheat, millo maize, corn, and alfalfa were being successfully raised.

The Buckeye Hills are south of and partly encircle the farms irrigated by this project. They are composed principally of granite but appear to contain also a small amount of schist. Powers Butte, an outlier of these hills, near

[79] Schrader, F. C., unpublished report.

Arlington, consists of much younger rock, mostly flat-lying beds of lava, probably of Tertiary age. Tertiary rocks, both lava and sedimentary, are also found at the Gillespie dam, at the west end of the Buckeye Hills.

Buckeye to Gila Bend.—A quarter of a mile west of the main street of Buckeye is a road running south across Gila River to Gila Bend, a distance of about 35 miles. It is reported that a large proportion of the travelers from Phoenix to Yuma in recent years use this road to Gila Bend and follow the Southern Pacific Railroad to Yuma. From the fork the route is south to Gila River on a fairly good section-line road. The bed of Gila River is here about a mile wide. In 1918 difficulty in crossing the river at this point was to be expected, but the increased traffic since then has probably resulted in improvement of the road. Beyond the river the road passes irrigated farms and crosses the Buckeye Hills, where it is rough but has easy grades. Thence it extends southwest and south to Gila Bend. There are no steep grades and few places where doubt as to the correct road might arise.

Buckeye to the Gila Bend Mountains.—From the fork near Buckeye the main road on the north side of the river continues west past irrigated farms, most of which have wells, to Palo Verde. It is a good dirt road, generally kept in fair repair.

Palo Verde is a farming community with a population in 1920 of 325. In 1918 it contained three stores, a post office, a blacksmith shop, and a large, attractive schoolhouse. Gasoline, oil, tires, groceries, and supplies can be bought. Good water can be obtained from the schoolhouse well and from several others west and north of the town.

From Palo Verde the dirt road continues west across Hassayampa River, whose sandy bed has but little water in it at most seasons. Frequently a small amount of waste water from the Buckeye canal, which ends at the river somewhat over a mile north of the road, is present at the crossing. There is rarely any difficulty in crossing the river except when it is in flood.

A short distance beyond the Hassayampa the road forks, and this fork is marked by a group of signs, including a Geological Survey sign. One road that continues west around the north side of a small basalt hill and is known as the Parker cut-off offers an alternate route to Los Angeles by way of Parker or Ehrenberg. The other road, which is the Yuma route, turns abruptly south and skirts the east and south sides of a basaltic lava flow to Arlington. Ancient pictographs can be seen at several places on the low cliff that forms the southeast end of the lava flow. A number of specimens of the basalt with the Indian writing on them have been removed, so that now only the poorer examples remain. The road around the base of this cliff is on soft silt and is consequently very difficult to keep in good repair. Not infrequently portions of it are flooded by the Arlington canal, which flows along the east side of the road and crosses it through a concrete culvert just before the road bends west. Arlington precinct had in 1910 a population of 75; in 1920 this had increased to 299. The houses are scattered over a considerable area, mostly south and west of the store. Irrigation is carried on, the water being obtained from Gila River by means of the Arlington canal. The home camp of the Flower Pot Cattle Co. is at Arlington. The green-roofed bungalows of two of the partners in this company are on the Yuma road just west of the store and post office. At this store gasoline, oil, and general supplies can be purchased.

From the Arlington store either the road going south and then west or that going west and then south can be used by the traveler bound for Yuma. The latter is usually somewhat preferable. These roads come together about 2 miles from Arlington. The distance on each is approximately the same.

The Gila Bend Mountains, one of the largest ranges in this part of Arizona, lie between Arlington and Agua Caliente, the next settlement on the road to Yuma. There are two roads across them known as the old and new roads. The new road is at present much more generally used by automobilists than the old one. For this reason and because drinkable water is to be had at somewhat shorter intervals, the new road is slightly the safer of the two. This road is, however, about 3 miles longer and has steeper grades than the old one. Consequently, parties traveling with stock often take the old road.

New road across the Gila Bend Mountains.—From the crossroads 2 miles southwest of Arlington, where the new road starts, it runs over the desert to the mountains, going through a portion of the extensive mesquite thickets that mark the course of Centennial Wash. During the greater part of the year this road is good, but it becomes somewhat cut up if there is much travel over it during a protracted spell of dry weather. In the thickets of Centennial Wash there is a road fork marked by a Geological Survey sign. The road to the northwest leads past the Red Water Well of the Flower Pot Cattle Co. to a junction with the old road through Eagletail Valley that was used by freight teams between Harquahala and Phoenix before the railroad came. This road passes within short distances of three other wells, also belonging to the Flower Pot Cattle Co., which is the largest stock raiser in this section of the State.

On reaching the border of the Gila Bend Mountains the new road passes the Surprise windmill belonging to the Flower Pot Cattle Co. From this point it winds across a hummocky plain dotted with lava hills, passing the Dixie mine, which is worked intermittently for copper. There is a well on the west bank of the wash just west of the mine buildings and a few yards north of the road. When the miners are there it is cared for, and at such times excellent water can be obtained from it. In spite of the trap door that covers the well it seems to be possible for animals, such as rabbits and rats, to find an entrance. When they do they drown. If no one is living at the mine to clean the well out, the bodies of these unfortunate animals remain in the well and render the water unfit to drink.

At Fourth of July Butte, a small but steep-sided and prominent butte of lava, the road turns south and leads down a rather steep declivity which should be descended with some caution. The big wash just beyond this is Fourth of July Wash, where water is reported to be obtainable at most seasons by digging in the sand 200 to 300 yards downstream from the road. The road continues, skirting the north side of Yellow Medicine Butte and passing Willow Tanks and Yellow Medicine Tank (Pl. XVI, *B*). On this stretch of the road there are many curves and sharp pitches, but on the whole the road is good. None of the washes crossed are likely to give any particular trouble.

Just beyond Yellow Medicine Tank is the beginning of a 3-mile stretch of good graded road, built by the State in the winter of 1917. It was planned to construct a State highway between Yuma and Phoenix by way of Antelope Bridge, of which this stretch and the three or four other pieces of graded road between this place and Yuma were to be parts. The portion of the road built in the Gila Bend Mountains is a good example of highway engineering in a mountainous country and gives promise that when the projected highway is completed it will provide what is now sorely needed—a good all-year road between the State capital and Yuma. This stretch crosses a spur of the granite mountains that may be considered to form the backbone of the Gila Bend Mountains. The road abounds in curves, and the grades are necessarily steep, but a car in good condition will have no difficulty in climbing them.

At the west end of the graded road is Loudermilk Wash, which should be approached with some caution, because of the sharp turn in the road. A short distance beyond this wash is a fork leading to State Well. West of the fork the road has a number of curves and several sharp pitches. Some of the pitches might possibly give trouble to a car that was heavily loaded or a poor hill climber. Near the point where the road emerges from the mountain is a wide wash that might give a little trouble. Somewhat more difficulty is likely to be experienced in crossing these mountains on the eastbound trip than on the westbound trip, but in either direction a reasonably good car will get through safely.

After leaving the mountains the road leads south across the desert, heading directly for the black lava hills north of Agua Caliente. The road skirts these hills on the east and south to Agua Caliente.

Old road across the Gila Bend Mountains.—The old road across the Gila Bend Mountains is still used to a considerable extent. The distance between Arlington and Agua Caliente is 3 miles shorter by this road than by the new one, and there are fewer curves and steep grades. Many old settlers prefer it to the new road, largely because they are accustomed to using it. Travelers with stock or on foot often use it on account of the shorter distance. Many foot travelers prefer the new road, however, because it is better supplied with watering places and is more traveled, so that the chance of being picked up is greater. The long stretches of sand and silt along Gila River and several rather troublesome washes that have to be crossed make the old road less desirable than the new one for automobile travel.

In the first 4½ miles out of Arlington the road passes through irrigated country, which has already been described (p. 69). Then it enters the desert and goes through the mesquite thickets that mark the course of Centennial Wash. (See p. 41.) The desert floor here is composed of fine silt, with some sand. Usually the road across this area is in good shape, but after a prolonged spell of dry weather it may become cut up, especially if there has been much traffic. Beyond Centennial Wash the road improves. Near the border of the mountains the road to the Webb mine (Arizona Gold Hill Mining Co.) forks to the left, and a little farther on the mine buildings can be seen on a hillside about a mile south of the road. Just beyond this point wagon tracks lead to the right. These go to the Van Hagen windmill, one of the cattle-watering places of the Flower Pot Cattle Co. The windmill itself may be seen flashing in the sun about three-tenths of a mile to the north. The supply of water from this well is intermittent and never very large. Webb Well, less than a mile farther on and only 150 yards off the road, furnishes much better drinking water. The water from this well is used to operate a test mill treating gold ore from the Webb mine. The well is not a public watering place, but water could be obtained here if a traveler were in need, though the privilege should not be abused.

From Webb Well the road follows a gradually narrowing valley in the mountains to Woolsey Tank. It runs for the most part over bedrock, in some places thinly covered with alluvium, and is a good mountain road with no bad grades, curves, or washes.

The portion of the Gila Bend Mountains traversed by the old road has a somewhat less varied topography than that crossed by the new one, but it is, perhaps, rather more picturesque. The mountains near the road are all carved from Tertiary rocks, mostly lavas. Faulting has been more pronounced and on a larger scale here than farther north. The strata of lava and associated sedimentary rocks, horizontal or nearly so when originally laid down, have been broken and the fragments moved about by the mountain-building forces until they now dip at various angles and in several directions. The erosion of these rocks, heterogeneously arranged and varying greatly in hardness, has led to the development of fantastic forms. Sheer cliffs and castellated pinnacles alternate with smooth rounded hills. Vivid reds and ochers contrast with somber browns and blacks. Woolsey Peak rears its dark head in dignified majesty on the southeast.

Roads branch from the main road both east and west of Woolsey Tank to accommodate travelers from either direction and lead to the camping ground on the north side of the wash. So many persons have camped here that dry wood for fires is scarce, but water may be obtained at the tank, in the wash just to the south. This tank is one of the oldest known watering places in these mountains, having been discovered about 1873 by the doughty old pioneer Captain Woolsey. It is a natural rock tank, filled with sand. Water remains in it all the year round. (See Pl. XVII, *B*.) The presence of the sand does much to protect the water from evaporation and makes it possible for a tank that is much used by stock and is only about 10 feet in diameter to retain water through even an unusually long dry season. The water, being entirely unprotected from contamination, is not fit for human consumption. In February, 1917, the Flower Pot Cattle Co. started to sink a shaft in an attempt to follow indications of gold ore at one side of a smaller wash which here joins the wash containing the tank. This shaft after being sunk to a depth of about 10 feet filled with water so rapidly that work on it had to be stopped. It is now used as a well from which travelers can obtain drinking water that is usually clean and good. (See p. 229.) Some further work on this prospect, which its owners call the Perhaps mine, was done in the early part of 1918. Should development continue it may cease to be a watering place.

The geology of Woolsey Tank and its vicinity is somewhat complex in detail. The south bank of the wash near the tank is composed of gray jointed basalt capped by coarse, poorly consolidated conglomerate. The conglomerate is of Pleistocene or late Tertiary age. Whether this particular mass of basalt is intrusive or extrusive the writer could not determine. Similar rock occurs in the neighborhood, both as surface flows and as intrusive bodies of various sizes and shapes. It was eroded after its consolidation, and the conglomerate was laid down by stream action on its eroded surface. Afterward uplift took place, and the conglomerate was tilted gently to the northwest here and elsewhere in the vicinity.

In the bank of the wash near the Perhaps mine shaft conditions are somewhat different. The basalt is absent, and in its place is some rhyolitic lava. Lying on this is a mass of thin-bedded red sandstone composed of fragments of the lava. This sandstone dips at an angle of 15° W. and probably underlies the basalt and forms the basin of Woolsey Tank. On the irregular eroded surface of this tilted sandstone is conglomerate, coarser than that resting on the basalt but very similar and undoubtedly a part of the same formation. Up the main wash south of the tank and well the rocks exposed in the east bank are arranged in heterogeneous fashion. Basalt in irregular masses and dikes cuts in various directions through a red conglomerate whose pebbles are subangular and range in diameter from a quarter of an inch to 3 feet.

A short distance beyond Woolsey Tank a fork is reached. The right-hand road goes over a little hill on a fairly steep grade; the left-hand road goes along the bed of the wash, where the loose gravel gives rather poor traction, and rejoins the right fork about a quarter of a mile farther west. The road from this point to the border of the mountains has no bad grades or curves but runs for 2 miles in the gravel bed of a wash. If the gravel in the ruts has not been well packed by the recent passage of vehicles or if the automobile is heavily loaded trouble may be experienced in this portion of the road. Many cars pass over it, however, without any difficulty. Some interesting bits of geologic history can be read in the exposures in the banks of this wash, if the traveler has the time to study them.

At the border of the mountains the road leaves the bed of the wash but follows closely beside it and crosses it several times before both road and wash reach the flood plain of Gila River, 5¼ miles from the mountains. The road runs between the terraces bordering the wash for all of this distance. It extends along the river flood plain to a point within about 2 miles of the high basalt buttes that stretch from the main mass of the Gila Bend Mountains to the river. The sand and soft silt of the flood plain make very poor road material. In dry weather chuck holes and high centers are abundant, and in wet weather mud makes this portion of the road almost or quite impassable. Ordinarily, however, travel over it presents no really serious difficulties.

About 2 miles from the buttes the road leaves the flood plain for a distance and passes over the gravel of the valley fill, which makes a much better road material. One of the washes crossed in this portion of the road might possibly give a little trouble. On reaching the buttes the road descends perforce to the flood plain and skirts the buttes. This part is a fair valley road. At one point an old irrigation ditch is crossed by a bridge made of poles, which in the early part of 1918 was in a very poor condition. If this bridge has not been repaired, passage over the ditch will be difficult. After rounding the end of the high buttes the road goes up a rather steep and rough ascent to the surface of a low lava mesa and runs over this for 3 miles. Thence it makes a more gentle descent to the valley floor. From this point to Agua Caliente the road, though rough and dusty in dry weather and muddy in wet weather, presents no particular difficulties, with the possible exception of one wash somewhat less than 4 miles from Agua Caliente, which might give trouble to an eastbound automobile. The road turns rather abruptly in the bottom of the wash, and the east bank is steep and sandy. With good driving, however, the average car will have no difficulty.

Industries in the valley of Gila River along old road.—At the present time there is little activity in this portion of the Gila Valley. Some cattle range over it, and a cattlemen's camp has been set up near the river. One enterprising man has established an apiary in this vicinity but does not live with his bees. (For the location of the camp and apiary see the log, p. 129, also Pl. IV.) On the south side of the river, opposite the big lava buttes, J. W. Jordan has a small ranch, on which the principal crop is alfalfa. This ranch is on the adobe flats deposited by the river at a point where the lava walls that here line the river on both sides recede somewhat. The ranch house is a very substantial structure of adobe, originally used as a station on the stage line which ran along that bank of the river from Yuma to Gila Bend and thence across the desert to Tucson. It was then called Oatman's Flat station. The flat on which it stands was named in memory of the Oatman family, who were attacked by Apaches here in the days of emigration to California. Most of the party were killed, and two young girls were carried into captivity.[80]

The remains of a pumping plant, irrigating ditches, and plowed land passed by the road on the north side of the river near the buttes mark the place where there was an unsuccessful attempt to irrigate the land. At and near Agua

[80] Dellenbaugh, Frederick, The romance of the Gila River, p. 45, 1909.

Caliente several small ranches have been started and irrigation is carried on in a small way.

At Point of Rocks, just west of Oatman Flat, the lava walls come close together and the river flows through a comparatively narrow passage between them. Some irrigation from canals with a headgate at this place has been attempted, and several unsuccessful attempts to build diversion dams have been made. The first work was undertaken about 30 years ago. Nothing is being done here now, nor does there appear to be any immediate prospect of the renewal of activity. (See p. 100.)

Agua Caliente to Palomas.—Between Agua Caliente and Palomas there are at present two possible routes. The new road, often referred to locally as the "Mesa road," follows the western border of the lava hills north of Agua Caliente nearly to their northwestern extremity, then crosses the desert to Palomas. The desert floor here is a mixture of gravel and silt. When the road was new it was good, because the cars did not break through the comparatively hard crust, but under continued use this crust gave way. In the early part of 1918, after a long-continued period of drought, there were many rough stretches, full of chuck holes and very dusty. The last 2.7 miles before reaching Palomas lie in the flood plain of Gila River. Here the road after a long dry spell is a succession of chuck holes. If the car is very light, it may be possible to abandon the road altogether and to run on the unbroken surface of the plain. This surface is very easily broken, however, and an attempt to leave the beaten track is liable to end in failure.

The old road, often called the "River road," is now seldom traveled, although still passable. It leads over soft flood-plain deposits, which have been much cut up during recent floods of Gila River. Consequently, the road not only has the numerous chuck holes and superabundant dust characteristic of valley roads but also has many curves and sharp pitches that are due to the necessity of crossing several steep-sided gullies of recent origin.

Palomas is a small town composed of scattered adobe and wooden houses which in 1920 had a population of 46. A large proportion of the inhabitants are Mexicans. It was the center of the Palomas irrigation district, which at one time enjoyed considerable prosperity. (For a brief description of this project see p. 99.) Since the flood of 1905, which washed out the canal heading and did considerable other damage, very little farming has been done in this vicinity. Overflow irrigation is practiced on a small scale, and in recent years a little farming by means of water pumped from wells has been attempted. (See p. 216.) Several of the Mexican ranchers have herds of cattle.

Palomas to Norton.—Between Palomas and Norton the route follows the river flats for the most part. No one road has become established for the whole distance. Travelers follow the particular route that happens to be in the best condition at the time. It is best to ask for advice as to just which route to follow. There are several ranches and homesteads along the way, and the traveler may get off the main road on a road leading to some one of these ranches. However, for the most part these branch roads are comparatively little traveled and consequently can be distinguished from the main road. None of them will lead one very far astray, except the road 4 miles west of Palomas, which goes by way of Deep Well and Castle Dome to Dome, where it rejoins the road to Yuma. The fork where this road branches off is marked by a United States Geological Survey sign, so that there should be no danger of taking it by mistake. The main road runs in general a little south of west with few pronounced turns, except the one just west of Texas Hill, an isolated lava hill about halfway between Palomas and Norton.

The road by way of Deep Well was once the main road between Yuma and Palomas and is still preferred by some because it avoids the long stretches of bad road on the flood plain of Gila River. It is over 19 miles longer than the river route, passes through the Castle Dome Mountains, where some of the grades are steep, and is not now kept in repair. The principal objections to the route at present are that very few people pass over it or live near it, so that if anything went wrong it would be hard to get assistance, and also no water is available for long stretches. From the fork mentioned above, 4 miles west of Palomas, the road leads across the desert past Middle Well and Deep Well to the Castle Dome Mountains, where it joins the road from Quartzsite to Dome. A United States Geological Survey sign here indicates the road to take. Middle Well and Deep Well are now caved and abandoned, and no water is available at either. These wells and also the Star Well, about 2½ miles north of Deep Well, were sunk during the mining activity in the vicinity of Kofa, in the S. H. Mountains, to supply water to the King of Arizona and North Star mines. When the King of Arizona mine was shut down Middle Well was bought by Mr. Abel Figueroa to be used as a watering place for cattle. This well is now badly caved, and Mr. Figueroa intends to put down another in the near future, which is to be about 10 miles east of Middle Well and a number of miles off the present road. Some distance south of the point where the road reaches the Castle Dome Mountains there is said to be a series of natural rock tanks where good water can be obtained at all seasons. A road to these tanks branches from the main road between Deep Well and the mountains.

From the point where the road from Palomas and Deep Well joins that from Quartzsite the route leads through the Castle Dome Mountains to the Castle Dome mine. The road is rather rough and has steep grades. McPherson and Ladder tanks are on this route 1½ miles and half a mile, respectively, from the road. Water can usually be obtained from them, and also at the Castle Dome mine. From the mine there is a very good plains road to Gila River, opposite Dome, and the ford across the river usually presents little difficulty except in time of high water. (For a more detailed description of the portion of this route which lies on the Quartzsite-Dome road see pp. 188–190.)

The King of Arizona, North Star, and other mines in the Kofa district are now shut down, but development work may be resumed on some of them. These mines were examined in 1914 by Edward L. Jones, jr.,[81] and the following data are taken from his report.

The King of Arizona deposit was discovered in 1896, and the mine was a continuous producer of gold and silver ore until the summer of 1910, when the low grade of the ore did not permit profitable operation. The surface ore was extremely rich, much of it being worth $1 a pound. Ore of this grade was packed or hauled to a small cyanide mill at Mohawk, on Gila River, 45 miles away. A 225-ton mill was built at the mine in 1899 and was operated until the mine closed. The mine produced gold and silver bullion to the amount of $3,500,000, gold greatly predominating in value.

The deposit at the North Star mine, 1½ miles north of the King of Arizona, was discovered in 1906 by Felix Mayhew. Development work was started in 1907 and continued to August, 1911, when the ore available was of too low grade to work. A cyanide mill was built in 1908. The mine produced approximately $1,100,000 in gold and silver, principally gold. The surface ore was

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[81] Jones, E. L., jr., A reconnaissance in the Kofa Mountains, Ariz.; U. S. Geol. Survey Bull. 620, pp. 151–164, 1916.

of exceptionally high grade. One streak of ore on the footwall is said to have been worth $6 to $20 a pound. Thousands of dollars' worth of ore is said to have been stolen. Here, as in the King of Arizona mine, the gold tenor decreased rapidly with depth.

The ore bodies in these two mines are in brecciated zones and veins in andesite of Tertiary age. The vein matter is brecciated andesite, usually silicified and accompanied by stringers of calcite and quartz. Manganese occurs in these deposits in brownish calcite or as stains in the vein matter. The gold is said to be free and very finely divided. The ore of the North Star differs from that of the King of Arizona in the absence of calcite and in the abundance of chalcedonic quartz and pyrite. (For a general account of the S. H. Mountains and of the mineral deposits in them see p. 187.)

The Norton ranch and post office was a place of some importance when irrigation was in progress along the river in this vicinity and later when the King of Arizona and other mines in the Kofa district were in operation. The old store building, a number of other buildings, and some substantial corrals remain, but no supplies of any kind are now kept at the store. There is a well from which somewhat salty but drinkable water can be obtained. In 1920 Norton precinct had 88 inhabitants.

Some farming is still carried on in this vicinity. Several small ranches lie east of the place, and some irrigation by means of water pumped from wells is being done on the desert north of it. The Hicks ranch, a mile west of Norton, and some others farther west show that this district has not been entirely abandoned.

Norton to Antelope Bridge.—West of Norton the route continues to follow the river flood plain. Between Norton and Antelope Bridge is perhaps the roughest portion of the road. In dry weather it is simply a succession of chuck holes. In wet weather the mud makes travel over it very difficult and probably at times impossible.

For the first few miles beyond Norton the scene is desolate in the extreme. Old fences, dry irrigation ditches, and cleared fields that still show the marks of the plow testify to much farming activity in the past. Since the disastrous flood of 1891 nearly all the settlers have left the district, and it is rapidly reverting to wilderness. Bare brown tracts of sun-baked silt alternate with tangled thickets of mesquite trees. These thickets are alive with small game that feed on the mesquite beans. Rabbits are everywhere, and in their season coveys of quail literally cover the ground along the roads.

Like every other road that follows a river flood plain this one changes rapidly, and there are usually several alternate roads, but no difficulty is likely to be experienced in finding the way. The road from Norton leads a little south of west and then due west to a point 3½ miles north of Antelope Bridge, where it turns and leads due south to the bridge.

Antelope Bridge across Gila River was completed in the fall of 1915. It is a concrete bridge built by the State of Arizona jointly with Yuma County at a cost of $55,000. This brige was a very important addition to the road between Yuma and Phoenix, as it provided a convenient and safe means of crossing the treacherous Gila except during an unusually high flood. It was, however, washed out in 1920. The residents of the vicinity are reported to maintain a ford in good condition here. (See p. 230.) The south approach to the bridge leads over bedrock at the base of Antelope Hill, an isolated hill about 580 feet high, composed of gray arkose, a sandstone formed from granitic débris. The beds of arkose strike nearly due east and dip gently to the south. The rock is as a whole somewhat coarser grained near the base of the hill than farther up the slope. Probably this hill is a fault block, with a fault bounding the steep northern face.

There is an adobe house and several corrals near the bridge, but they are now abandoned and dilapidated. A driven well is situated in the bushes west of the corrals, but it is now out of repair, and no water can be obtained from it. The abandoned Antelope canal had its headgate near this point. It runs by the side of the road in the direction of Wellton.

Antelope Bridge to Wellton.—The road from the bridge to Wellton is somewhat similar to that between the bridge and Norton. It has fewer chuck holes but more dust. Near Wellton several branch roads leading to ranches are passed. With the exercise of care and judgment there should be no difficulty in avoiding these and keeping on the main road.

Wellton is a station on the Southern Pacific Railroad and the center of a small farming community. In 1920 the town had a population of 88. The Antelope canal, which was used in the past to irrigate land in this neighborhood with water from Gila River, is now abandoned, but several wells have been put down in recent years to obtain water for irrigation. (For data on some of the wells in this vicinity see p. 226.)

Wellton to Dome.—There are at present two ways out of Wellton going west. One is an ungraded road along the railroad. The other is a graded but very soft section-line road starting at Gamble's Hotel. These roads join a mile west of the town. (See p. 230.) The route continues along the valley bottom, nowhere very far from the railroad but not running beside it for the first 9 miles. New branch roads have been made by the farmers who have recently arrived in the district, and others will doubtless be made in the future. With the railroad on one side and the river on the other, it is impossible to go very far out of the way even if one of the branch roads is taken by mistake. The road is somewhat similar to that between Palomas and Wellton but is on the average rather better, with fewer chuck holes and less dust. For the last 8 miles into Dome the road follows the railroad rather closely. This part is graded and in fairly good condition.

Dome is a station on the Southern Pacific Railroad. Most of the houses are made of adobe and are occupied by Mexicans. This is the approximate site of Gila City, which was formerly a placer-gold camp of some importance. The placers in this vicinity are said to have been discovered by Colonel Snively in 1858.[82] At one time over a thousand people are said to have been gathered here,[83] but the "city" had a life of only a few years, as the placers were not rich enough to be worked in a locality where water was scarce and transportation facilities poor. This city rose and fell before the coming of the railroad. A little placer mining is still carried on by Mexicans and Indians in the mountains in this vicinity, but the chances that enough placer gold will ever be found to make this district an important producer are small indeed.

Dome to Yuma.—From Dome to Blaisdell, a distance of 6.7 miles, there is a good graded road. At Blaisdell, a siding on the railroad, is a quarry from which the county obtains rock for building roads. Beyond Blaisdell no improvement has yet been made on the road. It leads across the flood plain of Gila River, which is here very sandy, to Yuma. The route changes frequently with changing conditions. The road that appears to be most traveled should be followed, but in general it is advisable to keep as close as possible to the edge of the flood plain, often referred to as the "mesa line."

[82] Hinton, R. J., Handbook to Arizona, p. 154, 1878.

[83] Idem, p. 172.

It is practically impossible to construct a permanent road across these shifting sands, but it was planned to build a road between Yuma and Blaisdell over the desert south of the flood plain, and according to recent information from the office of the State highway engineer this road has already been constructed.

Yuma is a wide-awake, flourishing town, with several hotels, numerous stores and ice plants, electric light and power, and gas for cooking and heating. Its principal streets are paved with asphalt. A considerable force of troops is stationed there. The population according to the 1910 census was 2,914, but it has increased with irrigation development and in 1920 was 4,237.

Yuma is one of the older towns in Arizona. The first white man to visit its site was Father Eusebio Kino, a Spanish missionary, who made a trip down the Gila to its junction with Colorado River in 1700 and found an Indian ranchería there, which he named San Dionisio.[84] During the gold rush to California in 1848 and 1849 many emigrants crossed Colorado River on the ferry here. It has been estimated that 60,000 people crossed here before 1851, but that figure is probably too high. Fort Yuma, on the California side of the river, was named in 1851. No permanent settlement appears to have been made on the Arizona side until the Gadsden Purchase in 1854 made the present site of Yuma United States territory. The town was called Colorado City, Arizona City, and finally Yuma. Its real growth dates from 1864, the year when Yuma County was established. The county seat was moved from La Paz (a settlement, now abandoned, west of Quartzsite) to Yuma in 1871 and has remained there since. The first steamboat to come up the river was the *Uncle Sam* in 1852. The Southern Pacific Railroad reached Yuma from California in 1877 and Tucson in 1880.

The reconnaissance work for the Yuma irrigation project of the United States Reclamation Service[85] was begun in 1902, and the first irrigation under this project was done in 1907. The Laguna dam was completed in March, 1909, the Colorado River siphon on June 29, 1912, and the entire project was 64 per cent completed on June 30, 1917. The irrigable area, when the project is complete, will be 110,000 acres, of which 73,000 acres could have been supplied with water during the season of 1916, and 29,483 acres was actually irrigated. The principal crops raised are long-staple cotton, alfalfa, millo maize, Kaffir corn, feterita, wheat, and barley.

The following quotation from the report of the Reclamation Service will give a good idea of the irrigation plan:

> The irrigation plan of the Yuma project provides for the diversion of water from the Colorado River at the Laguna dam, 10 miles northeast of Yuma, Ariz., into a canal system heading on the California side, conveying water to the irrigable lands on that side of the river, including those in the Yuma Indian Reservation, crossing the river at Yuma through an inverted siphon, and serving lands in the Yuma Valley below the town of Yuma. The plan also provides for large pumping plants below Yuma on the east main canal for raising water to irrigate 40,000 acres of mesa land. The lands adjacent to the Colorado River are protected from overflow by means of levees. The United States claims all waste, seepage, unappropriated spring and percolating water arising within the project and proposes to use such water in connection therewith. The Laguna dam, 340 miles of canals and laterals, including 19 miles of drainage ditches, the Colorado River siphon, 930 feet in length and 14 feet in diameter, and about 74 per cent of the levee system are completed.

[84] The historical facts here given are taken from Bancroft, H. H., A history of New Mexico and Arizona.

[85] U. S. Reclamation Service Sixteenth Ann. Rept., pp. 60–68, 1917.

PHOENIX TO PARKER.

[For logs see pp. 133–139.]

There are various routes and combinations of routes from Phoenix to Parker. All of them are used to a greater or less extent by travelers from and to points in California. Each is referred to locally as the "Parker cut-off." From Phoenix the traveler may follow in a general way the line of the Santa Fe, Prescott & Phoenix Railway through Wickenburg, Wenden, and Bouse to Parker, or he may leave the railroad at Wenden and go to Parker by way of Cunningham Pass. Other routes lead through Buckeye Valley, past Winters Well, the Palo Verde mine, and Tolladay's Well, through Harrisburg Valley, and thence either through Wenden and Cunningham Pass to Parker or through Salome and Bouse, along the railroad, to Parker. The choice depends on individual preference and on the condition of the roads. The route by way of Wickenburg is more than 15 miles longer than that by way of Buckeye and Winters Well, but in the early part of 1919, after a prolonged drought, many travelers were taking it to avoid the stretches of badly cut up road near Winters Well and on the Harquahala Plain. The Wickenburg road was not traveled by the writer, but logs are given on pages 139–142. After periods of heavy rains the road by way of Wenden and Cunningham Pass is reported to be better than that along the railroad through Bouse. Some prefer the road through Cunningham Pass at all seasons of the year, except immediately after heavy rains, when all these roads present difficulties.

Some travelers from Arizona to California use the ferry over Colorado River at Ehrenberg instead of that at Parker. They follow one of the Parker cut-off routes in Arizona either to Vicksburg or to Bouse, both of which are stations on the Atchison, Topeka & Santa Fe Railway, and thence go to Quartzsite and Ehrenberg.

Hassayampa River to Palo Verde mine.—The route to Parker by way of Buckeye Valley is the same as the route between Phoenix and Yuma as far as the road fork just west of Hassayampa River, 43.7 miles from Phoenix and 155.2 miles from Yuma. Only the part west of this fork is usually spoken of as the "Parker cut-off." At this fork there are several signs, including one put up by the United States Geological Survey. The road to Parker leads somewhat north of west; the road to Yuma turns south. The Parker road skirts the north side of a low basalt hill for a distance of 1.4 miles. This part of the road is rough and rocky. Near the north end of the hill a slightly used road branches off to the north. This and any other faint road that may be noted between this point and Winters Well, with one possible exception mentioned below, are to be avoided. The road leading north from the end of the basalt hill is a part of the old route to the Vulture mine and Wickenburg. The road between the Vulture mine and Wickenburg is still in use, but the practicability of the road from the mine south along Hassayampa River is doubtful. One automobile made the trip from Palo Verde to the Vulture mine in December, 1919. It is reported to have been, when in use, a good road for most of the distance, but the original road has been in part washed out by floods of Hassayampa River.

At the point where the main road turns northwest, leaving the basalt hill, there is a road fork at which a Geological Survey sign indicates the main road. The other road continues west and is a part of an old route through Eagletail Valley to Harquahala that was used for freighting between Phoenix and the Harquahala mine before the railroad in the vicinity of the mine was built. After a long dry spell, when the main road between the fork and Winters Well is badly cut up, some travelers take this road west for 5 miles to the point where a road from Arlington crosses it. They then turn north on the crossroads and follow it past a windmill to a point 5.6 miles farther on, where they return to the main road. The distance is increased about 4½ miles by this detour, but the road is slightly better.

The main road goes straight across the broad silt-covered valley west of Hassayampa River from the point where it leaves the basalt hill above mentioned to Winters Well, passing in the last 10 miles along the northeast border of the Palo Verde Hills. Some large washes are crossed, but none of them present any difficulties. When not cut up by much travel this road is good, but automobiles soon wear deep ruts into the soft silt. Plate XIV, *B*, shows a typical piece of this road, from a photograph taken late in 1917 after a prolonged period of drought, when there had been considerable travel over the road in the previous few months and the heavy ore-laden motor trucks from the old Mexican mine had cut deep ruts in it. In September, 1917, the same road was not in nearly as poor condition.

At Winters Well there is a ranch house, with its accompanying outbuildings and corrals, and two wells with windmills, from which good water can be obtained. E. H. Winters has a number of wells for watering his cattle in the valley in the general vicinity of Winters Well. Data on these wells are given on pages 227–228.

West of Winters Well a road branches off to the north and leads to the Old Mexican mine, and a little farther on there is a trail leading south. Any doubt as to which is the main road should be dispelled by the Geological Survey signs near these road forks. One of the signs is on a big palo verde tree on the bank of a wash just west of the ranch. This wash should be approached with some caution, not because there is any particular difficulty in crossing it but because from either direction the view of the road immediately beyond is obscured, and if two automobiles happened to meet here an accident might result.

The road follows the north side of the Palo Verde Hills, turning almost due west until it reaches the Palo Verde mine. There are two roads leading to this mine, one for travelers in either direction. The United States Geological Survey sign is near the point where the western of these branch roads leaves the main road, but it is visible from the other fork also.

Hassayampa Plain.—The open plain through which Hassayampa River flows, bounded on the north by the Vulture Mountains, on the east by the White Tank Mountains, on the south by the Palo Verde Hills, and on the west by the Bighorn Mountains, may be called the Hassayampa Plain. It is not merely the valley of Hassayampa River, for many, perhaps most, of the washes that cross it reach the Gila by courses that are independent of and generally parallel to that of the Hassayampa.

The part of this plain west of the river is now utilized by E. H. Winters and the Flower Pot Cattle Co. as a cattle range. Mr. Winters has 11 wells scattered over this part of the plain, and the Flower Pot Co. has 5, mostly close to Hassayampa River. Data on these wells are given on pages 227–228. The soil appears to be good, and if an adequate source of irrigating water could be found, this part of the plain would doubtless become valuable farming land. At present there does not seem much likelihood of obtaining water in amounts sufficient to make the venture profitable. There was at one time a dam for the storage of water for irrigation in the canyon of Hassayampa River north of Wickenburg, but this was washed out in the flood of 1890, causing 70 deaths and considerable other damage.[36]

[36] Montgomery, John, oral communication.

An attempt was made some years ago to farm land on the east side of the river north of Palo Verde. The soil here also is probably suitable for irrigation, if water is available. It was planned to obtain irrigating water from wells. Some wells were sunk and a little water was found; irrigation was started, but the water at hand was insufficient, and for this and other reasons the attempt ended in failure. The settlers are reported to have come largely from the city of Los Angeles and to have been unaccustomed to life on the desert and not experienced in farming by irrigation.

The Hassayampa is little more than a very large wash. It is dry much of the year except near Palo Verde, where it usually contains a little return water from the Buckeye canal. At the point where the road crosses it west of Palo Verde it has only one channel, but farther north there are several channels wandering over the surface of the flood plain between well-defined terraces. The terraces are 5 to 15 feet high and, where observed about 4 miles upstream from the road crossing, are three-quarters of a mile apart.

Vulture Mountains.—The mountains that can be seen in the distance to the north of the Parker cut-off road on the Hassayampa Plain are the Vulture Mountains. They extend from Hassayampa River near Wickenburg westward for more than 20 miles and come close to if they do not actually reach the northeast end of the Harquahala Mountains. As that part of the country was not visited during the present investigation not much information was obtained regarding the Vulture Mountains, the eastern and northern part of the Bighorn Mountains, and the northeast end of the Harquahala Mountains.

The Vulture Mountains are probably made up largely of pre-Cambrian metamorphic rocks, but some of the more recent volcanic rocks are also present. Blake[87] wrote an interesting account of the geology of a part of this range, which is given below:

The vein at the Vulture is in ancient slates and gneissic rocks, probably more ancient than the slates at Cave Creek. From these outcrops we rise upon the undulating surface of low hills of volcanic origin or outflow, generally soft and amygdaloidal, of local extent, having been cut through by long erosion to the bed. In places the argillaceous slates pass into dark-colored hornblende slates, becoming compact, gneissic, and syenitic, and all much seamed and ribbed with dikes of feldspathic or granite rock, and with porphyritic dikes to the summit, about halfway, and thence upon granite to the Hassayampa. Passing up the Hassayampa above Grant's store and the old Vulture mill, there is a bluff of comparatively modern lava, which flowed out over the terrace of river gravel and has protected it from washing away. From near this place the long regular slope extends upward to the base of the mountains, about 6 miles. It is covered with grasses and Cactacea, but very few or no trees nor shrubs of great size. The soil appears to be exceedingly rich and fertile whenever water is put upon it and to be composed largely of volcanic mud and ashes, or the débris and silt from the decomposition of lavas and tufaceous deposits. This soil and slope appear to be most admirably adapted to viticulture and would no doubt produce grapes from which a most superior grade and variety of wine could be made. This slope and soil extend to the mountains at Antelope, and beyond Barney Martin's old place is near to the base of Rich Hill, sometimes called Weaver Mountain. The side next to Martin's is composed of a fine-grained white granite, with a large amount of quartz in it and black mica. It is gneissic, in regular layers, and appears like a highly altered old sandstone. The bedding (gneissic layers) pitches northerly at a low angle—about 30° to 35°. It may be called a granulitic granite; it appears to form the lower part of the mountain, the upper portion having a darker and brown color.

West of Antelope (or Martin's) the slate formation crops out and as at other places is marked by a white quartz vein, dipping northward and resembling the quartz lode known as the Leviathan, of which it is supposed to be a

[87] Blake, W. P., Report of the governor of Arizona, 1899, pp. 139–140.

part, separated by some great fault, heave, or displacement. This quartz seemed quite barren and worthless for gold mining, though there may be rich pockets of coarse gold. Granite crops out west of the Leviathan lode hill. It is a granular gray granite of coarse texture and has some isolated crystals of feldspar. The Marcus gold vein traverses this rock in an east and west direction, and the granite is much altered and decomposed along its course.

The old and well-known Vulture mine is situated in these mountains. The road to this mine up Hassayampa River is now almost never used except by an occasional sheepman. The road from Wickenburg to the mine is still open and is sometimes used, although the mine has been shut down for some years. The distance from Wickenburg to the mine, according to C. G. Puffer, is 13.7 miles. There is a drilled well at the mine reported to be 2,000 feet deep.

The Vulture deposit was discovered in 1863[88] by either Herman Ehrenberg or Henry Wickenburg, both of them well-known pioneers. Short descriptions of this mine by W. P. Blake, Territorial geologist, will be found in several of the annual reports of the governor of Arizona. He thought well of the mine and considered that development at depth would disclose good ore. He states that in its early history the mine produced more than $4,000,000.

Saddle Mountain.—Saddle Mountain, south of the Palo Verde mine, is a prominent and well-known landmark for many miles around. It is visible from both roads between Arlington and Agua Caliente, as well as from that in Eagletail Valley and the Parker cut-off. Structurally it is a jumble of fault blocks, but no attempt to work out the structure in detail could be made in the time available. The shape of this mass of huge rock fragments is irregular and jagged in the extreme. Erosion has softened the outlines but little, and sheer, almost unscalable cliffs are the predominant topographic features. The mountain takes its name from the great saddle which divides it into two separate parts along an east-west line somewhat south of the middle. The rocks dip away from this saddle both north and south. The highest point of the mountain is 2,000 to 2,500 feet above its base.

The rocks composing the mountain are for the most part volcanic. The lavas noted are fine-grained reddish felsites, somewhat coarser hornblende felsites, and gray vesicular basalts. The felsites, or at least most of them, have the composition of latite. There are also considerable thicknesses of fragmental rocks ranging from agglomerates and breccias of distinctly igneous character to rocks consisting of angular fragments of lava about an inch in diameter in a white calcareous matrix. (See p. 24.) In the more acidic lavas and the agglomerates are numerous geodes of chalcedony and quartz, and much of the quartz shows radiating structure. In certain cliffs there are some peculiar hollows in beds of conglomerate and agglomerate, some of which almost amount to caves. (See Pl. XVIII, *B*.) These appear to be due to a sort of concave exfoliation. They are not the result of solution or erosion.

Palo Verde Hills.—North of Arlington and east of Saddle Mountain are a group of low hills which extend from a point near the Palo Verde mine to the vicinity of the town of Palo Verde. The Parker cut-off passes along their northern border. These hills, which do not rise more than 500 feet above the plain, are composed almost entirely of basaltic lava of Pleistocene age, except those close to Saddle Mountain. The butte to the left of the road just east of the Palo Verde mine is made up of fine-grained hornblende granite. A number of the basaltic hills are conical and from a distance have the appearance of ancient volcanoes, now somewhat worn and dissected by erosion. Time did not permit confirmation of this conjecture by closer examination.

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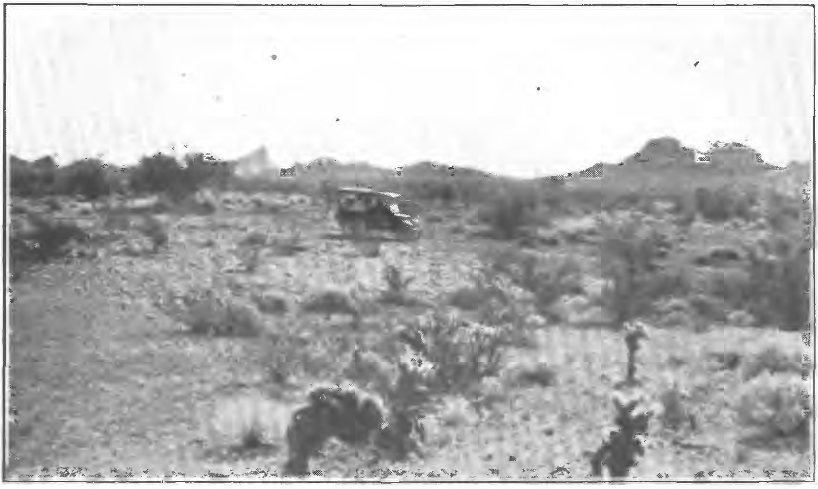
[88] Hinton, R. J., Handbook to Arizona, p. 144, 1878.

A. VIEW LOOKING NORTH FROM THE CONCRETE BRIDGE OVER AGUA FRIA RIVER AT COLDWATER.

B. A FIELD OF LONG-STAPLE COTTON ON THE BUCKEYE ROAD NEAR CASHION.



A. PLAIN IN GILA BEND MOUNTAINS NEAR FOURTH OF JULY BUTTE LOOKING NORTH.

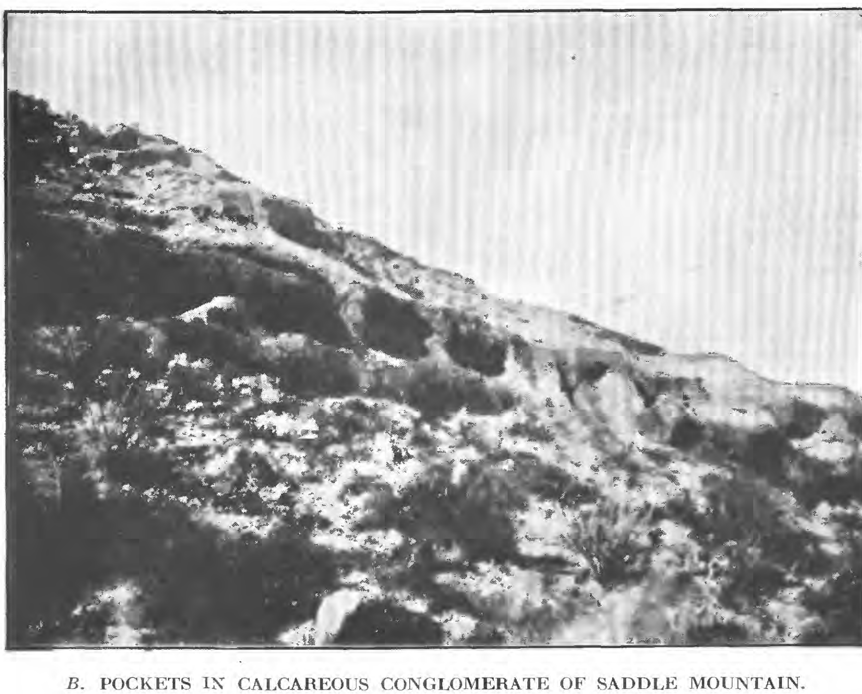
B. YELLOW MEDICINE WELL, GILA BEND MOUNTAINS, FROM THE WEST.

A. WOOLSEY PEAK FROM WOOLSEY TANK.

Men in foreground are setting one of the United States Geological Survey signposts.

B. WOOLSEY TANK.

A. SADDLE MOUNTAIN, LOOKING SOUTH.

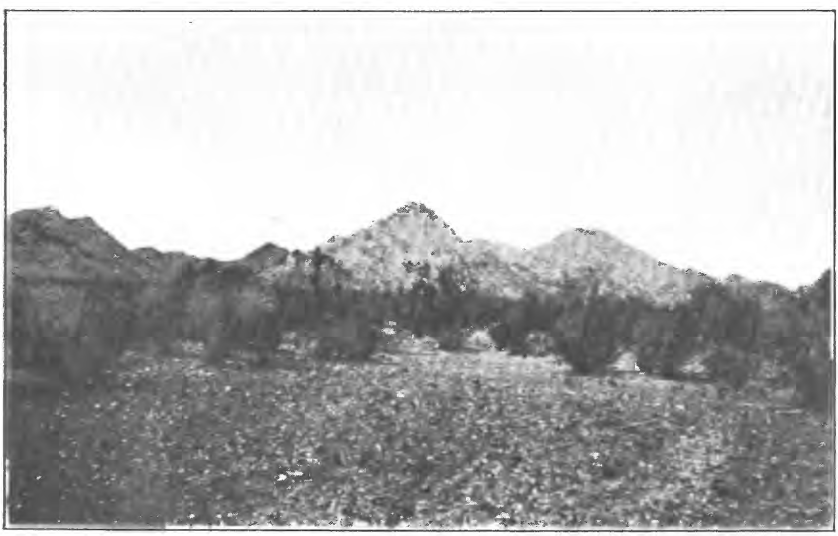


B. POCKETS IN CALCAREOUS CONGLOMERATE OF SADDLE MOUNTAIN.

Due to a sort of concave exfoliation.

A. COURTHOUSE ROCK AND EAGLETAIL MOUNTAINS, LOOKING SOUTHEAST.

Eagletail Peak in the left distance.



B. HILLS OF CHLORITIC SCHIST AT SOUTH END OF BIGHORN MOUNTAINS, NEAR PALO VERDE MINE.

A. COLORADO RIVER AT PARKER.

Showing bridge of Atchison, Topeka & Santa Fe Railway.

B. BUSH'S FERRY ACROSS COLORADO RIVER AT PARKER, LOOKING NORTH.

Palo Verde mine to Salome and Wenden.—No difficulty will be encountered in finding the way across the adobe floor of the Harquahala Plain. The bends in the road are few, and the only forks of any consequence are marked by United States Geological Survey signs. The road may on the whole be considered good, although if there has been much travel and a long period of dry weather it will be found somewhat cut up. Burned Place and Bighorn wells are watering places on this road, but only at the former is a convenient faucet for obtaining clean water provided.

Near the northwest end of the plain, 30½ miles from the Palo Verde mine, a road branches off to the north. This road goes through Tehahatchipi Pass to Wenden, and travelers bound for Wenden are sometimes advised to take it because it is more than half a mile shorter than that by way of Tolladay's Well and Harrisburg Valley. When traveled in October, 1917, however, it was in poor condition and there were numerous curves and steep grades, a few of which were difficult to surmount. Until considerable improvements are made on this road it is not recommended to automobile travelers.

At the entrance to the pass connecting the Harquahala Plain and Harrisburg Valley an embankment with a corresponding excavation will be noted. This is locally referred to as "the dam." When this work was done the intention was to dig down to bedrock, which was supposed to be near the surface at this point, and put in a dam that would force the ground water to rise, thus providing a cheap source of irrigating water. The project was abandoned before a great deal of work was done. As the well drilled near Tolladay's Well in 1918 reached a depth of 76 feet before bedrock was struck, the cost of damming the ground water at this place would probably have been found prohibitive.

At Tolladay's, where water can be obtained, there is a house, corrals, and an old and a new well.

The road through Harrisburg Valley has been so well marked with signs by the Geological Survey that there should be no difficulty in traveling it. However, new roads are likely to be built or old ones revived by miners with properties in the surrounding mountains. Roads that branch off the main road should in general be avoided. Travelers bound for Wenden and beyond should take the fork to the right 5 miles west of Tolladay's Well. This fork is marked by a Geological Survey sign. The road to Wenden crosses the western extremity of the Harquahala Mountains by an easy pass and thence continues as a good plains road. It passes Peters Well, one of the old stage stations now used as a watering place for cattle.

Harrisburg Valley has a soft soil, and consequently the road through it is sometimes cut up, although not excessively so. The crossing of Centennial Wash at the west end of the valley presents no difficulties. From this point to Salome there is a good plains road. At the crossroads south of the railroad at Salome the traveler may either go across the railroad into the town or turn west and continue to Bouse and Parker.

Harrisburg Valley has been in the past the scene of much more activity than at present. Nothing now remains of the old town of Harrisburg, but it is reported that in the boom days of mining in this vicinity there were several hundred people here and a number of pumping plants. Now there are probably only a dozen inhabitants in the whole valley. One of these, Mr. Reid, of the Harquahala Livestock Co., is irrigating from four wells.

Salome, which had a population of 73 in 1920, is one of the shipping points for the Harcuvar mining district. It has a store where gasoline, oil, and supplies can be obtained, a small hotel and restaurant, and a post office. The railroad well supplies the town with good water. Data on this and other wells near Salome are given on pages 220–221.

Harquahala Plain.—The extensive plain through which the Parker cut-off passes between the Palo Verde mine and Tolladay's Well is floored for the most part with a compact adobe soil that might prove suitable for cultivation if water could be obtained, but the possibility of procuring sufficient water for irrigation seems at present to be remote. The water table lies at too great a depth for pumping from wells to prove profitable. There are, however, several tracts of rather good grazing land. The Harquahala Livestock Co. and Parker Cattle Co. have cattle on this plain and have put down a number of wells to supply water for their stock.

The several lines of mesquite trees and bushes that extend across the Harquahala Plain in a southeasterly direction mark the course of Centennial Wash, which is described on pages 202, 204–206, 212–213.

Lone Mountain is an eminence of granite rising abruptly from the surface of the plain 9 miles southeast of Tolladay's Well. North of the Parker road are a number of buttes and hills, composed mostly of basalt.

Eagletail Mountains.—The Eagletail Mountains form a very highly colored range and for this reason are very conspicuous. They are built up of nearly horizontal flows of lava of Tertiary age interbedded with thick layers of tuff. The total thickness of the beds is more than 1,000 feet and must originally have been greater. The lava beds rest on an irregular surface of pre-Cambrian metamorphic rocks, most of which are granitic gneiss. Gneiss of this character crops out in some washes on the northern border of the range and forms a large part of the hills that project northeastward from the main mass of the mountains in T. 1 N., R. 10 W. The flows and tuffs are cut by pipes, dikes, and sills of felsitic igneous rock. The diversity of types of rock in these flows and intrusions is shown by the variety of colors exhibited. Nearly every flow is different in color from those above and below it, and each stands out from the others with clean-cut boundaries. Among the colors are brilliant yellow, soft green, vivid red, somber brown and dun, and creamy white, with streaks of purple, heliotrope, and other hues. The petrographer who is interested in Tertiary igneous rocks would find much to interest him here and in several of the other ranges in this region where similar rocks occur. The time available for the present investigation was so short that little attention could be given to such questions.

In a general way the beds strike parallel to the trend of the range, approximately N. 55 W., and dip gently to the southwest. Steep scarps on both sides of the range suggest that it was produced by faulting the downthrown blocks forming Little Horn Valley to the south and Harquahala Plain to the north. The fault on the north face apparently disappears toward the east, where hills of gneiss extend for some distance out into the plain. The range has been broken to some extent by subordinate faults, and the beds of which it is composed show local crumpling and folding. These minor disturbances of the strata, together with the intrusion of cylindrical plugs of igneous rock, have resulted in the development of a broken and rugged surface with many fantastic forms. Plate XIX, *A*, gives a general view of this range. Unfortunately, it was taken on one of the cloudy days that occasionally occur in winter even in this "land of perpetual sunshine," and in consequence the strata in the sides of the mountains can not be seen in the photograph. The plugs or pipes of intrusive rock already mentioned give rise to striking land forms, of which Courthouse Rock, shown in Plate XIX, *A*, is a typical example. It is composed of cream-colored lava, in part weathered to a yellowish brown, and towers 1,000 feet sheer above its base, which is circular and only a few hundred feet in diameter. With the exception of a few cracks, mostly vertical, the walls are smooth and almost vertical nearly to the summit, where the cylindrical column has been partly broken by weathering. This peak is reported to have been scaled, truly a worth while bit of mountain climbing. The range itself takes its name from a similar but even higher peak, near its east end, whose summit is broken up into three points and has a fancied resemblance to an eagle's tail sticking straight up into the air.

Bighorn Mountains.—The Bighorn Mountains extend northward from the vicinity of the Palo Verde mine. Little is known about them except what can be seen from the Parker cut-off to the south. They are built up principally of nearly flat-lying strata of lava and tuff of Tertiary age. If, as is probable, the prominent yellow strata are tuff, this rock predominates in the range. Near the Palo Verde mine is an outlying hill belonging to this range. (See Pl. XIX, *B*.) This is composed of green chloritic schist. No similar rock was observed elsewhere in the region, but it may safely be referred to the pre-Cambrian complex and indicates that in this range, as elsewhere, the Tertiary rocks rest on a basement of ancient metamorphic rocks.

The name Calico Peak, which has been given to one of the prominent eminences, suggests the brilliant coloring which the variegated lavas and tuffs give to this range. The range is named from a peak that has a fancied resemblance to the horn of a mountain sheep.

Little Harquahala Mountains.—South of Harrisburg Valley, between the Harquahala Mountains and the Granite Wash Hills, are the Little Harquahala Mountains. (See Pl. III.) On some maps they are shown as a part of the Harquahala Mountains, but they really constitute a distinct range, as there is a well-defined alluvial plain between them and the Harquahala Mountains proper.

The Little Harquahala Mountains form a rugged range that rises to a maximum altitude of about 2,600 feet above sea level. They are composed of metamorphic rocks—schist, limestone, dolomite, and gneiss—of probable pre-Cambrian age. Near Granite Wash Pass, at the west end of the range, Bancroft[89] mapped an area of granite which he considered to be Mesozoic. Extending south from these mountains, almost to the Eagletail Mountains, and also scattered along the western border, are small basalt buttes. Small mines and prospects have been located in these mountains. Both gold and copper have been found. The largest mine is the Harquahala, which is described on page 193.

Salome to Vicksburg.—On the south side of the railroad, opposite Salome, is a cross road, marked by a United States Geological Survey sign, where the road from Phoenix by way of Wickenburg and Wenden joins the road from Phoenix by way of Buckeye. From this point the road follows the railroad more or less closely all the way to Parker. From the crossroads westward to Granite Wash Pass, a distance of 2½ miles, there is a good plains road. The road through the pass was also good in the winter of 1918, but as it is in the bed of a wash for some distance its condition probably changes with every flood. Although the hills here are not high they are rugged and picturesque, and to a lover of mountain scenery the view is beautiful. On the whole, the

[89] Bancroft, Howland, Reconnaissance of the ore deposits in northern Yuma County, Ariz.: U. S. Geol. Survey Bull. 451, 1911.

road to Vicksburg after leaving the hills is good. The descent to the Ranegras Plains west of the hills is steep, and consequently an excellent view across the plains is obtained from the road. There are several basalt hills near Vicksburg. When the westbound traveler sees the flat tops of the outlying mesas of the Plomosa Mountains behind these hills, the appearance from some points of view is that of a broad area of mountainous country to the south and west. In reality the hills near by are only small and scattered outliers of the hills through which he has just come, and the nearest part of the Plomosa Mountains is more than 10 miles away and is separated from these hills by the adobe flats of the Ranegras Plains, sun baked and almost devoid of vegetation. For recent data on this road see page 230.

The Granite Wash Hills are separated from the Little Harquahala Mountains on the south by Granite Wash Pass and are partly separated from the Harcuvar Mountains on the north by the pass often called Tank Pass, because of the tank or spring near its summit. There is no sharp topographic break between them and the Harcuvar Mountains, and Bancroft[90] considered them a part of this range. The Granite Wash Hills are a rugged mass. They consist of schist and other metamorphic rocks together with limestone and granites. According to Bancroft,[91] the granite is probably of Mesozoic age. He describes several prospects in these hills, and there is at the present time considerable activity in copper prospecting here.

In 1918 Vicksburg had very few inhabitants. No one lived there except those connected with the railroad, perhaps half a dozen whites and a few Mexican section hands. There is a post office in the railroad station, and the section foreman keeps a provision store in his house a short distance west of the station. The other houses and shacks in the town are all deserted. The population of Vicksburg precinct was 96 in 1920. The Atchison, Topeka & Santa Fe Railway Co. drilled a well here but failed to get water and had to sink another at McVay, 6 miles farther west, where it was more successful. Water is brought to Vicksburg in tank cars and can be obtained from the cistern at the section house. Vicksburg is the shipping point for a number of small mining properties in the mountains north of it. If one of these should develop into an important mine, Vicksburg would regain the comparative prosperity it enjoyed when it was the railroad terminus of the mail route to Quartzsite. A shorter and better road to Quartzsite was built from Bouse in 1910, and the mail has since gone over this road.

Vicksburg to Bouse.—The 20-mile stretch between Vicksburg and Bouse is a good desert road which has recently been improved by the county authorities. The alinement of the Vicksburg end of the road was not changed, but the grade of the old road was improved and the crossings of washes put in good shape. Farther west the county abandoned the old alinement and made a piece of straight road along the railroad. In 1918 travel still followed the old road, however, the new road not being used because, although graded and straight, it was soft. The old road has many curves but has a much better surface. This is a common result of attempts at road improvement in this section of the country. Usually the money available for highway construction is entirely inadequate for the construction of good new metaled road. Under these circumstances it would seem to be wiser to spend the money on hand in improving the road already in existence, even if it is crooked, by doing away with the steep pitches, building concrete dips across bad washes, etc., rather

[90] Bancroft, Howland, Reconnaissance of the ore deposits in northern Yuma County, Ariz.: U. S. Geol. Survey Bull. 451, p. 21, pl. 1, 1911.
[91] Idem, p. 104.

than to lay out a straight road across the desert, grade it, and cut away the brush but leave the surface soft.

Near Bouse is a series of low black hills and buttes north of the railroad composed of basalt. The presence of white volcanic ash in a wash crossed by the road shows that the volcanic forces that produced the hills sometimes acted with explosive violence. The hills are known as the Bouse Hills. The log of the railroad well at Bouse shows that the lava extends out under the valley fill for a considerable distance. This is probably one of the principal reasons why it is possible in this town to get water at depths of only 25 to 50 feet.

In 1910 Bouse had a population of 200, but in 1920 it had only 167. It is the junction of the Arizona & Swansea Railroad with the main line of the Atchison, Topeka & Santa Fe Railway from Phoenix to Parker. The Arizona & Swansea Railroad runs to the smelting and mining town of Swansea, 22 miles to the north, in the Buckskin Mountains. Bouse has several stores and hotels, a post office, and two garages. There is a railroad well here, also a number of privately owned wells, the water from some of which is being used for irrigation. The quantity of water available does not appear to be great, and the quality is not very high. Consequently it is unlikely that any considerable amount of irrigation will be done. The town is the railroad shipping point for Quartzsite, 24 miles to the southwest, and for the mining properties near that town and in the Plomosa Mountains. Thomas Bales and others have cattle interests on the Ranegras Plains, near the northwest end of which Bouse is located. (For data on wells in Bouse and on the Ranegras Plains see pp. 202–203, 207, 216, 223–225.)

Bouse to Parker.—The road out of Bouse is well marked with signs, and there should be no difficulty in finding the way. It is south of the railway, but at some distance from it so that the railway tracks are not visible from considerable parts of the road. A short distance beyond Bouse the road passes around the northern extremity of the Plomosa Mountains. There are several small mines in this end of the mountains, and roads to them branch off from the main road at several points. The mining companies have placed signs at some of these forks, and at all of them the Parker road is so good and so well marked as to be easily distinguished. (For a description of the Plomosa Mountains see p. 184.)

The road follows in general the Bouse Wash to a point about 15 miles from Bouse, where the wash continues westward to Colorado River and the road swings northward. This wash is larger and longer than the average wash in this region. It is crossed and recrossed by the road several times in its course. Somewhat more than 2 miles west of the turn where the road finally leaves the wash there is a small mountain range composed largely of pre-Cambrian gneiss but capped in part by basalt. At the north end of these mountains are a number of hills composed of partly consolidated Pleistocene gravel capped by basalt. This basalt laps up over the gneiss and is probably a part of the same flow or series of flows that caps the range.

The desolate and sandy plain north of the Plomosa Mountains and south of the Buckskin Mountains is known as Cactus Plain. A number of small hills scattered over the plain to the north can be seen from the Bouse-Parker road. Those close to the road are in large part composed of limestone, some of which shows hematite stains and other signs of mineralization. Some prospecting has been done here. The composition of the hills farther north is not known. Near the mountains the fill underlying the plain is gravelly, but most of Cactus Plain is floored with fine silt and sand which is blown about by the winds. Much of this sand has been carried by the wind from the flood plain of Colorado River. There is a scattered and scanty vegetation of palo verde, ironwood, and creosote.

The road for the first 15 miles out of Bouse has recently been improved by the county authorities and is very good. The rest of the road to Parker in 1917 was bad but passable. The county had a large force at work extending the improved portion of the road in December, 1917. It is planned soon to construct as good a road as possible as far as the boundary of the Colorado River Indian Reservation. This work will improve the worst stretch of the present road, but it will leave 10 or 11 miles of sandy unimproved road between the reservation line and Parker. East of the mountains mentioned above there are innumerable gullies, and the road no sooner gets out of one gully than it plunges into another. Fortunately there is somewhat less sand here than nearer Parker. After leaving the gullied area the road for a distance of about 3 miles is on a comparatively flat, somewhat sandy plain. The road leaves the plain and descends in a large gully 1½ miles long, with much sand in the bottom, to the flood plain of Colorado River. It remains on the flood plain, passing Indian farms, for 1½ miles, and then ascends to the wide terrace on which Parker is situated and continues over a sandy plain to Parker. This stretch and the stretch on the flood plain are sandy but present no particular difficulties.

No wells so far as known have been put down along this part of the road except those near Parker and one dry hole in the Bouse Wash, in sec. 5, T. 7 N., R. 17 W., near the Little Butte mine. The dry hole in the Bouse Wash is reported to have been sunk 105 feet, all in rock, without striking any water. In sinking the shaft at the Little Butte mine the first water was struck at a depth of 150 feet. The shaft is now down 650 feet on the incline, corresponding to a vertical depth of 400 feet, and contains a considerable quantity of water. (For data on wells in the vicinity of Parker see pp. 217–218.)

Parker is a division point on the Atchison, Topeka & Santa Fe Railway and the only town in the Colorado River Indian Reservation. It contains several stores, hotels, and garages, a post office, a moving-picture house, and an ice plant. The population was 500 according to the census of 1910 but only 282 in 1920. There are several wells in the town, all of which supply good water. (See pp. 217–218.) A small amount of irrigation is done in the town with water pumped from wells.

The railroad crosses Colorado River at Parker on a structural steel bridge (see Pl. XX, *A*), but there is no provision on this bridge for foot travelers or vehicles. The ferry at this place, known as Bush's Ferry, is equipped with a boat 65 feet long propelled by twin screws driven by gasoline engines. (See Pl. XX, *B*.) The charge is $2 per automobile. Foot travelers are carried free if the boat is crossing with an automobile; if a special trip has to be made for a person on foot the charge is the same as for an automobile.

The agency and school of the Colorado River Indian Reservation are west of the town of Parker, and the town itself is within the reservation. The following data regarding the reservation were obtained from the report of the Commissioner of Indian Affairs for the fiscal year ended June 30, 1917. The Indians on the reservation belong to the Mohave, Chemehuevi, and Kawia tribes. The Cocopa Indians come under the jurisdiction of the agency but do not live on the reservation. The total area of the reservation is 240,699 acres, of which 6,100 acres was under the reservation irrigation project and 1,149 acres are actually cultivated by the Indians during the fiscal year. The value of the crops raised was $73,112. The total value of the horses, mules, and cattle owned by the Indians was $79,249. The number of Indians on the reservation was 1,207, of whom 321 were able-bodied male adults. In 1920 the population of the part of the reservation in Arizona was 1,049, including the 282 inhabitants of Parker. Extracts from a report on irrigation in the reservation, by A. L. Harris, are given on pages 108–117. More recent information on irrigation here and at other places on the lower Colorado River is contained in reports submitted to the Committee on Irrigation of Arid Lands of the House of Representatives.[92]

Harquahala Mountains.—The Harquahala Mountains form one of the most prominent ranges in southwestern Arizona. Harquahala is a word of Indian origin, reported to mean "running water" (harqua, water; hala, running).[93] This name is supposed to have been given it because of the occurrence of a small spring-fed stream in the northeastern part of the range which is reported to flow at all seasons. Harquahala Mountain, the central mass of this range, has an altitude of 5,669 feet above sea level and is much the highest point in the area covered by this guide. Its bold, smooth front and massive, rounded summit give it a dignity and impressiveness that are lacking in the more elaborately carved mountains found in most of the ranges. Eagle Eye Peak, at or near the northeast end of the range, is also prominent. It is reported to owe its name to the presence of a cave in its side which, when seen at a distance, has a fancied resemblance to the eye of an eagle.[94]

The range is composed largely of metamorphic rocks belonging to three different series. Of these series the two oldest are almost certainly pre-Cambrian and the youngest may be as young as Paleozoic. Lithologically the youngest series shows some resemblance to rocks of Paleozoic age elsewhere in Arizona, but in the absence of fossils its age can not be definitely determined.

The oldest of the metamorphic rocks are granitic gneiss, with which are associated small amounts of highly metamorphosed schist. These rocks are overlain by fine-grained calcareous quartz-mica schists and quartzite. Some of the rocks at the Socorro mine belong to the least metamorphosed sediments of this range. Bancroft[95] has studied the section exposed here and gives the following description of it:

> Coarse-grained granite which shows some schistosity is the basal rock in this locality and is similar to the pre-Cambrian granite so universally present in this area. Resting unconformably upon the granitic rock is a series of slightly metamorphosed sediments, of which about 150 feet of fine-grained grayish-red quartzite forms the base. This is overlain by several hundred feet of yellowish-brown limestone, the upper portion of which contains intercalated argillites and quartz-mica schists. Strata of schistose shaly limestone and a rock very closely resembling a dolomite (containing, however, fragments of quartz) were noticed near the contact of the quartzite and the overlying limstone. A great number of pseudomorphs of hematite after pyrite were noted in parts of the basal granite in the vicinity and also in a rock near the contact between limestone and quartzite in the ridge just south of the shaft house. One specimen of quartz-mica schist taken from the dump and reported to have come from the 325-foot level about 350 feet south of the shaft shows abundant amounts of tourmaline and pyrite scattered through it. The whole sedimentary series has been tilted so that it now occupies diverse positions. The prevalent direction of dip, however, is east or southeast, the amount varying from 30° to 80°. Faulting has also taken place on a large scale. Small quartz veins are present

[92] Hearings before the Committee on Irrigation of Arid Lands, House of Representatives, 67th Cong., 2d sess., on H. R. 11449, A bill to provide for the protection and development of the lower Colorado River basin; Appendix A, Reports on the Parker, Fort Mohave, and Cibola irrigation projects, Arizona, 1922.

[93] Marsh, Newton, Wenden, Ariz., personal communication.

[94] Jones, E. L., personal communication.

[95] Bancroft, Howland, Reconnaissance of the ore deposits in northern Yuma County, Ariz.: U. S. Geol. Survey Bull. 451, pp. 111–112, 1911.

in all of the formations, and calcite veins are not uncommon in the fractured limestone. A minette dike similar to that seen in the Valensuella workings was noted cutting the limestone on the ridge projecting southward from the mine, and this is possibly an accompaniment of the main granite intrusion found several miles farther west.

These sedimentary rocks are among the youngest formations in the range, and it is believed probable that they may be of Paleozoic age.

Bancroft's descriptions of the ore deposits on the Hercules, Socorro, and San Marcos properties in these mountains [96] show that many faults occur. The fact that the northwest side of the range, facing McMullen Valley, is much steeper and less carved by erosion than the southeast side, facing the Harquahala Plain, suggests that the former may be a fault scarp.

Some prospecting for gold and copper has been carried on in these mountains, but there is not a great deal of mining activity in them at present.

Wenden to Butler Well.—Wenden is a town on the Atchison, Topeka & Santa Fe Railway, which, according to the census of 1910, had a population of 175; in 1920 the population of Wenden precinct was 129. The town contains several stores, a garage, two hotels, and a post office. Good water is obtained from the town well, from which it is piped to most of the houses. The town is a shipping point for mines in the Harcuvar and Harquahala mountains and for the products of farmers and cattlemen living in Harrisburg, McMullen, and Butler valleys. Only a very small amount of irrigation is carried on here.

There is a belief among local people in McMullen Valley that artesian water could be obtained here by drilling a deep well. This belief does not seem well founded, as there is nothing in the geology of this locality to suggest such a possibility. The belief appears to be based on such occurrences as the following: In 1905 E. S. Jones drilled a well on his land in the NE. ¼ sec. 9, T. 3 N., R. 13 W., without encountering any appreciable amount of water to a depth of 202 feet, where he struck a strong flow that quickly rushed up until it stood within 100 feet below the surface. As the records of several wells in this locality show that the water table is at a depth of about 100 feet, this rise was to be expected and does not imply that water under sufficient head to rise to the surface would be found by going deeper. There is a rumor that the water in an old well in Wenden, now out of commission, once rose as far as the surface, but this rumor was not substantiated. The table on page 226 shows that ground-water conditions in this valley are of the usual kind for this region. The only things that can be considered particularly unusual are the short distance to water in the old Wenden town well and the rather great depth to water in the railroad well at Salome.

The road goes due north from Wenden nearly to the foot of the Harcuvar Mountains, a distance of 6 miles. This road is good in dry weather if it is not cut up by too much travel, but in wet weather it is muddy and consequently bad. The road is reported to be excellent shortly after a rain, when the ground has dried out, because the old ruts have been filled and new ones have not yet been formed. Only a day or two is required after even a very heavy rain for the surface of the ground to become dry. Branch roads leave the main road to the west at several points, but the only ones at which any doubt is likely to arise are marked by United States Geological Survey signs.

At the end of the straight stretch the road turns east and the ascent of the Harcuvar Mountains through Cunningham Pass commences. In the lower part of this ascent there are several turns in the road and some washes are crossed, none of which present notable difficulties to automobiles. A number

[96] Op. cit., pp. 109–115.

of branch roads on both sides of the mountains lead to mines or prospects. Most of these turn off to the west. Some of those where doubt might arise as to the proper route are marked by United States Geological Survey signs. Such roads change frequently, as old prospects are abandoned and new ones are opened, and it was therefore impracticable to place signposts at every fork. The large mining concerns and some of the smaller ones have erected wooden signs at the forks leading to their properties. Signs have also been erected by garage owners and others. Consequently, if the traveler exercises judgment, he is not likely to take the wrong road. Moreover, as none of the mines in this section are far from the main road, he would not be delayed very long if he should take one of these branch roads by mistake.

Near one of the forks leading to the property of the Desert Mining & Development Co., 9 miles from Wenden, there is a well about 100 yards southeast of the road which is banked up with rock and dirt so that the top of the curbing is 6 feet above the level of the ground. It is covered with boards to exclude dirt and animals. Water can be obtained by lowering a bucket with a rope. The water is satisfactory for drinking, although it has a perceptible taste. The depth to water from the top of the curbing in October, 1917, was 61.6 feet.

The Harcuvar Mountains form one of the most prominent and conspicuous ranges in the territory covered by this guide. Their topography is more serrate than that of the Harquahala Mountains, to the south. Harcuvar Peak, near their west end, rises 4,391 feet above sea level. The Harcuvar Mountains are composed almost exclusively of pre-Cambrian rocks, both metamorphosed sedimentary rocks and gneissic granite. According to Bancroft,[97] granite of probable Mesozoic age occurs near the west end of the range. Harcuvar Peak is composed of granite of this age. Bancroft says that considerable contact metamorphism took place in the vicinity of the intrusions. He considers this granite to be the source of the mineralization in the Harcuvar Mountains and Granite Wash Hills. Dikes of vogesite, minette, pegmatite, and aplite are associated with the granite. A number of small mines and prospects will be noted in passing over Cunningham Pass on the road between Wenden and Parker. Considerable activity in copper prospecting was in progress in 1918, and several promising strikes were reported. Bancroft gives a number of geologic descriptions of prospects in the Harcuvar Mountains.

The road through Cunningham Pass is a good though rough mountain road. The northern slope is on the whole steeper and longer than the southern but has no very steep grades. From the foot of the northern slope the road leads northwestward across Butler Valley to Butler Well. It is a fairly good plains road but has a few short sandy stretches, especially near the mountains.

Butler Valley lies between the Buckskin Mountains on the north and the Harcuvar Mountains on the south. The east end was not visited, but from the main road some hills and small mountains can be seen extending partly across the valley at that end. At the west end are the Granite Wash Hills, the Bouse Hills, and some scattered buttes south of the Buckskin Mountains. These groups of hills and buttes partly close the valley at this end. Cunningham Wash, carrying the drainage of Butler Valley, passes between the Granite Wash Hills and Bouse Hills to its confluence with Bouse Wash.

Butler Valley is used as a cattle range for the Renada ranch. It has a fairly good growth of grass, and much of its soil would be suitable for cultivation if water were available. The ranch has three wells (see pp. 205, 220), but Butler Well is the only one of these that is near an important road. A supply of water is generally kept in the tank at this well for the convenience of

[97] Bancroft, Howland, op. cit., p. 29.

travelers. This was originally a dug well, but it was drilled deeper in 1911 and was further improved in 1918. The Renada Ranch Co. plans to sink a number of other wells in the valley and hopes to do some irrigation if sufficient water of suitable quality can be found.

The Renada ranch is about 5 miles east of the Butler Well on a good plains road. It is also reached by a road that leaves the main road just north of Cunningham Pass, where a United States Geological Survey sign has been erected. The road from Wenden to Alamo, on Williams River, by way of Cunningham Pass crosses the eastern part of this valley. There is also a road leading southwestward from Butler Well along Cunningham Pass to Graham Well, one of the other wells belonging to the Renada ranch.

Butler Well to Osborne Well.—From Butler Well the road leads northwest over the desert for about 3 miles and then crosses a spur of the Buckskin Mountains for about 7 miles. The road across the desert is fairly good. Two faint roads branch off from it, and a United States Geological Survey sign is placed at the plainer of the two. In the mountains the road is winding and has a few steep grades but is on the whole a good mountain road. A Geological Survey sign near the west end of this stretch marks the point where a little used road branches to the northwest. This branch reaches the Arizona & Swansea Railroad at Midway, a short distance north of the point where the Parker road reaches it. At Midway there is a water tank which is usually kept filled by the railroad company. Prospectors often camp here. Travelers from Wenden to Swansea will find the distance somewhat shorter by taking this branch rather than following the Parker road to the railroad. The Parker road runs south along the railroad for a short distance and then crosses it and swings to the north. The point where the road reaches the railroad and the point where it leaves the railroad are both marked by Geological Survey signs. An old mine shaft, 55 feet deep, is passed somewhat less than a quarter of a mile beyond the railroad. It probably once contained water, as an old wooden sign says "Water here," but in September, 1917, it was dry.

About 3 miles from the railroad the road turns west and passes through low hills. Red wind-blown sand is found here, but not enough to be troublesome. Dunes of this red sand cover considerable tracts of Cactus Plain, to the southwest. From this turn the road skirts the Buckskin Mountains for about 9 miles to a road fork. On account of numerous washes from the mountains that cross the road, there are many sharp pitches, but none of them are excessively steep. The road to the north goes to Osborne Well, a distance of 1 mile. The main road continues 1 mile to a fork, where another road to Osborne Well, here less than half a mile away, branches off the main road. Both forks are marked by United States Geological Survey signs. Westbound travelers desiring to go to Osborne Well would take the first fork mentioned; eastbound travelers would take the second one. Both roads are fairly good as far as the well. A road leads north along the wash from Osborne Well through the Buckskin Mountains. This road is reported to be practicable for wagons but would probably present considerable difficulty to an automobile.

At Osborne Well there are a number of houses, one of which is marked "Office." The well is on the bank of a wash. It has a wooden headframe, a trapdoor to keep animals and dirt out, and a rope, windlass, and buckets with which to obtain the water, which is apparently of good quality except that it may be contaminated with dead animals. This place is a camp belonging to Mr. Osborne, of Parker, who has mining interests in the Buckskin Mountains.

Buckskin Mountains.—The Buckskin Mountains, also called the Williams Mountains, extend along both sides of Williams River for 35 or 40 miles.

Only the southern border was visited during this investigation. Bancroft[98] gives the following account of these mountains:

North and south of Williams River the country for several miles is built up by low foothills which gradually rise to the base of a few prominent peaks, among which Planet is by far the most noteworthy, and these constitute the Williams Mountains. They are so decidedly different from the other ranges in the area that the presence of foothills is worthy of remark.

Foothills occur to some extent on the southern border of the mountains also. The whole range is much more elaborately carved by erosion and a far less compact unit than most of the other ranges in this region.

The Buckskin Mountains are composed mostly of pre-Cambrian rocks of igneous and sedimentary origin. Near Osborne Well outcrops of a fresh gray granite with no suggestion of gneissic structure were noted. This granite in places contains grains of specularite. Shallow prospect holes have been sunk in it. Probably it belongs to the group of intrusive rocks that occur in a number of the ranges in this area and are considered to be Mesozoic. Lava, tuff, tuffaceous conglomerate, and sedimentary rocks occur in a number of places in the range. They were observed at Osborne Well and north and west of that place, and Bancroft[99] mentions such rocks at several prospects in these mountains. As seen north of Osborne Well these rocks rest unconformably both on the pre-Cambrian rocks and on the more recent granite. They may be referred with considerable certainty to the Tertiary period. Grayish tuff and tuffaceous conglomerate are exposed at a number of places north of the Parker road west of Osborne Well. Much of the tuff is very thinly and regularly bedded, suggesting deposition in a lake.

About 6 miles west of Osborne Well, on the north side of one of the outlying hills of the Buckskin Mountains, is a scarp in which a peculiar igneous rock is plainly exposed. This is an intrusive rock of Tertiary age that differs in several respects from any seen elsewhere in the region. Microscopic examination shows that it is a gabbro with coarse granulitic texture. The igneous mass has a very irregular outline, but the greatest extension of the exposed part is in a horizontal direction. On the west are beds of brown sandstone dipping about 10° south and striking roughly east. The contact of this rock with the gabbro is very irregular, and the sandstone is somewhat baked along it. Directly overlying the igneous rock is a basalt flow that caps the hill and is only 50 feet or so thick. When seen from a distance the lower part of the igneous mass seems to have a rough horizontal stratification, probably due to jointing. The upper part does not exhibit this apparent stratification but weathers in rounded masses 2 feet or more in diameter. The rock in these masses is full of grains of calcite, which give it a pseudo-amygdaloidal appearance. The texture differs somewhat from that of the underlying portion, being on the whole coarser.

This irregular mass of gabbro was clearly intruded into the brown sandstone, which almost certainly belongs to the Tertiary. Whether the gabbro is of Tertiary age and was exposed by erosion before the eruption of the basalt that now covers it, or whether it is Pleistocene and was intruded into its present position subsequent to the deposition of the lava is not known with certainty. The field relations suggest the second alternative, but it is difficult to understand how a coarsely crystalline igneous rock could be formed so close to the surface. Capping all the other rocks in the western part of the range is a thick basalt

[98] Bancroft, Howland, op. cit., p. 21.
[99] Idem, pp. 66, 67, 75, 77.

flow which gives a characteristic mesa topography to this area. At Osborne Well basalt rests unconformably on a tuffaceous conglomerate. Lee[1] states that in Williams Canyon the Temple Bar conglomerate, of Quaternary age, nearly 1,000 feet thick, is overlain by this basalt, which is there 800 feet thick.

Osborne Well to Parker.—The Wenden-Parker road after leaving the fork south of Osborne Well continues to skirt the mountains, following very closely the course of Osborne Wash. At a point about 9 miles from the fork the wash turns somewhat to the north, but the road continues west to Parker. A short distance east of this point two prominent hills on the south are passed. The more westerly of these is known as Black Peak, because of its cap of black lava, and is a well-known landmark. The other hill has a steep scarp of bare rock on the north side, which can be distinctly seen from the road. This is the place where the peculiar intrusive mass mentioned on page 179 occurs.

The last 6 miles of the road to Parker leads over Cactus Plain and, though very sandy, is not very rough and is passable. Trouble might be experienced here if large amounts of sand should happen to be blown into the road by the wind. This stretch would be bad in very wet weather. (For a description of Parker and vicinity, see pp. 174–175.

Bouse to Swansea.—The road from Bouse to Swansea runs northward along the Arizona & Swansea Railroad and crosses the Wenden-Parker road 12 miles from Bouse. From this point it continues 10 miles farther to the mining town of Swansea, at which is the only smelter in this section of the country. For the first 12 miles from Bouse the road is a good desert road that crosses the railroad four times. Beyond this stretch the road enters the mountains. The 10 miles from the Parker road to Swansea was not traveled during the present survey, but the road is reported to be a good mountain road. It crosses the railroad several times. At Midway there is a water tank which is usually kept filled by the railroad company.

VICKSBURG TO QUARTZSITE.

[For log see pp. 142–143.]

The road between Vicksburg and Quartzsite is one of the routes used by travelers on the way to or from California by way of Ehrenberg Ferry. The alternative route is that between Bouse and Quartzsite, described on pages 183–184. Vicksburg is a station on the Atchison, Topeka & Santa Fe Railway 20 miles southeast of Bouse. Both towns are on the Parker cut-off. (See pp. 123–124.)

For travelers between Ehrenberg and places east of Vicksburg the route by way of Bouse from Quartzsite is 14 miles longer than that direct to Vicksburg, but the road is much better, especially in wet weather.

The direct road between Quartzsite and Vicksburg is a part of the old stage and military road between points in California and Wickenburg, Prescott, and Phoenix, in Arizona. Quartzsite, then called Tyson's or Las Posas, was a station on the stage line, and Desert Well, 5 miles southwest of the present town of Vicksburg, was another. Vicksburg was not then in existence. The next station to the east was at Mesquite Well, south of the present town of Salome. (See p. 213.) East of this the next station is locally stated to have been at Cullins (Colling's) Well, about 15 miles farther on. Peters Well, south of Wenden, was also used at one time as a station on the stage line. R. J. Hinton[2] gives a list of stage stations. The station he calls Flint's is probably Mesquite Well, and the one he calls McMullen's is at or near Peters Well.

[1] Lee, W. T., Geologic reconnaissance of a part of western Arizona: U. S. Geol. Survey Bull. 352, p. 54, 1908.

[2] Handbook to Arizona, appendix, 1878.

The road goes south between the now deserted shacks of Vicksburg, then southwest to Desert Well. It is a good desert road for this distance but would be somewhat muddy in wet weather.

At Desert Well is a windmill, water tank, and corral belonging to Mr. Thomas Bales, a local cattleman, and an old adobe house. A regiment of cavalry was camped at this place for many months during the Apache troubles. The well is 35 or 40 years old. It was originally dug by the Government for military purposes. The few scattering mesquite trees about the well furnish the only verdure for miles around.

Beyond Desert Well on the westbound trip care must be taken to keep sufficiently to the right to avoid getting on the road leading southeastward to Bales's ranch or that leading southward to Twentymile Well and the mine of the Shamrock Mining Co. There is a road from this mine back to the Vicksburg-Quartzsite road, so that the detour would add only half a mile to the trip. The road should be avoided, however, as some stretches of it have sufficiently high centers to be likely to cause serious trouble to an automobile, especially one that is low hung. The Geological Survey sign at Desert Well should aid in starting the traveler on the right road.

This portion of the Ranegras Plains is made up of extensive adobe flats. In times of flood layers of fine silt are spread over the flats, which are soon dried out by the sun. A crust of hardened mud is thus formed whose surface makes an excellent roadway as long as it is not broken. Once the crust is crushed, however, the wheels of vehicles sink into the soft silt beneath, and deep ruts with high centers between them are soon formed. This condition has led to a multiplicity of tracks across these flats, for as fast as one set becomes too deeply worn another is started. The traveler will have to use his judgment in picking out the one to follow. If his car is lightly laden, it may be wise to abandon the tracks entirely and run on the crust. In wet weather it is difficult but usually not impossible to cross these flats.

Just before the Bear Hills are reached the road from Twentymile Well and the Shamrock mine comes in. Twentymile Well is 2.6 miles southeast of this point, and in an emergency water can be obtained there, but no provision is made for travelers.

The road passes through the outlying hills and crosses an inclosed valley where creosote, ironwood, and palo verde afford a welcome relief from the utter barrenness and desolation of the adobe flats. Then the steep ascent of the Plomosa Mountains is commenced. The road is passable in all kinds of weather but is steep, has several curves, and is very rough, even for an Arizona mountain road. (For a description of the Plomosa Mountains see p. 184.)

The old Guadalupe mine is passed on the left near the summit of the mountains. This mine or prospect has been shut down for a number of years. Some rich gold ore is reported to have been found here, and even now a search of the dumps about the open cuts reveals flakes of gold in some of the quartz fragments. From this point the road descends, flanked by basalt mountains and buttes, to La Posa Plain and crosses the valley to Quartzsite.

The road between Bouse and the Plomosa mine joins the Vicksburg-Quartzsite road from the north a short distance west of the Plomosa Mountains, and a little farther on it leads off southward to the Plomosa mine, which can be seen on the flank of the mountains from which it gets its name. This is a placer gold property, the largest in the vicinity, and has been worked intermittently for a long time. There are Geological Survey signs at the points where the Plomosa road joins and leaves that between Vicksburg and Quartzsite. Another

Geological Survey sign at Tyson's Well, on the outskirts of Quartzsite, should remove any doubt the traveler may have as to which of the crossroads to take.

In the boom days of placer and quartz mining in the Dome Rock and Plomosa mountains Quartzsite was a lively place, with a number of stores and saloons. It is still the center for the prospecting that is being done in the vicinity, but there is much less activity now than formerly. The cattlemen who have stock on La Posa Plain made their headquarters in the town, and small tracts of land are irrigated here and near by.

Quartzsite consists very largely of adobe houses, many of which are deserted, but contains also several wooden houses of more recent construction. The census of 1910 credits the town with 300 inhabitants; in 1920 the precinct had 117. There is a store and post office here and a hotel. No automobile supplies are obtainable. Mail is brought in and taken out by the daily automobile stage from Bouse. Good water can be obtained from several wells. Curiously enough the town has a swimming pool, which is popular in the summer. This is a concrete tank, originally intended as a reservoir from which to supply placer workings. Insufficient water was obtained by the wells put down for this purpose, but enough is available to make the tank serviceable as a swimming pool.

Quartzsite is still an important point in this portion of the country, because of the numerous roads that radiate from it. The road to Ehrenberg Ferry leads west, that to Bouse northeast, and that to Vicksburg east. To the south are the road to Castle Dome, Dome, and Yuma, the only practicable road in Arizona by which Cibola can be reached, and the road to New Water Pass. Cibola is a small town on Colorado River where there is some irrigation, but the principal industry is raising bees for honey. In 1920 Cibola precinct had 19 inhabitants. The road to New Water Pass is used by prospectors. A burro trail extends from this pass to Alamo Spring, but it is reported that there is no practicable automobile road. More or less prospecting is still going on in the Dome Rock Mountains, and the prospectors make their headquarters in Quartzsite. They follow one of the main roads out of town, then leave it at convenient places to reach their prospects in the mountains. More work on these prospects and small mines is done in winter than in summer, because of the summer heat. In consequence a traveler using one of the main roads in the winter will find more freshly made tracks branching off to one side or the other than he would find in summer and must guard against going astray by following such tracks. This precaution is necessary in any part of this region where prospecting is going on, but usually there is no difficulty if a little care is used in determining which is the correct road to take.

The table that gives data on wells in La Posa Plain (p. 220) shows that water can be obtained here at comparatively slight depths, but the quantity so far developed is small. Placer miners put down some deep wells in this vicinity some years ago, with results that are said to have been favorable, but the records of these wells are not available. Mr. Weber is reported to be irrigating 6 or 7 acres about 1½ miles northwest of Quartzsite from a well only 16 feet deep. All the wells regarding which information was obtained extend to a hard caliche. Perhaps the presence of this impermeable material accounts for the slight depth at which water is found. Gravel cemented with caliche is found in many places near the mountains surrounding La Posa Plain. Doc Clark's deep well in the southern part of the plain passed through a hard material that was probably of this character and encountered no water below it. In this connection Bancroft's statements[3] regarding conditions in

[3] Bancroft, Howland, Reconnaissance of the ore deposits in northern Yuma County, Ariz.: U. S. Geol. Survey Bull. 451, p. 88, 1911.

the vicinity of the placer workings of the New York-Plomosa Co. are interesting. He says:

In certain old drainage channels which led away from the southwestern part of the Plomosa Mountains is found an auriferous conglomerate of granite, schist, and quartz fragments cemented by lime carbonate. In thickness this conglomerate or "cement rock" varies from a few inches to a great many feet, the depth depending largely on the shape and size of the formerly existing channels. It is certain that placer gold occurs in this cement rock, but no data of the average tenor or the probable cost of working could be obtained. It was evidently the intention of the company to work the cemented material in mills. The quartz veins in the mountains close at hand are thought to be a reasonable source of origin for the gold found in the placers.

Jones [4] writes as follows regarding the placer ground on the east side of the Dome Rock Mountains:

At the time the region was visited the Orofino tract, owned by the Catalina Gold Mining Co., was the only one on which work was being done, and this work consisted of testing the ground, partly to determine its gold content and partly to determine the advisability of working the wash with dry concentrating machines of large capacity. The following information was obtained on the ground, the data as to the gold content and like matters being supplied by Mr. E. L. Dufourcq, the engineer in charge. The placer ground owned by this company comprises 640 acres of land, in which test holes were sunk every few hundred feet. The holes ranged in depth from a few feet to 30 feet. The material taken from each excavation was run through a small concentrator to determine its gold content, and the results showed that the gold content ranges from a few cents to over $1 per cubic yard, the average being 38 cents. The colors run from less than 1 cent to 24 cents each, and the gold is fine, being worth about $19 an ounce. The gold-bearing material differs from that of the La Paz placers in that it consists of unconsolidated rock débris and an underlying cemented gravel. The loose material ranges in depth from a few feet to 12 feet, and the cement is of variable depth—at least 18 feet in places. The gold is said to be distributed through both the unconsolidated and the cemented material.

It is possible that this widespread occurrence of cemented gravel with unconsolidated wash above it may have an important geologic significance. It strongly suggests that the valley fill in La Posa Plain may have been deposited at two distinct periods and that it is the older fill which is now partly consolidated, the younger being as yet unconsolidated.

BOUSE TO QUARTZSITE.

[For log see pp. 143–144.]

For a long time the only way to reach Quartzsite from points farther north in Arizona was over the stage road by way of Desert Well. When the Santa Fe, Prescott & Phoenix Railroad was built the freight to and from Quartzsite passed through Vicksburg. About 1910 a mining engineer on a trip from Bouse to examine a prospect in the Plomosa Mountains discovered an easy pass through these mountains about 10 miles south of Bouse, and subsequently a road was built from Bouse to Quartzsite through this pass with money furnished in part by citizens of Bouse and in part by the county. This road is 6 miles shorter than the road from Vicksburg to Quartzsite, avoids the adobe flat near Desert Well, and is not nearly so rough where it goes through the mountains. There are no watering places on it, but as it is only 24 miles long this is not a serious disadvantage.

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[4] Jones, E. L., jr., Gold deposits near Quartzsite, Ariz.: U. S. Geol. Survey Bull. 620, pp. 52–53, 1916.

Just beyond Bouse Wash, on the outskirts of Bouse, there is a stretch of adobe soil where the road may be a little cut up, but this road in general is not in bad condition. It is said that part of the adobe can be avoided by taking the road to the right (the Parker road) at the fork marked by the United States Geological Survey sign, 0.2 mile from the railroad station, continuing on this road for about half a mile to the next Geological Survey sign, and then turning sharply to the left, as indicated by the sign. There is probably little choice between these two ways of leaving Bouse for Quartzsite. Beyond the adobe there is a good plains road as far as the mountains. The forks of the road where doubt may arise are marked by Geological Survey signs. The road goes through the mountains by a low and easy pass, running for much of the distance in the bed of a wash. At the southwest border of the mountains is a fork marked by a Geological Survey sign. From this point to Quartzsite there is a very good plains road.

The Plomosa Mountains are a complex range consisting chiefly of metamorphic rocks of probable pre-Cambrian age. Near the Little Butte mine, at the extreme north end of the range, and possibly elsewhere, are limestones lithologically similar to those at the Socorro mine, in the Harquahala Mountains, and hence probably Paleozoic. (See p. 176.) Lavas, fine-grained intrusive rocks, and Tertiary sedimentary rocks are found in a number of places in the Plomosa Mountains. In the southern part of the range many of the peaks are capped by thick flows of Pleistocene olivine basalt. The buttes of red conglomerate of probable Tertiary age about 7 miles southwest of Bouse are conspicuous from the Bouse-Quartzsite road. In the pass by which this road traverses the mountains are some dikes of chalky white porphyritic soda rhyolite or quartz-soda trachyte.

Deposits of gold, copper, lead, and iron are known in the Plomosa Mountains, but no large mines have been developed. The gold placers on the slopes of the range have received considerable attention. The New York-Plomosa Co. in particular has done much work here. It has recently installed new dry-washing machinery. The placers and many of the bedrock deposits have been described by Bancroft.[a]

QUARTZSITE TO EHRENBERG.

[For log see pp. 144–145.]

The road from Quartzsite to Ehrenberg Ferry goes west from Quartzsite through the Dome Rock Mountains, passes down the alluvial plain west of them, and then goes southwest over the flood plain of Colorado River to Ehrenberg Ferry. Through the mountains the road is rough, but the grades are not excessive. It follows the gravel beds of washes for short distances in several places, but in December, 1917, all portions of it were easily passable. There are United States Geological Survey signs at some of the road forks.

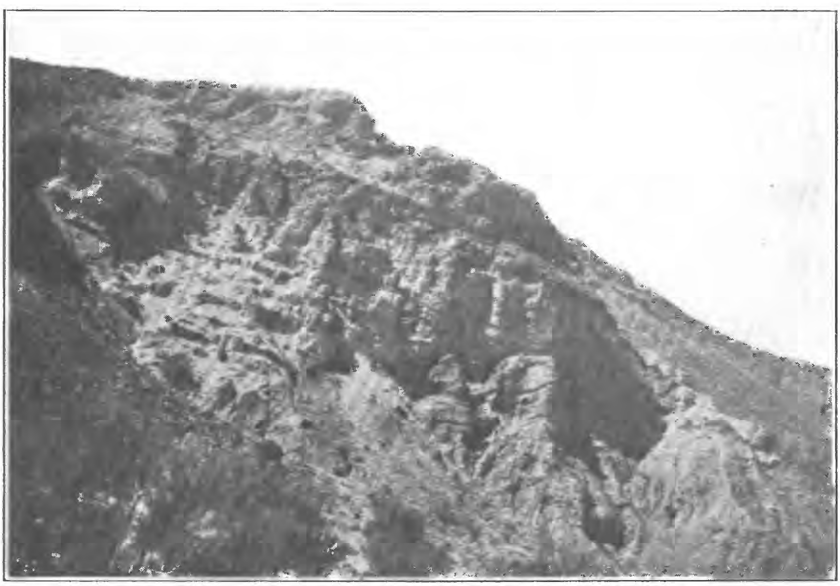
Gonzales Wells, 9 miles from Quartzsite, is the only watering place on the road. There are two dug wells here, one of which is provided with a rope and buckets by means of which water of fair quality can be obtained.

West of Gonzales Wells there are two forks that are not marked by Geological Survey signs. These are mentioned in the log, and both are so faint that they are readily distinguishable from the main road. The road across the alluvial plain west of the mountains is good; that across the river flood

[a] Bancroft, Howland, Reconnaissance of the ore deposits in northern Yuma County, Ariz.: U. S. Geol. Survey Bull. 451, pp. 87–95, 1911.

A. FINELY BEDDED LIMESTONE WITH OVERLYING BASALT AT BORDER OF BUCKSKIN MOUNTAINS ABOUT 12 MILES EAST OF PARKER.

Photograph by O. E. Meinzer.



B. SCARP ON NORTH SIDE OF BLACK BUTTE, CACTUS PLAIN.

From Parker road, looking north. Photograph by O. E. Meinzer.

A. DESERT WELL, ABOUT 5 MILES FROM VICKSBURG, FROM THE EAST.

B. EHRENBERG FERRY FROM ARIZONA BANK OF COLORADO RIVER.

Showing automobile being ferried across.

C. GONZALES WELLS, DOME ROCK MOUNTAINS.

A. HORSE TANKS, CASTLE DOME MOUNTAINS.

B. GAP BETWEEN CLANTON HILLS AND GILA BEND MOUNTAINS THROUGH WHICH HARQUAHALA ROAD PASSES.

From Clanton's Well, looking southwest.

plain is sandy, but little difficulty is likely to be experienced in traversing it. Soon after reaching the flood plain at a point about 2 miles from the ferry the traveler passes a reverse fork, from which a road leads up the river past the abandoned town of La Paz to Parker. This road is poor but passable. Between La Paz and Parker there are several roads along the river. The route to follow must be left to the discretion of the traveler. Water can be obtained from sloughs in the river flood plain. The La Paz Gold Mining Co., which has a mine in the Dome Rock Mountains, started in December, 1917, to drill for water at La Paz. If these efforts are successful, they will furnish a good watering place on this road.

The Dome Rock Mountains, which lie between La Posa Plain and Colorado River, are a rugged range rising 3,000 feet or more above the sea. North of them are some detached groups of hills; to the south are the Chocolate and Trigo mountains, about which little is known.

The Dome Rock Mountains are composed chiefly of pre-Cambrian gneiss and schist, but they also contain granite of probable Mesozoic age[6] and several intrusive masses of fine-grained acidic rocks, which are probably of about the same age as the Tertiary lavas.

The gold placers on both the eastern and western slopes of these mountains have long been famous. The lack of water and the fineness of much of the gold have interfered seriously with the development of these deposits, and only desultory small-scale work is going on at present. Placer mining began in this district with the discovery of the La Paz diggings by Capt. Pauline Weaver[7] in 1862. La Paz and Ehrenberg, a few miles south of it, both on Colorado River, were flourishing towns during the boom days of the placers. The county seat was at La Paz until 1871,[8] when it was moved to Yuma. According to Jones[9] La Paz maintained a population of 1,500 until 1864, when, with the apparent exhaustion of the placers and the discovery of new diggings in other districts, large numbers left it. From that time the population steadily decreased, and with the additions to the Colorado River Indian Reservation in 1873, 1874, and 1876, which included much of the placer ground and greatly restricted mining, La Paz became practically deserted. At present there are only some crumbling adobe buildings to mark the site of the once prosperous town. Ehrenberg, at first called Mineral City, was founded in 1863[10] and flourished with the decay of La Paz, but it lost prominence when the railroad was built to Yuma in 1877. At present no one lives at the site of the old town, but the name is kept alive by the Ehrenberg Ferry.

Lode mining as well as placer mining has been done in the Dome Rock Mountains, but no mines of much importance have been developed. Deposits of gold, copper, and mercury occur here, and some of the prospects are described by Bancroft.[11]

[6] Jones, E. L., jr., Gold deposits near Quartzsite, Ariz.: U. S. Geol. Survey Bull. 620, p. 48, 1916.

[7] Idem, p. 49.

[8] Bancroft, H. H., A history of Arizona and New Mexico, p. 616, San Francisco.

[9] Jones, E. L., jr., op. cit., p. 49.

[10] Bancroft, H. H., op. cit., p. 616.

[11] Bancroft, Howland, Reconnaissance of the ore deposits in northern Yuma County, Ariz.: U. S. Geol. Survey Bull. 451, pp. 78–86, 1911.

QUARTZSITE TO DOME.

[For log see pp. 146-150.]

The road south from Quartzsite forms a convenient means of getting from the northern to the southern part of Yuma County. It is more used for this purpose than the Harquahala road, farther east. Dome is only 20 miles from Yuma, the county seat and metropolis. As a whole, the road is good, although there are some rough stretches in it.

Roads across La Posa Plain.—There are two roads across La Posa Plain, the old one and that constructed in 1917 by the county. The new road is soft in places but will probably prove the better road when it has been used a little longer. It has been marked with signs by the United States Geological Survey and more recently by Yuma County. The county had just started on its work when the field work of the Geological Survey ended, and hence the locations of the county signs can not be given. They are wooden posts and signs, painted white, with the names and distances in black. Signs were placed on the southern half of this road by the B. F. Goodrich Co. some years ago, when it was a part of the direct route between Yuma and Phoenix. (See p. 161.)

The old road across La Posa Plain is often recommended by local people. It is slightly less rough than the new one, but there is really little choice between them in that respect. The distances do not differ much. The old road is not marked with signs, however, and as there are a number of branches from it the chances of getting off it are greater. Many of the branch roads lead into the Dome Rock Mountains, where it is easy to get lost. Several parties have been lost in this way. This road is therefore not recommended to strangers. However, the log of it on pages 147 and 150 and the description on page 187 should prove of service to anyone traveling it for the first time. As already stated, this road is a portion of the only route in Arizona to the town of Cibola, on Colorado River.

The new road crosses a number of washes, some of which have rather steep banks. Some of the stretches of adobe soil are soft, and the road across them may be somewhat cut up. The comparative abundance of vegetation on this plain is in pleasant contrast with its absence from many valleys in this region. Palo verde and ironwood line the numerous washes, and there are a number of small tracts where the galleta and other grasses grow luxuriantly. Some cattle now range here, and many more would be able to do so if sufficient water was available. Except for the wells at Quartzsite and that belonging to Kuhn & Hagley near the old road 6 miles south of Quartzsite there are no watering places for cattle on this plain.

Near the south end of the plain, 26 miles from Quartzsite, a derrick to the west of the road marks the place where Doc Clark made an attempt to find water. He encountered small amounts at depths of 100 and 150 feet, but not enough for his purpose. The well was down about 700 feet and was dry when he suspended operations, but he expected to resume work at an early date.

About 2½ miles south of the Clark dry well, at the east end of a group of small rocky hills, there is a stone cabin which is about half a mile west of the road where it turns to enter the Castle Dome Mountains and is a well-known landmark. At one time the road went by this cabin and through a pass between the Castle Dome and Chocolate mountains to Castle Dome, but this is now abandoned.

The old road south from Quartzsite follows the border of the Dome Rock Mountains more closely than the new one. The road to Dome does not enter any mountains until it reaches the Castle Dome Mountains, nearly 30 miles from Quartzsite. Consequently, if a traveler bound to Dome on the old road finds himself entering mountains soon after leaving Quartzsite he may know that he has made a wrong turn and should retrace his course. As noted in the log of this road (p. 147) there are three places on it where in an emergency it is possible to get water. In this respect the old road has an advantage over the new one.

The road to Cibola was not traveled beyond the wash containing sand tanks mentioned in the log, and little is known about it. The road is reported to be rough but practicable, and it was to be improved and its alinement somewhat changed by the county. The road to Ehrenberg from the wash above referred to is almost impassable.

S. H. Mountains.—The S. H. Mountains were not visited during this investigation. They were observed only from the road between Quartzsite and Dome at a distance of several miles to the east. Consequently the boundaries and extent of the range are not definitely known. Their general trend is northwest. They are separated from the Plomosa Mountains by New Water Pass, and from the Castle Dome Mountains by a broad pass dotted with buttes and hills. Nothing is known about the southeastern extremity of the range except that the White Tank (Tank) and Palomas ranges are situated near it. Whether the Tank Mountains are distinctly separated from the S. H. Mountains or are an extension of that range is not known. Probably there is no very wide pass between the two ranges. The S. H. Mountains are called the Kofa Mountains by Jones, after the mining settlement of Kofa, but the name S. H. is much better known.

The King of Arizona and North Star mines (pp. 161–162) are in these mountains. The following notes on the geology of the range are based on the report by Jones,[12] who studied the deposits at these mines and others near Ocotillo, on the north side of the range, and on field observations made during the present investigation. The mountains contain extrusive igneous rocks resting on an eroded surface of much older rocks. The extrusive rocks are intricately dissected into small flat-topped mesas, jagged spires, and other fantastic forms. They comprise rhyolite and andesite, with accompanying tuff, breccia, and local thin beds of grits overlain by olivine basalt. Olivine is a sparse constituent of the andesite also but becomes more abundant toward the top of the series. This indicates a close relation and possibly a gradation in composition between the andesite and the overlying basalt. Jones gives the probable thickness of the series of volcanic rocks as 2,000 feet, which is certainly a moderate estimate. He says that in places the basalt flows are 300 feet or more thick. Some of the more acidic lava flows in the western part of the range are even thicker than this. The lava series rests on a basement of highly metamorphosed sedimentary rocks with associated pegmatite dikes of probable pre-Cambrian age. These ancient rocks are intruded by granite and by diorite and monzonite porphyry dikes that are probably Mesozoic.

Castle Dome Mountains.—The Castle Dome Mountains, which are entered about 30 miles south of Quartzsite, are carved into weird and fantastic forms, and the scenery in some parts of them is both impressive and beautiful. The first pass through them going southward is low and presents no difficulties. On leaving it the road enters a small valley cut by several washes and bordered on the west and south by the main range of mountains, and on the east and north by hills. In this valley several roads branch off to the Horse Tanks, a well-known watering place for cattle as well as for travelers. Water can

[12] Jones, E. L., jr., A reconnaissance in the Kofa Mountains, Ariz.: U. S. Geol. Survey Bull. 620, pp. 151–164, 1916.

always be obtained here, but it may often be difficult to get any clean enough to invite drinking. Tanks are reported to occur for some distance up the canyon above the big ones reached by the road, and it is probable that those farthest upstream will be found to be the cleanest. The roads to these tanks from the main road are rough but entirely practicable.

The main Quartzsite-Dome road crosses into the interior valley, passes out through the encircling hills, and then skirts the east side of the mountains for 4 miles. This stretch is a good plains road. At the point where the road again enters the mountains it is joined by the road from Deep Well on the west. This fork is marked by a United States Geological Survey sign. From this point the road follows the old road from Phoenix by way of Deep Well and Palomas to Yuma. It goes through the mountains for nearly 5 miles, then skirts them for about 4 miles more to Castle Dome. In the mountains the road is rough and some of the grades are steep. The first portion of this stretch is in the gravel bed of a wash. A car in poor condition might have trouble here or on some of the steeper grades, but the road is traveled constantly and little or no trouble is experienced. There are two sets of natural rock tanks near this road where water can be obtained.

The Castle Dome Mountains form an irregular-shaped range with general north-south trend, about 30 miles long and somewhat more than 7 miles wide at the widest place. Geologically they are similar to the S. H. Mountains, described on page 187, except that they contain no Mesozoic intrusive rocks, so far as known. The exposures of pre-Cambrian schist are very scanty, being observed during the present investigation only in the vicinity of the Thumb Butte mine, in the southern part of the range. There is great diversity in the composition of the lavas. Hills of basalt occur at the south end, and this rock may be sparingly present elsewhere in the mountains, but most of the lavas are acidic. The prevalent colors are brown, yellow, gray, and cream. Considerable yellow tuff occurs. Some dark coffee-colored obsidian was noted. Fine-grained intrusive rocks cut the lavas in numerous places. The rocks have been faulted, probably to a marked extent.

The forms produced by the erosion of these lava flows are striking and picturesque in the extreme. Sheer cliffs are the rule. The impression conveyed by a casual glance in many places is that of a mass of angular blocks thrown together in confusion. Elsewhere sharp-pointed peaks and fantastic knobs cut the sky line.

Castle Dome is the dominant peak of the range and is a very prominent landmark, visible for many miles. It is a knob carved from a thick lava flow with vertical columnar jointing. This mountain was originally and rather more appropriately called Capitol Dome[13] by the officers at Fort Yuma in 1853, from its fancied resemblance to the dome of the Capitol at Washington.

The Castle Dome Mountains have been prospected without success except in a few localities, the only important one of which is the Castle Dome mining district, at and near Castle Dome. The largest mine in the district, reported to be more than 600 feet deep, is passed on the road from Quartzsite immediately before reaching the group of wooden houses that constituted the settlement. The place is now deserted except for a caretaker and his family, who are usually to be found there, but a few prospectors live in the hills near by. The 1920 census gives the population of the precinct as 22. There has been some talk of reopening the Castle Dome mine, but nothing definite had been done in this direction when the place was last visited, in January, 1918. Water

[13] Blake, W. P., Report of the Territorial geologist, in Report of the governor of Arizona, 1899, p. 106.

is pumped from the mine by the caretaker into a tank near the shaft and is piped from the tank to some of the houses. Much of this piping is now out of order, and the tank is none too clean.

The following notes on the district are abstracted from Blake's report.[14] The veins may be said to have been rediscovered in 1863, as there are evidences that they had previously been worked either by the ancient inhabitants of the country or by early Spanish explorers. After their rediscovery they were worked continuously for a number of years and yielded considerable lead-silver ore. The ore is galena, and the principal gangue mineral is fluorite. The rocks of the district are compact fine-grained mica and clay slates traversed by numerous dikes or intrusive mases of a chocolate-colored porphyry. Porphyritic felsite was noted during the present investigation, but the sedimentary rocks were not seen. They doubtless belong to the pre-Cambrian schist, which is known to underlie the lavas.

Chocolate Mountains.—Between the Castle Dome and Trigo mountains is a little-known range called the Chocolate Mountains. This should not be confused with the range of the same name in California northwest of Yuma. The range is separated from the Castle Dome Mountains by a pass, according to the reports of those who have traversed the old road that once ran through this pass, but no break can be seen from any point on the present road. The mountains are composed largely of pre-Cambrian metamorphic rocks, but more recent lavas are present in places.

The Free Gold group of prospects in these mountains is described by W. P. Blake,[15] who says that at the time he wrote a well-defined vein carrying free-milling gold ore was being developed on a number of claims and that an average mill rock running $30 to the ton could be mined.

Castle Dome to Dome.—From Castle Dome to Gila River there is an excellent plains road. All forks at which any doubt is likely to arise are marked by United States Geological Survey signs. Numerous washes are crossed, but these are not likely to give trouble. The only one that might possibly do so, because of the steepness of the ascent out of it, can be avoided by taking the left-hand road at the fork 20.5 miles from Castle Dome. (See log, p. 147.)

During a large part of the year the amount of water in Gila River where this road crosses is negligible, and often no water whatever is encountered in the road. The flood plain here is, however, so sandy that there may be difficulty in crossing, although usually there is little trouble. A Mexican who lives near Dome uses flatboats to ferry vehicles across the river when there is too much water to ford. He wades in the water, pushing the boat in front of him. In times of flood it is impossible to cross here.

The course followed by the road changes frequently because of changes made by the river, and consequently a number of sets of tracks will be noted. Those which appear to have been most traveled recently should be followed. No difficulty is likely to be encountered in finding the road across the river going south. In going north from Dome, however, it is possible to get on a set of tracks leading to some Mexican adobe houses downstream from the road on the north bank of the river. Some buildings and a windmill at the point where the road leaves the flood plain will serve as a landmark.

The extensive Castle Dome Plain, north of Gila River near Dome, is strewn with gravel, and except along the washes has but little vegetation. The soil for the most part is hard-packed adobe mixed with gravel. Little or none of it is free from gravel, and consequently it is not well adapted to agriculture.

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[14] Blake, W. P., op. cit., pp. 106–107.
[15] Report of the governor of Arizona, 1899, pp. 61–62.

Probably this fact and the comparative scarcity of native grasses accounts for the total lack of wells in this plain. There are a few shallow dug wells on the flood plain of the river but none on Castle Dome Plain.

The plain is crossed by numerous large gravelly or sandy washes that form braided patterns. Consequently the roads cross washes at short intervals. The gravel bottoms of the washes are fairly firm, so that no difficulty is encountered in crossing them. Their banks are nowhere high, and on the main road several of the steepest have been cut down to easy grades. Near the south end of Castle Dome Plain the flats occupied by the washes lie between terraces which in some places are more than 20 feet high. These flats are in places fully half a mile wide. They are covered with a luxuriant growth of ironwood and a subordinate amount of palo verde and other bushes.

A range of low hills and buttes west of the road between Castle Dome and Dome extends from north to south through the center of the plain. This range is composed in part of recent basalt, especially near the southern extremity, but is believed to contain ancient metamorphic rocks also. The region farther west was not visited, but the range appears to be narrow, and the plain evidently continues west of it to the hills bordering Colorado River. These hills and the Trigo Mountains north of them were also not visited, and little is known about them. From a distance the Trigo Mountains appear to be built up largely of lavas, probably of Tertiary age. The range has many sharp and jagged peaks.

The Laguna Range, at the southwest border of the Castle Dome Plain, and the Muggins Mountains, at the southeast border, are both composed for the most part of pre-Cambrian metamorphic rock, chiefly granitic gneiss. Small amounts of the more recent lavas occur in both ranges.

PALOMAS TO SALOME.

[For log see pp. 150–151.]

The old road between Palomas and Salome by way of Harquahala is now rarely used except by a few State and county officials, who find it a convenient route northward from the Palomas and Mohawk valleys. Probably less than half a dozen automobiles pass over it in a year. In the days before the Arizona & California Railroad (now the Atchison, Topeka & Santa Fe) was built freight between the Harquahala mine and Aztec, on the Southern Pacific Railroad, 7 miles south of Palomas, passed over this road. In consequence the road is still commonly spoken of as the Harquahala freight road. It is reported to have been excellent when in regular use, and even now it is better than the average unimproved road in this part of Arizona.

The country traversed by this road is one of the most uninhabited portions of the lower Gila region. Between Palomas and Harquahala no habitations except the cattleman's shanty at Clanton's Well are seen. Some parts of the region are being utilized as cattle ranges, and the number of cattle will doubtless increase as more wells are drilled. The prospects for agriculture do not appear to be bright, at least for the present. Ground water is deep, and the soil contains much gravel and caliche. Considerable prospecting has been done, but except for the deposits in the Little Harquahala Mountains (see p. 171) nothing of value has been found.

Palomas to Freighter Well.—The route follows the main Phoenix-Yuma highway for 2.7 miles north from Palomas. This stretch of road is on the silty flood plain of the Gila and is consequently rough. About a mile out of Palomas several tracks swing to the east (right) and lead to Agua Caliente by the old road, but these should be avoided. At about the point where the road leaves the flood plain it forks. The right fork leads to Agua Caliente and Phoenix. The road straight ahead leads to Harquahala. From this fork the road winds for more than 20 miles over the gravel surface of the desert and crosses several washes. In the fall of 1917 these washes presented no difficulties, but they should be approached with a certain amount of caution. No attempt is made to keep this road in repair, so that should the road be washed out by some flood the damage done is not likely to be remedied for a long time.

The Palomas Plain has a fairly steep gradient as it ascends toward the mountains. It is composed of gravel mixed with finer material. The vegetation is of the usual types; creosote bushes predominate, but palo verde lines the washes. A little mesquite was noted in a wash near the river. Several lava-capped buttes are scattered over the plain.

To the west are the Palomas Mountains and other small and irregular ranges, at the eastern extremities of which are lava-capped mountains and mesas. Farther west the lavas give place to the older crystalline rocks, and there is a corresponding increase in the jaggedness of the topographic forms. East and northeast of the road are the Gila Bend Mountains.

At 25 miles from Palomas the road enters a narrow gap between the Gila Bend Mountains and some hills to the west of them. Immediately after passing through this gap into the valley beyond a fork is reached, where there is a Geological Survey signpost. A little to the north is an old dug well, now caved and dry. This is known as the Nottbusch or Freighter Well and was the only reliable watering place between Palomas and Harquahala in the days when the freight teams used this road. A supply of good water, ample for the teamsters' needs, is reported to have been obtained from it. (See p. 208.)

The Harquahala road turns sharply to the west at the fork. A recently made and less well-marked road leads northwest to a mining camp. The road that comes in from the east at this point is one recently made by Mr. J. E. Clanton and his associates in the cattle business. This road follows the Harquahala road west for a short distance, but where the latter turns in a more northerly direction the new road leaves and continues west to Hoodoo Wells and Alamo Tank. At the point where it leaves the main road it is so comparatively faint and obviously more recent that no difficulty will be found in distinguishing it from the old freight road. On this new road, 0.6 mile east of the fork at the dry well, is a well recently put down by Mr. Clanton. Drinking water can usually be obtained here, although no large supply of water is kept on hand.

Freighter Well to Harquahala.—On leaving the fork at the old Freighter Well the road crosses Nottbusch Valley in a general north-northwesterly direction. This valley is about 12 miles long by 4 miles wide and is almost entirely inclosed by hills and mountains. The only outlet for its drainage is the gap through which the road from Palomas enters it. Here four good-sized washes unite into one to pass through the breach in the wall of hills. This large wash does not maintain its individuality far beyond the gap, but breaks up into a series of smaller ones. Drainage from the small valley that lies immediately north of Nottbusch Valley enters it through the sinuous canyon nearly 2 miles long in the northern hills. This canyon separates the Little Horn Mountains, west of Nottbusch Valley, from the Cemetery Hills, east of it, and is the canyon utilized by the Harquahala road in passing north out of the valley.

The alluvial fill of the valley is not deep. Clanton's Well entered bedrock at a depth of 30 feet, but nearer the center of the valley the fill is doubtless somewhat thicker. It is much finer than that in the plain to the south of the gap. The surface material throughout much of the valley is fine gravel and silt mixed with abundant caliche. The presence of this caliche is the reason why the road across this valley is still in good condition, although no repairs have been made on it for many years.

The Clanton Hills are south of Nottbusch Valley and west of the gap through which the road enters the valley from the south. They are about 5 miles long and 1½ miles wide at the widest place and have a maximum altitude of less than 500 feet above the plain. They consist almost exclusively of flat-lying gray cherty fine-grained limestone with numerous concretions, some of which resemble fossils in superficial appearance. There are considerable breccia and some faults in the limestone. Subsequent to the faulting hot solutions circulated through the fault breccias, as is shown by iron stains and by marked silicification of the limestone fragments. No definite evidence of valuable mineralization was found. At the east end of the hills is exposed a bed of reddish quartzose sandstone, about 30 feet thick. At the west end of the hills and scattered over the plain south of them are a number of buttes of basaltic lava of Pleistocene or late Tertiary age.

That portion of the Gila Bend Mountains that lies east of the Clanton Hills and forms the southern border of Nottbusch Valley is composed largely of Tertiary rocks of volcanic origin. The abundance of yellowish and cream-colored tuff testifies to the explosive violence of the ancient volcanoes. The mountains that form the southeast boundary of the valley also belong to this range. Some of them are basalt buttes, but most were carved from granite and similar rocks.

West and northwest of the valley are the Little Horn Mountains, whose steep and somber fronts loom above it in impressive dignity. They are composed principally of Tertiary lava, tuff, and sedimentary rocks, and the basal crystalline complex crops out in some of the washes. Extending east from these mountains and separated from them by the sinuous canyon already mentioned are the Cemetery Hills, a range of hills and buttes composed of similar rocks.

Near the upper end of Nottbusch Valley the road is in places very indistinct, and some care is required to avoid getting off it. The road passes to the east of a prominent and somewhat isolated lava butte and enters the canyon by which it passes through the mountainous northern border of the valley. In this canyon the road is in a gravel-bottomed wash for the greater part of a mile. Some difficulty may be experienced in traversing this stretch, especially if there has been no recent travel to break and pack a track. A natural tank, called Deadman Tank or Road Tank, is reported to occur near the road in this wash. It was dry at the time of visit and was not found. Where the road leaves the canyon, it enters a small valley similar to Nottbusch Valley and skirts the east side of a series of buttes that connect the Little Horn and Eagletail mountains. The detrital fill of this valley contains much caliche, and consequently the road is good. Bunch grass, salt bush, creosote bush, and a few good-sized mesquites were noted. About 2 miles beyond the wash and somewhat over 6 miles south of the Eagletail Mountains there is a dry dug well, 69 feet deep, on the west side of the road. The fantastically carved peaks of the Eagletail Mountains are visible for a long distance from the south. These mountains are described on page 170.

North of this valley the road goes through a low and easy pass in the Eagletail Mountains and then takes a straight course over the Harquahala Plain for 10 miles until it reaches the southern border of the Little Harquahala Mountains. The plain is described on page 170 and the mountains on page 171.

At several places on the Harquahala Plain the old freight road has been worn down into the soft silty soil as much as 2 feet. As the old ruts are now filled with loose sand it is advisable not to try to use the old road. The traveler should either follow one of the more recent and lightly marked tracks paralleling the old road or else pick out a new way for himself, being careful to keep close enough to the old road to avoid any danger of losing the direction. No difficulty will ordinarily be experienced in doing this except in wet weather, when the mud may be troublesome.

After entering the Little Harquahala Mountains the road runs along the valley of a big wash for 1¼ miles, crossing the wash at one place, and then ascends to the Harquahala mine office and post office. When the mine was in active operation there was a town of several hundred people in the valley just below it. If the traveler does not desire to visit the mine, by taking one of the numerous roads that crisscross in all directions here he can avoid climbing the hill to the office and continue along the valley toward Salome. No difficulty is likely to be encountered in finding the main road northward on the other side of the deserted shacks of the old town.

Harquahala mine.—The Harquahala is one of the best-known mines in the old Centennial mining district, now part of the Harcuvar district. The following description is taken for the most part from the report by Bancroft.[16] The original prospect was located November 14, 1888, by Harry Wharton, Robert Stein, and Mike Sullivan. It passed through various hands, and at the time of Bancroft's visit in 1909 it was owned by the Bonanza & Golden Eagle Mining Co. and was called the Bonanza mine. The total production of ore from the mine when Bancroft wrote amounted to $3,631,000. The altitude of the mine is approximately 1,800 feet. Water is obtained by a pipe line 30,000 feet long from a well in Harrisburg Valley. The mine equipment consists of two hoists, an air compressor, a 40-stamp mill, an engine, four oil-fired double boilers, two Blake crushers, and a 5,050-foot tramway connecting the Bonanza mill with the Golden Eagle mine, 1 mile north, owned by the same company. This tramway is now out of repair. The workings in 1909 consisted of a shaft inclined at an angle of approximately 60° and attaining a vertical depth of 205 feet below the collar and about 7,000 feet of levels, drifts, crosscuts, and winzes.

The ore shoots appear to have occupied shear zones extending through the sedimentary series of intercalated limestone, shale, and quartzite which forms the country rock of the mine into the basal granite. Bancroft considered that the pay portions of the deposit had been largely worked out. When visited by the present writer in January, 1918, the mine had been shut down for some time but was being unwatered with the intention of resuming operations. The basal granite mentioned above is impregnated with pyrite and carries some copper. The managers believe that sufficient copper can be developed at depth to put this mine once more in the dividend-paying class.

Harquahala to Salome.—The first 5-mile stretch out from Harquahala is a good mountain road. There are many curves, but no excessive grades and no bad washes. When traveled in January, 1918, it was in excellent condition, having just been repaired by the mining company, which has placed warning signs at all points of possible danger on this road. Several roads and trails going to prospects in the vicinity and to Harrisburg Valley lead off it, but none of them are likely to confuse the traveler. Vegetation is scanty, and the bare rocky slopes rise steeply to pointed summits.

After emerging from the Little Harquahala Mountains the road skirts them for a short distance and then heads north to Salome. At a shack on the right

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[16] Bancroft, Howland, Reconnaissance of the ore deposits in northern Yuma County, Ariz.: U. S. Geol. Survey Bull. 451, pp. 105–108, 1911.

there is a well in the field, but it is not used, and no facilities are provided for obtaining water. At 8 miles from Harquahala the road passes through the ruins of an old adobe house where there is a well and windmill, the property of the Harquahala Livestock Co. This is Mesquite Well, an old stage station.

At the crossing of the Atchison, Topeka & Santa Fe Railway just out of Salome several roads come together. A United States Geological Survey sign is placed here. The road east along the railway goes to Wenden, Wickenburg, and Phoenix (see pp. 140–141); that to the southeast goes to Palo Verde and Phoenix; and that to the west goes to Vicksburg and Parker (see pp. 165–171). A description of the town of Salome is given on pages 169–170.

WATERING PLACES.

SCOPE OF DESCRIPTIONS.

The watering places in the area covered by this report are described below in alphabetic order. The part of the area mapped lying south of Gila River is described in reports by Bryan.[17] Some wells that are more or less widely separated have been grouped together for convenience of description, but only such wells as do not constitute watering places for travelers. The wells in each of these groups belong either to one owner or to one community. For example, although the town of Parker is a watering place, all the individual wells in it are not watering places for travelers in the ordinary sense of the term. Every watering place is listed separately, although a number of such places may be owned by a single person or company. In this chapter the available information regarding the water at the several places is given. Any other data of interest regarding them are given either in the route descriptions or in the sections on history, geology, and other features. General discussions of ground-water conditions in certain areas will be found in the route descriptions.

The data here given are as reliable as it was possible to obtain but must be used with discretion, as changes of various kinds may have occurred since the examination was made. Figures as to depth of wells, etc., are based on direct measurement so far as possible, but in many places such measurement was impracticable, and for these the most reliable information obtainable is given.

QUALITY OF WATER.

The statements in these pages in regard to the quality of water are made primarily with reference to its use for drinking by men and animals. Some of the statements are based only on the use of the waters by the writer and others; a greater number depend on the results of analyses.

[17] Bryan, Kirk, Guide to desert watering places in the Papago country, Ariz.: U. S. Geol. Survey Water-Supply Paper 490–D, 1922; The Papago country, Ariz.: U. S. Geol. Survey Water-Supply Paper 499 (in preparation).

Nearly all the analyses here presented were made in the water-resources laboratory of the United States Geological Survey. In addition to the figures for constituents in the waters certain computed values are given which are helpful in classifying waters for various uses. These computations and classifications are discussed at length in earlier reports.[18]

Sodium was not determined in all the analyses. A value reported as "calculated" is the amount which with the calcium and magnesium present is chemically equivalent to the acid radicles.

Total hardness (H) is the calcium carbonate equivalent to the total calcium and magnesium and is calculated by the formula $H=2.5Ca+4.1Mg$.[19]

The scale-forming ingredients are assumed to be silica and such compounds of calcium and magnesium that the total quantity is given by the formula $SiO_2+2.95Ca+1.66Mg$.

The quantity of ingredients that may cause foaming in boilers is calculated at 2.7 times the combined quantities of sodium and potassium. The alkali coefficient is that proposed by Stabler.[20] He assumes that the relative toxicities of sodium as sulphate, chloride, and carbonate are 1, 5, and 10, respectively, and that the maximum tolerance of sensitive cultures is 1,500 pounds of sodium as sulphate in 4 feet of soil over an area of 1 acre. The alkali coefficient (k) is the number of inches of water that would yield upon evaporation sufficient salts to render a 4-foot depth of soil injurious to the most sensitive crops.

If the quantity of sodium is not more than sufficient to balance the chloride, $k=\frac{2{,}040}{Cl}$. If it is more than equivalent to all the chloride and not more than equivalent to all the sulphate in addition, $k=\frac{6{,}620}{Na+2.6Cl}$. If it is more than equivalent to all the chloride and sulphate, $k=\frac{662}{Na-0.32Cl-0.43SO_4}$.

Chemical character is expressed by the symbols of the predominating basic and acid radicles, as Ca (calcium, which includes magnesium) or Na (sodium, including potassium), and CO_3 (carbonate and bicarbonate), SO_4 (sulphate) or Cl (chloride).

Standards of quality for domestic use must vary with localities and individuals, and any classification will be open to question.

[18] Stabler, Herman, Some stream waters of the western United States, with chapters on sediment carried by the Rio Grande and the industrial application of water analyses: U. S. Geol. Survey Water-Supply Paper 274, pp. 165–181, 1911. Mendenhall, W. C., Dole, R. B., and Stabler, Herman, Ground water in San Joaquin Valley, Calif.: U. S. Geol. Survey Water-Supply Paper 398, pp. 50–82, 1916.

[19] The figures used with chemical symbols in this discussion represent parts per million of the radicles.

[20] U. S. Geol. Water-Supply Paper 274, p. 179, 1911.

The following limiting values in parts per million have been taken for classification as "good" in this report: Hardness, less than 200; chloride radicle (Cl), less than 250; sulphate radicle (SO_4), less than 300; iron (Fe), less than 1.5; carbonate radicle (CO_3), equivalent to sum of carbonate and bicarbonate radicles (HCO_3), less than 200; total solids, less than 500.

Waters with analyses exceeding these limits in any respect have been classed as "fair," "poor," "bad," and "very bad," according to the number and magnitude of the excesses. The classification for domestic use may be lower than one that would be made solely with reference to drinking. Excellent drinking waters frequently are so hard as to be very poor for use in laundry work, and quantities of iron that are not unpleasant to taste may cause inconvenience by staining enameled ware and plumbing fixtures and articles washed in the water.

Classification for boiler use with reference to scale and foaming has been based on the table given below.

Ratings of waters for boiler use.

Scale-forming constituents.			Foaming constituents.		
Parts per million.		Classification.[a]	Parts per million.		Classification.[b]
More than—	Not more than—		More than—	Not more than—	
....	90	Good.	....	150	Good.
90	200	Fair.	150	250	Fair.
200	430	Poor.	250	400	Bad.
430	....	Bad.	400	....	Very bad.

[a] Am. Ry. Eng. and Maintenance of Way Assoc. Proc., vol. 5, p. 595, 1904.
[b] Idem, vol. 9, p. 134, 1908.

Classification for irrigation is based on the alkali coefficient (k) proposed by Stabler and conforms to the limits given by him in the following table:

Classification of irrigation waters.[a]

Alkali coefficient.	Class.	Remarks.
More than 18......	Good......	Have been used successfully for many years without special care to prevent alkali accumulation.
18 to 6............	Fair.......	Special care to prevent gradual alkali accumulation has generally been found necessary except on loose soils with free drainage.
5.9 to 1.2..........	Poor......	Care in selection of soils has been found to be imperative and artificial drainage has frequently been found necessary.
Less than 1.2......	Bad.......	Practically valueless for irrigation.

[a] U. S. Geol. Water-Supply Paper 274, p. 179, 1911.

Waters are classified as to mineral content according to the following table:

Rating of waters by total solids.

Total solids (parts per million).		Classification.
More than—	Not more than—	
.....	150	Low.
150	500	Moderate.
500	2,000	High.
2,000	.....	Very high.

DETAILED DESCRIPTIONS.

Agua Caliente.—A small community in Maricopa County, in sec. 19, T. 5 S., R. 10 W., near Gila River, 15 miles east of Palomas, Yuma County. In 1920 the population of the precinct was 57. The presence of a group of hot springs has caused the place to acquire a certain reputation as a health resort. Seventeen concrete-walled tanks have been built to receive the water from the springs and provide bathing places, and shacks have been erected over the tanks. Each tank is provided with a spout to permit it to drain freely, and thus to keep clean. If the spout of any of the tanks is stopped up, the water level is said to rise a few inches only. Besides these tanks, there is a concrete tank about 30 by 60 feet that was intended to be used as a plunge or swimming pool but proved to be a failure because not enough water would flow into it to provide sufficient depth for swimming, so that it is now abandoned. One of the springs has been fitted with a concrete bowl 2½ feet in diameter and is used exclusively for drinking. This is known as the "fountain." The water from all these springs collects in a pond and overflows onto the land to the south. This water has been used to some extent for irrigation. Water for use in the hotel is pumped by means of a windmill from the springs into a storage tank placed above the house. In the pond and plunge pool are a number of small fish of rather peculiar appearance. They resemble greenish perch and have a maximum length of about 5 inches.

Besides the springs already mentioned, there is another about a quarter of a mile east of them and a short distance south of the schoolhouse. At this spring is an old adobe house. The proprietor of Agua Caliente, Althee Modesti, permits the use of the house and spring without charge. The water from these springs has no disagreeable taste and is not greatly mineralized. (See analysis, p. 198.) The temperature of the water in a number of the tanks was read in August, 1917, and is given below. The numbers are those used by the proprietor.

	°F.		°F.
Tank No. 1	100	Tank No. 10	104
3	103.5	12	104
4	103.5	14	102
5	102.5	15	102.5
6	100	16	103
7	99	17	103
8	100	Fountain	100
9	103		

Mud collects in the bottom of the bathing tanks, and mud baths constitute a portion of the treatment given. The spring water bubbles up through this mud, and this bubbling is especially strong in tank No. 4.

Analysis and classification of water from Agua Caliente Hot Springs.[a]

[Analyzed by W. P. Blake, Arizona School of Mines, University of Arizona. Parts per million except as otherwise designated.]

Silica (SiO_2)	[b] 39	Total dissolved solids [c]	672
Iron and aluminum oxides (Fe_2O_3 + Al_2O_3)	3.0	Total hardness as $CaCO_3$ [d]	48
Calcium (Ca)	12	Scale-forming constituents [d]	82
Magnesium (Mg)	4.5	Foaming constituents [d]	630
Sodium (Na)	228	Alkali coefficient (inches)	6.3
Potassium (K)	7.2	Classification:	
Lithium (Li)	Trace.	Chemical character	Na–Cl.
Carbonate radicle (CO_3)	.0	Quality for domestic use	Good.
Bicarbonate radicle (HCO_3)	67	Quality for boiler use	Very bad.
Sulphate radicle (SO_4)	151	Quality for irrigation use	Fair.
Chloride radicle (Cl)	194	Mineral content	High.

[a] Recalculated from hypothetical combinations in parts per 100,000 from analysis furnished by proprietor of springs.
[b] Reported as sodium silicate (Na_2SiO_3).
[c] By summation.
[d] Computed.

Besides these springs there are several shallow wells near Agua Caliente from which rather salty water is obtainable.

Aguila.—A small town in Maricopa County in sec. 14, T. 7 N., R. 9 W., and a station on the Atchison, Topeka & Santa Fe Railway, which has a well here. In 1920 Aguila had a population of 174. The data on the well here and the other wells belonging to the railway company were obtained through the courtesy of Mr. Howell Jones, land commissioner of the company. Data on other wells in the neighborhood are listed under the names of the owners.

Log of railroad well at Aguila.

	Thickness.	Depth.
	Feet.	*Feet.*
Sandy loam and gravel	270	270
Coarse gravel with streaks of clay	80	350
Coarse gravel and shale sheets [probably clay.—C. P. R.]	77	427
Cement gravel	23	450

The railway well is 450 feet deep and has a diameter of 15 inches at the top and 10 inches at the bottom. Water was struck in this well at 360 feet and rose 5 feet. The casing is perforated between the depths of 357 and 388 feet. A pumping test of three hours gave a yield of about 11 gallons a minute. The water is considered by W. A. Powers, chief chemist of the railway company, to be of good quality for boilers.

Analysis and classification of water from drilled well 450 feet deep of the Atchison, Topeka & Santa Fe Railway at Aguila.

[Analyst, M. D. Foster. Collected Mar. 21, 1919. Parts per million except as otherwise designated.]

Silica (SiO_2)	29	Sodium and potassium (Na + K)	50
Iron (Fe)	.58	Carbonate radicle (CO_3)	.0
Calcium (Ca)	17	Bicarbonate radicle (HCO_3)	160
Magnesium (Mg)	8.6	Sulphate radicle (SO_4)	25

Chloride radicle (Cl)	16	Classification:	
Nitrate radicle (NO_3)	Trace.	Chemical character	Na–CO_3.
Total dissolved solids at 180° C.	226	Quality for domestic use	Good.
Total hardness as $CaCO_3$[a]	78	Quality for boiler use	Good.
Scale-forming constituents[a]	93	Quality for irrigation use	Good.
Foaming constituents[a]	140	Mineral content	Moderate.
Alkali coefficient (inches)	19		

[a] Computed.

Aguila Land & Cattle Co.'s wells.—Three wells—one in sec. 16, T. 7 N., R. 9 W., with gasoline engine, 358 feet to water, 390 feet deep; one in sec. 32, T. 8 N., R. 9 W., with a windmill and gasoline engine, 352 feet to water, 410 feet deep; and one in sec. 15, T. 7 N., R. 10 W., with a windmill and gasoline engine, 288 feet to water, 310 feet deep.

Alamo Spring.—A spring in a small, partly inclosed valley on the north side of the S. H. Mountains, about 30 miles south of Vicksburg, Yuma County. Good water is reported to be obtainable from it at all seasons.

Alhambra.—A station on the Santa Fe, Prescott & Phoenix Railroad, about 5 miles from Phoenix. No definite information is at hand regarding it, but water can undoubtedly be obtained in this vicinity, as it is in the irrigated district. The population in 1920 was 918.

Apiary Well.—At a small apiary, about three-quarters of a mile south of the old road across the Gila Bend Mountains, 11 miles west of Woolsey Tank, and 20 miles east of Agua Caliente, in the SE. ¼ sec. 10, T. 4 S., R. 8 W. No one lives here, but there is a driven well, 25 feet deep, from which water can be obtained. It may be necessary to prime the pump in order to start it. The water is drinkable but is salty.

Analysis and classification of water from Apiary Well.

[Analyzed by C. H. Kidwell. Collected November 3, 1917. Parts per million except as otherwise designated.]

Silica (SiO_2)	32	Total hardness as $CaCO_3$[a]	415
Iron (Fe)	.42	Scale-forming constituents[a]	400
Calcium (Ca)	102	Foaming constituents[a]	900
Magnesium (Mg)	39	Alkali coefficient (inches)	3.8
Sodium and potassium (Na + K)[a]	335		
Carbonate radicle (CO_3)	.0	Classification:	
Bicarbonate radicle (HCO_3)	249	Chemical character	Na–Cl.
Sulphate radicle (SO_4)	180	Quality for domestic use	Poor.
Chloride radicle (Cl)	530	Quality for boiler use	Very bad.
Nitrate radicle (NO_3)	4.6	Quality for irrigation use	Poor.
Total dissolved solids at 180° C.	1,412	Mineral content	High.

[a] Computed.

Arlington.—A small town in Maricopa County on the Phoenix-Yuma road. There are several wells in and near the town. The best place for the traveler to obtain water is at the store. Water of fairly good quality is obtainable here. This is the last reliable watering place on the road to Yuma before Agua Caliente is reached. The following tables give data on several wells in and near Arlington. There are other wells besides those listed, but their characteristics are similar.

Records of wells in and near Arlington.

Owner or name.	Location.				Quality of water.	Type of well or spring.	Depth of well.	Diameter of well.
	Quarter.	Section.	Township S.	Range W.				
							Feet.	*Inches.*
1. Arlington Farm of Flower Pot Cattle Co.	NE.	28	1	5	Fairly good.	Drilled.	40	4
2. John Montgomery, residence owned by Flower Pot Cattle Co.	SE.	21	1	5	do.	do.	39	
3. District School 47	NW.	33	1	5	do.	do.	98	4
4. A. K. well		32	1	5	Poor	do.	150	4
5. W. W. Perry	SE.	5	2	5	Bad	do.	110	4
6. Arlington Store well, owned by Flower Pot Cattle Co.	SE.	21	1	5	Fairly good.	do.	50	4

Owner or name.	Depth to principal aquifer.	Depth to other aquifers.	Water level below surface.	Method of lift.	Yield.	Use of water.	Date of completion of well.	Remarks.
	Feet.	*Feet.*	*Feet.*					
1. Arlington Farm of Flower Pot Cattle Co.	25		25	Windmill	Ample.	Domestic.		
2. John Montgomery, residence owned by Flower Pot Cattle Co.	20		20	Hand pump	do.			
3. District School 47.	98	10	[a] 10	Hand pump and gasoline engine.	do.	Domestic.	1909	Salty water encountered at 10 feet.
4. A. K. well	90	10	[a] 10	Windmill	Small.	do.		
5. W. W. Perry		20, 40, 70	20	Hand pump	Ample.	Stock	1912	
6. Arlington Store well, owned by Flower Pot Cattle Co.			35	do.	do.	Domestic.		For analysis see below.

[a] Mr. Montgomery stated in October, 1917, that the water level in these two wells had risen 12 feet in 20 years.

Analysis and classification of water from drilled well at store in Arlington.

[Analyzed by C. H. Kidwell. Collected Jan. 12, 1918. Parts per million except as otherwise designated.]

Silica (SiO_2)	29
Iron (Fe)	1.4
Calcium (Ca)	53
Magnesium (Mg)	20
Sodium and potassium (Na + K)[a]	155
Carbonate radicle (CO_3)	.0
Bicarbonate radicle (HCO_3)	252
Sulphate radicle (SO_4)	106
Chloride radicle (Cl)	164
Nitrate radicle (NO_3)	2.6
Total dissolved solids at 180° C.	662
Total hardness as $CaCO_3$[a]	214
Scale-forming constituents[a]	220
Foaming constituents[a]	420
Alkali coefficient (inches)	11

Classification:
- Chemical character — Na-Cl.
- Quality for domestic use — Good.
- Quality for boiler use — Very bad.
- Quality for irrigation use — Fair.
- Mineral content — High.

[a] Computed.

Logs of wells in and near Arlington.

[Data furnished by Mr. John Montgomery.]

Well at John Montgomery's residence.

	Thickness.	Depth.
	Feet.	*Feet.*
Silt	4	4
Gravel	3	7
Light sand	13	20
Loose sand (water bearing)	18	38

Arlington Farm well.

Silt	4	4
Gravel	3	7
Tight sand	13	20
Loose sand (water bearing)	20	40

Well at District School No. 47.

Sand and gravel	60	60
Red clay	32	98
Fine white sand (water bearing)	?	98

A. K. well.

Sand and gravel	60	60
Red clay	90	150

The wells at Dan Millett's residence and at the Arlington store are similar to the Arlington Farm well. Mr. Montgomery states that in general all wells in this locality that have good water draw it from white sand encountered after penetrating 30 to 40 feet of red clay. Those that have gone deeper have found no water.

Avondale.—A station on the Buckeye line of the Arizona Eastern Railroad in Maricopa County, in sec. 19, T. 1 N., R. 1 W. The store at the station has a well 20 feet deep operated by a hand pump. The water is used for stock and some domestic purposes but is said to be unfit for drinking. This is not a convenient watering place for travelers.

Baragan's Well.—About a mile north of the new road between Agua Caliente and Palomas and halfway between these two places, in the NE. ¼ sec. 18, T. 5 S., R. 11 W. It is a dug well 74 feet deep, is owned by Frank Baragan, of Palomas, and is used as a watering place for stock.

Analysis and classification of water from Baragan's Well.

[Analyzed by M. D. Foster. Collected Sept. 11, 1917. Parts per million except as otherwise designated.]

Silica (SiO_2)	70	Sulphate radicle (SO_4)	30
Iron (Fe)	.46	Chloride radicle (Cl)	30
Calcium (Ca)	25	Nitrate radicle (NO_3)	1.4
Magnesium (Mg)	6.0	Total dissolved solids at 180° C.	561
Sodium and potassium (Na + K)[a]	165	Total hardness as $CaCO_3$[a]	87
Carbonate radicle (CO_3)	.0	Scale-forming constituents[a]	150
Bicarbonate radicle (HCO_3)	454	Foaming constituents[a]	450

[a] Computed.

Alkali coefficient (inches)	4.6
Classification:	
Chemical character	Na–CO_3.
Quality for domestic use	Good.
Quality for boiler use	Very bad.
Quality for irrigation use	Poor.
Mineral content	High.

Beardsley.—A station on the Santa Fe, Prescott & Phoenix Railroad about 24 miles from Phoenix. There is a section house here, and water can doubtless be obtained.

Bighorn Well.—On the Harquahala Plain, on the Parker cut-off, 6½ miles west of the Palo Verde mine, in T. 2 N., R. 8 W. It is used as a watering place for stock by the Harquahala Livestock Co. Water can be obtained here by travelers. The water is of good quality, as is shown by the analysis below. It is a dug well equipped with a hand windlass and a windmill.

Analysis and classification of water from Bighorn Well.

[Analyzed by C. H. Kidwell. Collected Dec. 5, 1917. Parts per million except as otherwise designated.]

Silica (SiO_2)	4.5
Iron (Fe)	.06
Calcium (Ca)	33
Magnesium (Mg)	9.0
Sodium and potassium (Na + K)[a]	148
Carbonate radicle (CO_3)	.0
Bicarbonate radicle (HCO_3)	123
Sulphate radicle (SO_4)	110
Chloride radicle (Cl)	159
Nitrate radicle (NO_3)	1.6
Total dissolved solids at 180° C.	527
Total hardness as $CaCO_3$[a]	119
Scale-forming constituents[a]	120
Foaming constituents[a]	400
Alkali coefficient (inches)	12
Classification:	
Chemical character	Na–Cl.
Quality for domestic use	Good.
Quality for boiler use	Bad.
Quality for irrigation use	Fair.
Mineral content	High.

[a] Computed.

Bouse.—A town in Yuma County and a station on the Atchison, Topeka & Santa Fe Railway in T. 7 N., R. 17 W. (See p. 173.) Water of fairly good quality for travelers is always available. The following data on several of the representative wells in this town will give an idea of the conditions there:

R. O. Worley has two wells, one in the SE. ¼ sec. 22, T. 7 N., R. 17 W., 29 feet deep and 25 feet to water, and the other in the SW. ¼ sec. 23, T. 7 N., R. 17 W., 45 feet deep and 37 feet to water. Both supply water for domestic use. The yield is said to be ample, and the water is of fair quality but is somewhat salty to the taste. E. F. Graham has a well in the SW. ¼ sec. 15, T. 7 N., R. 17 W., which he uses for his house and for irrigating a small patch of land. The quality of the water is said to be good. The railroad well at Bouse, drilled in 1910 and 1911, went 51 feet before striking water and stopped at 690 feet, where water that could be used in boilers was reached. This well has been tested at 30 gallons a minute. The lower part of the well is 6 inches in diameter.

Log of railroad well at Bouse.

	Thickness.	Depth.
	Feet.	*Feet.*
Sand, clay, and gravel	180	180
Cemented gravel with streaks of clay	150	330
Clay and shale	20	350
Reddish conglomerate	100	450
Grayish trap rock with clay streaks	240	690

There is said to be a well in Bouse Wash, in sec. 5, T. 7 N., R. 17 W., which went 105 feet, all in rock, without striking water.

Analyses and classification of waters from wells at Bouse.

[Parts per million except as otherwise designated.]

	1	2	3
Silica (SiO_2)	25	44	38
Iron (Fe)	.80	.51	.27
Calcium (Ca)	47	108	62
Magnesium (Mg)	5.6	55	12
Sodium and potassium (Na+K)	[a] 235	[a] 270	236
Carbonate radicle (CO_3)	.0	.0	.0
Bicarbonate radicle (HCO_3)	65	212	147
Sulphate radicle (SO_4)	328	379	299
Chloride radicle (Cl)	173	359	179
Nitrate radicle (NO_3)	14	9.1	4.7
Total dissolved solids at 180° C.	907	1,408	928
Total hardness as $CaCO_3$ [a]	140	496	200
Scale-forming constituents [a]	170	450	240
Foaming constituents [a]	630	730	640
Alkali coefficient (inches)	9.7	5.5	9.4
Classification:			
Chemical character	Na-SO_4	Na-Cl	Na-SO_4
Quality for domestic use	Fair.	[b] Poor.	Fair.
Quality for boiler use	Very bad.	Very bad.	Very bad.
Quality for irrigation use	Fair.	Poor.	Fair.
Mineral content	High.	High.	High.
Analyst	F. E. Keating.	F. E. Keating.	Margaret D. Foster.
Date of collection	Sept. 28, 1917.	Sept. 28, 1917.	Mar. 19, 1919.

[a] Computed.
[b] Poor on account of excessive hardness, which will cause trouble in washing; otherwise fair.

1. Dug well 29 feet deep, of R. O. Worley.
2. Dug well 45 feet deep, of R. O. Worley.
3. Drilled well 690 feet deep, of Atchison, Topeka & Santa Fe Railway.

Bradford Well.—One of Thomas W. Bales's cattle wells, about 9 miles south of Vicksburg and the same distance southeast of Desert Well. It has a windmill but no facilities for travelers. The well is 223 feet deep, and the depth to water is 180 feet. It is not on any regularly traveled road.

Brown's Well.—An irrigation well in the SW. ¼ SE. ¼ sec. 23, T. 5 N., R. 13 W. It is equipped with a gasoline pump that delivers 400 gallons a minute. The depth to water is 60 feet, and the depth of the well is 365 feet. The well is not on one of the regularly traveled roads but is near two such roads.

Buckeye.—A town in Maricopa County on the road between Phoenix and Yuma in T. 1 S., R. 3 W. It is a station on the Buckeye line of the Arizona Eastern Railroad. (See p. 154.) Good water is always available here for travelers. Data on several representative wells in and near the town are given in the following table:

Records of wells in and near Buckeye.

Owner or name.	Location.				Quality of water.	Type of well.	Depth of well.	Diameter of well.
	Quarter.	Section.	Township.	Range.			Feet.	Inches.
Johnson & Wetzler	NE.	32	1 N.	3 W.	Good.	Drilled.	174	[a] 60
Miller Bros	SE.?	28?	1 N.	3 W.	...do...	...do.....	106	....
Town Well	NW.	5	1 S.	3 W.	...do...	...do.....	160	....
D. P. Clanton (?)	....	5	1 S.	3 W.	...do...	...do.....	160	....
Buckeye Ice Co	SW.	5	1 S.	3 W.	...do...	...do.....	±135	....
Long's Hotel	NW.	7	1 S.	3 W.	...do...	...do.....	40-50	....
	NW.	12	1 S.	4 W.	...do...	...do.....	128	....

[a] Plank lagging, concrete top.

Records of wells in and near Buckeye—Continued.

Owner or name.	Water level below surface.	Method of lift.	Yield (gallons per minute).	Use of water.
	Feet.			
Johnson & Wetzler	54.5	35-horsepower Charter gasoline engine, centrifugal pump.	Ample	Irrigation.
Miller Bros	68	42-horsepower oil engine, 6-inch pump.	...do	Domestic, stock, irrigation.
Town Well	60	F. M. gasoline engine.	200	Town supply.
D. P. Clanton (?)	25	Windmill	Ample	Domestic, stock, irrigation.
Buckeye Ice Co	±35	...do	...do	Ice manufacture.
Long's Hotel	10	Hand pump and windmill.	...do	
.....	18	...do	...do	Domestic, stock, irrigation.

Burger Well.—An old well, now caved and abandoned, in sec. 24, T. 1 N., R. 8 W., on the old Harrisburg road. It was 133 feet deep, penetrated 132 feet of hard cemented gravel, and encountered water in white sand below the gravel. The water was bitter.

The Flower Pot Cattle Co. put down a well west of the Burger Well, in or near sec. 26, T. 1 N., R. 9 W., but it yielded very little water and was abandoned. It is 170 feet deep and 132 feet to water.

Log of abandoned well of Flower Pot Cattle Co.

	Thickness.	Depth.
	Feet.	*Feet.*
Caliche	132	132
Sand (?) (water bearing)	12	144
Red clay	26	170

Burned Place Well.—On the Harquahala Plain, on the Parker cut-off, 9 miles west of the Palo Verde mine, in sec. 11, T. 2 N., R. 9 W. It is used as a watering place for stock by the Harquahala Livestock Co. Water can be obtained here, if necessary, but no facilities are provided. The water is of fair quality, as shown by the analysis below. The well is 390 feet deep, and the depth to water is 230 feet. It is a drilled well with 6-inch casing, equipped with gasoline engine and pump jack. Water was first struck at 260 feet and rose immediately to a level 230 feet below the surface. The formation encountered in the upper part of the well is gravel, more or less cemented. The last 100 feet or so is in clay. No water was obtained in the clay. This well received its name from the fact that the camp of two prospectors, named Phelps and Hamilton, at this place burned down. The fire was extensive enough to leave traces that were plainly visible for a long time. These men were the first to locate and break the road from Harrisburg to Winters Well about 30 years ago.

Analysis and classification of water from Burned Place Well.

[Analyzed by C. H. Kidwell. Collected Dec. 6, 1917. Parts per million except as otherwise designated.]

Silica	36	Total hardness as $CaCO_3$ [a]	157
Iron (Fe)	4.0	Scale-forming constituents [a]	160
Calcium (Ca)	30	Foaming constituents [a]	520
Magnesium (Mg)	20	Alkali coefficient (inches)	7.1
Sodium and potassium (Na + K) [a]	193		
Carbonate radicle (CO_3)	14	Classification:	
Bicarbonate radicle (HCO_3)	202	Chemical character	Na–Cl.
Sulphate radicle (SO_4)	130	Quality for domestic use	Fair.
Chloride radicle (Cl)	136	Quality for boiler use	Very bad.
Nitrate radicle (NO_3)	75	Quality for irrigation use	Fair.
Total dissolved solids at 180° C	746	Mineral content	High.

[a] Computed.

Butler Well.—On the road from Wenden by way of Cunningham Pass to Parker, 21 miles from Wenden, in the SW. ¼ sec. 21, T. 8 N., R. 14 W. It is a stock well belonging to the Renada ranch. A supply of water is kept in the tank for the accommodation of travelers. It was originally a dug well 150 to 200 feet deep. The water supply at this depth gave out, and in 1911 or thereabouts the owners of the ranch had it cleaned out and drilled to a depth of 300 feet. Good water was found in gravel at a depth of 260 feet. When the well was visited in October, 1917, the water level was reported to be 260 feet below the surface. The amount of water obtainable was not deemed sufficient, and the owners were planning to drill deeper. This work has since been undertaken, but the results are not known.

Campbell Sheep Co.'s Well.—In sec. 10 or 12, T. 7 N., R. 8 W.; 435 feet to water, 450 feet deep; equipped with a gasoline engine.

Cashion.—A station on the Buckeye line of the Arizona Eastern Railroad, on the road between Phoenix and Yuma, 14 miles from Phoenix, in sec. 7, T. 1 N., R. 1 E. (See p. 153.) Water of fair quality is available here. It is piped from the Cashion ranch, about a mile to the south, and usually tastes of the pipe.

Castle Dome.—A mining camp occupied at the time of visit, in January, 1918, only by a caretaker and his family. It is on the road between Quartzsite and Yuma, 25 miles north of Dome, Yuma County, in the Castle Dome Mountains. (See pp. 188–189.) Water pumped from the mine is available for travelers, but as the tank is uncovered the water is usually not as clean as could be desired. If, as is possible, the mine is reopened, this defect will doubtless be remedied.

Cement Well.—A cattle well belonging to the Flower Pot Cattle Co., in sec. 22, T. 2 N., R. 5 W. It has a windmill, but no facilities for travelers and is not on a regularly traveled road. No one lives at or near the well. It is 150 feet deep and 85 feet to water.

Cemitosa Tanks.—Natural tanks near Alamo Spring, on the north side of the S. H. Mountains, nearly 30 miles from Vicksburg. Water can be obtained here during at least part of the year.

Chain Tanks.—A series of natural rock tanks in a canyon on the east flank of the Castle Dome Mountains a short distance south of the road to Deep Well. These tanks are reported to be large, and some of them are said to be reliable sources of water at all seasons. Tanks called White Tanks, White Horse Tanks, and other names have also been reported from this locality. It is not definitely known whether these are different sets of tanks or merely different names for the same one.

Cibola.—A small town on Colorado River. It is most conveniently reached from the California side of the river, although there is a road from Cibola to Quartzsite, connecting with roads to Bouse on the north and Dome on the south. Mail and freight come through Palo Verde, Calif. The principal industry is raising bees. Detailed data on the wells here are not available, but they are all comparatively shallow, the deepest being reported to be about 60 feet deep. Most of the farming is done on land subject to overflow by the river. Travelers can obtain water at the town.

Clanton's Well.—About 26 miles north of Palomas and half a mile northeast of the point where the road between Palomas and Harquahala passes through the gap between the Gila Bend Mountains and the Clanton Hills. It is a stock well belonging to J. E. Clanton and his associates in the cattle business. A cow puncher is kept on duty here, and water will usually be found on hand. It can always be obtained if the man in charge is present to operate the pump. The well is reported to be 328 feet deep and the depth to water 250 feet. The first 298 feet was drilled in rock, mostly or entirely limestone. The water is good, but the flow is not very strong. The well is reported to go dry in half an hour when it is pumped at the rate of a gallon a minute. The suction pipe extends to a depth of 313 feet.

Coldwater.—A store on the west bank of Agua Fria River, on the road between Phoenix and Yuma, 16.2 miles from Phoenix, in sec. 11, T. 1 N., R. 1 W. There is a well here equipped with a windmill and hand pump from which excellent water can be obtained. It is reported to be 30 to 35 feet deep, with depth to water 20 feet.

Courthouse Well.—On the Harquahala Plain, in sec. 16, T. 2 N., R 10 W.; used for watering stock by the Harquahala Livestock Co. It is a drilled well with 6-inch casing, equipped with a 6-horsepower engine and pump jack. It is 494 feet deep, 290 feet to water. The formations encountered in drilling are similar to those in Burned Place Well. (See p. 204.)

Coyote Well.—See Vinegaron Well.

Crabb Well.—Ten miles southeast of Aguila. This well is owned by D. D. Crabb. The depth to water is 235 feet, and the total depth 254 feet. It is equipped with a gasoline engine. About 5 miles southeast of this well is another in a wash, 32 feet deep, equipped with a windmill. This well goes dry in summer.

Cunningham Pass.—There are a number of mines and prospects in Cunningham Pass on the road between Wenden and Parker, about 10 miles from Wenden. Water might be obtained from any of these in an emergency. Near one of the forks leading to the property of the Desert Mining & Development Co., 9 miles from Wenden, is a well about 100 yards southeast of the main road. This well is banked up with rock and dirt, so that the top of the curb is 6 feet above the level of the ground. The top is covered with boards to exclude dirt and animals. Water can be obtained by lowering a rope and bucket. It has a perceptible taste but is satisfactory for drinking and cooking. The depth to water from the top of the curb was 61.6 feet in October, 1917.

Cullins Well.—One of the long established watering places in McMullen Valley, having been used as a stage station in the old days. It is about 10 miles east of Wenden, in sec. 33, T. 7 N., R. 11 W. No recent data regarding it are at hand, but it is believed to be still available as a watering place.

Deadman Tank.—A sand tank on the road between Palomas and Salome, 20 miles south of Harquahala, near the north end of the gulch along which the road passes through the Little Horn Mountains. It was dry when visited in 1918. It is also called Road Tank.

Deep Well (abandoned).—On the old road from Palomas to Castle Dome, 42 miles from Palomas. It is now caved and abandoned. It is reported to have been 1,180 feet deep and to have furnished a considerable amount of good water. (See p. 161.)

Desert Well.—At one of the abandoned stage stations, 5 miles southwest of Vicksburg, on the road to Quartzsite. (See Pl. XXII, *A.*) Ruins of an adobe house remain, but no one lives there now. The well is used by T. W. Bales as a watering place for stock. Travelers can obtain fair drinking water from the tank. The depth is reported to be 265 feet, and the depth to water 120 feet. This well was originally dug to a depth of 120 feet about 35 or 40 years ago and was deepened by drilling in 1916. An ample supply of water for stock is now reported to be obtained.

Dixie mine.—In the Gila Bend Mountains on the new road across this range 17.3 miles from Arlington. (See p. 156.) There is a dug well a few yards north of the road on the west side of the wash at the mine. It is equipped with a rope and two buckets. It has a wooden covering that was intended to prevent contamination by animals but is not altogether effective. When the well is cared for, as it is when the mine is operated, good water can always be obtained. When there is no one at the mine there is some danger of the water being contaminated by animals. The well is 37 feet deep, and the depth to water 32 feet—both from the top of curb, which is about 3 feet above the surface of the ground.

Dome.—A station on the Southern Pacific Railroad, 20 miles east of Yuma. It is the point at which the road from Quartzsite meets the present road from Phoenix to Yuma. The railroad company has a cistern here, and there are several shallow wells in and near the town. (See McDaniel's Well, p. 213.) Salty but drinkable water can be obtained at all times. A well 37 feet deep in gravel was dug for the railroad in 1918, but the water in it was found to be so bad that it was abandoned.

Dos Palmas Well.—Commonly called Dos Palms Well. It is a cattle well belonging to the Flower Pot Cattle Co., in sec. 8, T. 4 N., R. 4 W. It has a windmill but no facilities for travelers. It is 223 feet deep, and the depth to water is 205 feet. The supply of water is not abundant. No one lives here. It is not on a regularly traveled road. This well was difficult to drill because of the numerous boulders encountered. Another well was started 3 miles above it on Hassayampa River, but it had to be abandoned because of difficulties with boulders.

Ehrenberg Ferry.—The ferry across Colorado River for travelers between Quartzsite, Ariz., and Blythe, Calif., 19 miles west of Quartzsite. (See Pl. XXII, *B.*) There are no wells here. The river water can be used in case of necessity, but it is better, if possible, to wait until Blythe, 5 miles to the west, or Gonzales Wells, 10 miles to the east, is reached.

Engle Well.—In the NE. ¼ SE. ¼ sec. 1, T. 7 N., R. 8 W. This well is owned by Zagel Engle. It was uncompleted in the spring of 1918 but is doubtless now in operation. The depth to water is 431 feet.

Farra's ranch.—In the SW. ¼ sec. 1, T. 7 S., R. 14 W., about 12 miles west of Palomas, three-fourths of a mile south of the main highway. There are two wells here, only one of which is in use. This well gives an ample supply of fairly good water for domestic use. It is 19 feet deep, and the depth to water is 11 feet.

Fourth of July Tank.—Fourth of July Wash is a wide sand wash crossed by the new road across the Gila Bend Mountains, 6 miles west of the Dixie mine. Except in very dry seasons water is reported to be obtainable by digging in the sand of the wash 100 yards or less south of the road crossing.

Frandsen & Knudsen's Well.—On the road between Gila Bend and Buckeye, in the W. ½ sec. 33, T. 4 S., R. 4 W. It was 21.8 feet deep, and the depth to water was 11.9 feet October 25, 1917. The well is equipped with a windmill and small gasoline engine and is used for watering stock. As the analysis below shows, the water is too high in mineral matter for human consumption.

Analysis and classification of water from Frandsen & Knudsen's well.

[Analyzed by C. H. Kidwell. Collected Oct. 25, 1917. Parts per million except as otherwise designated.]

Silica (SiO_2)	44	Total hardness as $CaCO_3$ [a]	1,880
Iron (Fe)	.83	Scale-forming constituents [a]	1,600
Calcium (Ca)	432	Foaming constituents [a]	3,500
Magnesium (Mg)	196	Alkali coefficient (inches)	.8
Sodium and potassium (Na + K) [a]	1,305	Classification:	
Carbonate radicle (CO_3)	3.4	Chemical character	Na-Cl.
Bicarbonate radicle (HCO_3)	436	Quality for domestic use	Very bad.
Sulphate radicle (SO_4)	593	Quality for boiler use	Very bad.
Chloride radicle (Cl)	2,640	Quality for irrigation	Bad.
Nitrate radicle (NO_3)	14	Mineral content	Very high.
Total dissolved solids at 180° C.	6,010		

[a] Computed.

Freighter Well.—An old dug well, just north of the gap between the Gila Bend Mountains and the Clanton Hills, near the bank of one of the washes that converge here. This was a watering place in the days when the freight for the Harquahala mine went over the road from Palomas. It was dry and somewhat caved at the time of visit. J. B. Martin, of the Harquahala mine, says that in the freighting days there used to be an abundance of good water here. His impression was that the well was only 40 to 50 feet deep, but it may have been considerably deeper than this.

Galleta Well.—A cattle well belonging to the Flower Pot Cattle Co., in the SW. ¼ SE. ¼ sec. 24, T. 1 S., R. 7 W. It has a windmill but no facilities for travelers. The well is 129 feet deep and the depth to water 115 feet. No one lives here, and the well is not on a regularly traveled road.

Log of Galleta Well.

	Thickness.	Depth.
	Feet.	*Feet.*
Silt	3	3
Caliche	125	128
Gravel	1	129

Analysis and classification of water from Galleta Well.

[Analyzed by C. H. Kidwell. Collected Oct. 29, 1917. Parts per million except as otherwise designated.]

Silica (SiO_2)	33	Total hardness as $CaCO_3$ [a]	87
Iron (Fe)	.40	Scale-forming constituents [a]	110
Calcium (Ca)	20	Foaming constituents [a]	1,100
Magnesium (Mg)	9.1	Alkali coefficient (inches)	3.1
Sodium and potassium (Na + K) [a]	419		
Carbonate radicle (CO_3)	.0	Classification:	
Bicarbonate radicle (HCO_3)	381	Chemical character	Na-Cl.
Sulphate radicle (SO_4)	252	Quality for domestic use	Fair.
Chloride radicle (Cl)	297	Quality for boiler use	Very bad.
Nitrate radicle (NO_3)	5.1	Quality for irrigation	Poor.
Total dissolved solids at 180° C.	1,286	Mineral content	High.

[a] Computed.

Gila Bend.—A town on the Southern Pacific Railroad. Logs and other information regarding the railroad wells here are given on pages 79–84. Good water is always available.

Analyses and classification of ground-water supplies at Gila Bend.

[Analyzed by C. H. Kidwell. Collected Oct. 25, 1917. Parts per million except as otherwise designated.]

	1	2		1	2
Silica (SiO_2)	28	27	Total hardness as $CaCO_3$ [a]	30	279
Iron (Fe)	.52	.17	Scale-forming constituents [a]	56	330
Calcium (Ca)	8.3	96	Foaming constituents [a]	490	1,100
Magnesium (Mg)	2.2	9.5	Alkali coefficient (inches)	8.5	3.0
Sodium and potassium (Na+K) [a]	181	409	Classification:		
Carbonate radicle (CO_3)	.0	.0	Chemical character	Na-Cl.	Na-Cl.
Bicarbonate radicle (HCO_3)	27	76	Quality for domestic use	Good.	Poor.
Sulphate radicle (SO_4)	67	128	Quality for boiler use	Very bad.	Very bad.
Chloride radicle (Cl)	231	685	Quality for irrigation use	Fair.	Poor.
Nitrate radicle (NO_3)	7.3	6.4	Mineral content	High.	High.
Total dissolved solids at 180° C.	563	1,495			

[a] Computed.

1. Combined flow of old and new round-house wells, about 1,000 feet deep.
2. No. 1 well of Southern Pacific Railroad, about 1,000 feet deep.

Glendale.—A town on the Santa Fe, Prescott & Phoenix Railroad, about 9 miles from Phoenix. In 1920 the population was 2,737. Water is available for travelers.

Gonzales Wells.—On the road between Quartzsite and Ehrenberg Ferry, 9 miles west of Quartzsite, is a house and two rock-cribbed wells. (See Pl. XXII, *C*.) Both are equipped with windlass and bucket; the one near the road has a concrete collar and trapdoor and is the better one to use. It is 37 feet deep, with a depth of 30.2 feet to water. The water is of fairly good quality.

Goodmans Tank.[21]—The best known and most accessible of the tanks in the Dome Rock Mountains, in the northern portion of the range. The water is piped from depths of several feet from the sand that fills the natural tank. There are various other tanks in these mountains, some of which are reported to be near the road between Quartzsite and Ehrenberg Ferry, but no definite information was obtained in regard to them.

Hall Well.—An abandoned well about 5 miles northwest of Agua Caliente and 1½ miles off the main road. It was sunk by Mr. Hall about 1914. Its depth is 150 feet; depth to water, 97.8 feet; temperature of water, 83° F. (September 10, 1917). The well is cased with stovepipe casing 1 foot in diameter. There are no facilities for obtaining water, though at the time of visit enough baling wire was lying on the ground to lower a bottle down the well. This water had much iron rust in it and had a peculiar taste. It is scarcely drinkable.

Harquahala.—The town at the Harquahala mine, 9 miles south of Salome. (See p. 193.) There are no wells here, but a supply of water for the use of the men engaged in reopening the mine is piped from a well or wells in Harrisburg Valley.

Hayes Cattle Co.'s Well (dry).—At a point 11 miles northeast of Aguila and 3 miles northeast of Forepaugh the Hayes Cattle Co. drove a well to a depth of

[21] Jones, E. L., Gold deposits near Quartzite, Ariz.: U. S. Geol. Survey Bull. 620, p. 46, 1916.

375 feet and struck bedrock without encountering any water. It is incorrectly located on Plate III.

Hoist Well.—A cattle well belonging to the Flower Pot Cattle Co., reported to be in sec. 28, T. 1 S., R. 6 W. (?) It has a windmill but no facilities for travelers. The well is 130 feet deep, and the depth to water 24 feet. The supply of water is not abundant. No one lives here, and the well is not on a regularly traveled road.

Hoodoo Wells.—Two wells close together and of the same character, near Alamo Spring, on the north side of the S. H. Mountains, about 28 miles by road west of Clanton's Well. They are used for watering stock by Messrs. Clanton and Smith. Each was dug to a depth of 35½ feet and is equipped with a windmill and gasoline engine. The yield from these wells is reported to be about 2 gallons a minute. A yield of 12 gallons a minute can be obtained for four hours, after which no more water can be pumped for a time.

Horse Tanks.—A well-known series of natural rock tanks in the Castle Dome Mountains, about 2 miles off the main road from Quartzsite to Dome. (See Pl. XXIII, *A*.) Convenient and fairly good branch roads extend from the main highway to the tanks. (See p. 187.) There are reported to be about a dozen of these tanks. The upper ones are accessible only by arduous and perhaps dangerous climbing. In the three tanks at the end of the road the water was green with organic growths and had a somewhat disagreeable odor when visited in October, 1917. It is reported on good authority that the water in the upper and less accessible tanks is in much more drinkable condition at all times. Water remains in some of the larger tanks even in the dryest seasons. The lower tanks are used for watering stock as well as by travelers. The middle one of the three lower tanks has been improved by two low concrete walls set so as to increase its capacity. The wall on the downstream side has a 2-inch pipe let into it. This had a valve on the lower end and was intended to facilitate the drawing of water from this tank, either for cattle or for travelers' use. The tank is inaccessible to stock, so some such provision for making the water stored in it available for them was necessary. At the time of visit the pipe was clogged with sediment and the valve useless. This tank is the largest one actually observed during this investigation, but larger ones are reported to occur in the region. It is oval, and the longer axis is transverse to the course of the stream. The major axes of the oval are approximately 50 and 35 feet long. When full this tank alone holds at least 70,000 gallons.

Hot Springs Junction.—A town on the Santa Fe, Prescott & Phoenix Railroad, about 36 miles from Phoenix. Water from the railroad tank is sold to travelers.

Humming Bird Spring.—In the Bighorn Mountains near the Humming Bird mine, belonging to E. R. Cartwright, 17 miles by trail from the Palo Verde mine. Some water is reported to be available at all seasons, but in very dry weather the amount is small and the quality poor.

Huntman Well.—In sec. 18, T. 7 N., R. 9 W. Owned by H. Huntman. The depth to water is 381 feet, and the total depth 410 feet. The well is equipped with a windmill and gasoline pump. It is also reported to be called Rush Well.

Huttman Well.—In the SW. ¼ SW. ¼ sec. 18, T. 7 N., R. 8 W. Owned by Hugo Huttman. The depth to water is 380 feet, and the total depth 400 feet.

Imperial Well.[22]—North of the road between Dome and Yuma, on unsurveyed land, approximately in sec. 17, T. 8 S., R. 21 W. This well is owned by Alberto Imperial. It is 87 feet deep, has an 8-inch sheet-iron casing, and is equipped with a windmill and large iron tank.

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[22] Data collected by Kirk Bryan, U. S. Geol. Survey.

Jansen Well.—In the SE. ¼ SE. ¼ sec. 15, T. 7 N. R. 9 W. Owned by J. M. Jansen. The depth to water is 355 feet, total depth 393 feet. The well is equipped with a windmill and gasoline pump. At the time of visit it had run 48 days and nights continuously, pumping 125 gallons a minute without lowering the water level.

La Belle Well.—One of Thomas W. Bales's cattle wells in the Ranegras Plains, south of the Bear Hills. It has a windmill but no facilities for travelers and is not on any regularly traveled road. It is 409 feet deep, and the depth to water is 340 feet.

Ladder Tanks.—A series of natural tanks in the Castle Dome Mountains, half a mile east of the main Quartzsite-Dome road at a point 3 miles north of Castle Dome. When visited in October, 1917, the water in them was clean and good. Water can always be obtained here except possibly after an unusually prolonged drought. The tanks occur at the bases of a series of small waterfalls in a canyon carved in felsite. They are inaccessible to stock and difficultly accessible to any animals except birds. The lower tank can be reached with no great difficulty by an agile man, but the ascent to the upper ones would be attended with some danger.

La Paz.—An abandoned mining town on the east side of Colorado River, 4 miles north of Ehrenberg Ferry, on the road between the ferry and Parker. In December, 1917, wells were being sunk here to obtain water for use at the property of the La Paz Gold Mining Co. in the Dome Rock Mountains, a short distance to the east. It was planned to sink these wells deep enough to obtain good drinking water.

There are no wells along the road from Parker to Ehrenberg except some shallow ones in the Colorado River Indian Reservation near Parker. The water in all of these is probably too salty to be drinkable. The road is at no point far from the river, however, and water can readily be obtained from it or from sloughs along its course. This water will in general be found to be fit for consumption by stock and probably by men if it is boiled.

Lapham Well.—In sec. 15, T. 7 N., R. 10 W. Owned by Charles W. Lapham. It is not shown on the map because neither its exact location nor its relation to the well of the Aguila Land & Cattle Co., near by, is known. The depth to water is 288 feet (?), and the total depth of the well 338 feet. It is equipped with a windmill and gasoline engine.

Lapham Wells.—Frank C. Lapham owns three wells—one in the SE. ¼ NE. ¼ sec. 10, T. 7 N., R. 8 W., 430 feet to water, 450 feet deep, equipped with windmill and gasoline engine; one in the NW. ¼ NW. ¼ sec. 25, T. 7 N., R. 9 W., 361 feet to water, 410 feet deep, equipped with gasoline pump; and a third in sec. 27, T. 7 N., R. 8 W., which was driven 388 feet to bedrock without encountering water.

Lava Springs Well.—A cattle well belonging to the Flower Pot Cattle Co., in the southeast corner of the NW. ¼ NE. ¼ sec. 8, T. 1 S., R. 6 W. It has a windmill but no facilities for travelers. It is 169 feet deep. After a long dry spell it is unreliable. Its maximum capacity is less than 2 gallons a minute. No one lives here, and it is not on a regularly traveled road.

Log of Lava Springs Well.

	Thickness.	Depth.
	Feet.	*Feet.*
Silt	35	35
Lava boulders	110	145
White sand (water bearing)	1	146
Caliche	23	169
Sand (?) (water bearing).		

Liberty.—A farming town on the road between Phoenix and Yuma, 28 miles from Phoenix. Good water for travelers is available at the store. Data on some representative wells here are given below. The desert north of Liberty is being developed by sinking wells for irrigation.

Records of wells in the vicinity of Liberty, T. 1 N., R. 2 W.

Owner.	Location. Quarter-	Location. Section.	Quality of water.	Type of well.	Depth of well.	Diameter of well.	Character of water-bearing material.	Depth to which well is cased.
					Feet.	*Inches.*		*Feet.*
J. Schweikart	SW.	32	Good	Drilled	125	4	Gravel	
W. R. Beloat		6	Fair	...do	130	4	...do	130
Abandoned	SW.	16		...do	(?)			
I. D. Garrison	SE.	8	Good	...do	120			
B. W. Stone	SW.	10	...do	...do	78			
K. W. Weyser	SE.	5	...do	...do	260			

Owner.	Water level. Below surface.	Water level. Date of measurement.	Method of lift.	Yield.	Use of water.	Date of completion of well.
J. Schweikart	11 feet	Aug. 15, 1917.	Hand pump and gasoline engine.	Good	Domestic	
W. R. Beloat	11 feet	Nov. 9, 1917	3½-horsepower 2½-inch cylinder gasoline engine.	Ample	...do	1911
Abandoned	8 feet	Aug. 22, 1917.	None	None	None	
I. D. Garrison	100 feet	...do	2-horsepower gasoline engine.	Ample	Domestic, stock irrigation.	
B. W. Stone	72 feet 8½ inches.	April, 1915	Windmill	...do	...do	1915
	71 feet 7½ inches.	Feb., 1916				
	71 feet 6½ inches.	Aug., 1917				
K. W. Weyser	95 feet	Aug. 22, 1917.	32-horsepower F. M. gasoline engine.	...do	...do	

Lone Mountain Well.—In Harquahala Plain, in the SE. ¼ sec. 17, T. 3 N., R. 11 W. It is a cattle-watering place of the Harquahala Livestock Co. The analysis given below shows that the water is of good quality. No facilities are provided for obtaining clean water for human consumption. The well has a 5-inch casing and is equipped with a 6-horsepower gasoline engine and pump jack. It is drilled to a depth of 478 feet through clay, gravel, and sand. The water stands 400 feet below the surface. An ample supply is reported to be obtained.

Analysis and classification of water from Lone Mountain Well.

[Analyzed by F. E. Keating. Collected Dec. 7, 1917. Parts per million except as otherwise designated.]

Silica (SiO_2)	36	Sodium and potassium (Na + K)[a]	173
Iron (Fe)	.21	Carbonate radicle (CO_3)	19
Calcium (Ca)	25	Bicarbonate radicle (HCO_3)	195
Magnesium (Mg)	12	Sulphate radicle (SO_4)	90

[a] Computed.

Chloride radicle (Cl)	134	Classification:	
Nitrate radicle (NO_3)	16	Quality for boiler use	Very bad.
Total dissolved solids at 180° C	657	Quality for irrigation use	Fair.
Total hardness as $CaCO_3$ [a]	112	Mineral content	High.
Scale-forming constituents [a]	130	Chemical character	Na–Cl.
Foaming constituents [a]	470	Quality for domestic use	Good.
Alkali coefficient (inches)	7.2		

[a] Computed.

Near Lone Mountain is a well drilled 465 feet to bedrock, but dry and abandoned.

Loudermilk Well.—See State Well.

McClellan Well.—A cattle well belonging to the Flower Pot Cattle Co., in the SW. ¼ sec. 36, T. 1 N., R. 6 W. It is 102 feet deep and the depth to water is 53 feet. This well is not very reliable. No one lives here, and it is not on a regularly traveled road. Water was first struck at 102 feet in very hard caliche. It rose immediately to 53 feet.

McDaniel's Well.[23]—In the river flood plain near Dome, in sec. 6, T. 8 S., R. 20 W. Owned by E. W. McDaniel. It is 22 feet deep, 10 inches in diameter, and equipped with a windmill and 2½-inch cylinder. The depth to water is 12 feet. The water is so salty that it is not used for drinking.

McIntyre Well.—Near the railroad, 13 miles west of Aguila. It is 198 feet deep and is equipped with a windmill and gasoline engine.

McPherson Tanks.—A series of natural rock tanks in the Castle Dome Mountains, in a wash nearly 1½ miles from the Quartzsite-Dome road at a point 6½ miles from Castle Dome. The first tank is a hollow in the rock bed of the wash, partly filled with sand. The hollow measures about 6 by 11 feet, but when visited in October, 1917, it contained a pool of water only 1½ feet wide. About 175 feet farther up is the head of the wash. Here there is a succession of small waterfalls, with tanks at the foot of each. The lower tank is partly filled with sand; the others are clean. The lower tank is readily accessible but for this reason is readily contaminated. It would be impossible to get close enough to any of the other tanks to drink from them except by very skillful and somewhat dangerous climbing, but water could be obtained by means of a short rope and a bucket. The water in these upper tanks is fairly safe from contamination because of their inaccessibility. Water will always be found here except possibly after an unusually prolonged drought.

Mesquite Well.—An old well at what was once a stage station, about three-fourths of a mile south of Salome, along the road leading to Palomas, in sec. 16, T. 5 N., R. 13 W. It is now used by the Harquahala Livestock Co., of Wenden, for watering stock. It is a dug well, 3 feet in width. The owners report that it is 104 feet deep and that the depth to water is 98 feet. A measurement on September 30, 1917, showed that it was then 106 feet deep, with a depth to water of 102.5 feet. The windmill had been pumping slowly for a considerable time, so that the difference between the 98 feet reported and the 102.5 feet found by measurement probably indicates the amount of drawdown in this well. There is a gasoline engine here, as well as the windmill. Accommodations for travelers are not provided, but when the windmill is pumping very good drinking water is obtainable. (See analysis, p. 214.)

[23] Data collected by Kirk Bryan, U. S. Geol. Survey.

Analysis and classification of water from Mesquite Well.

[Analyzed by F. E. Keating. Collected Sept. 30, 1917. Parts per million except as otherwise designated.]

Silica (SiO_2)	26	Total hardness as $CaCO_3$ [a]	67
Iron (Fe)	.74	Scale-forming constituents [a]	90
Calcium (Ca)	19	Foaming constituents [a]	340
Magnesium (Mg)	4.8	Alkali coefficient (inches)	7.8
Sodium and potassium (Na + K) [a]	127		
Carbonate radicle (CO_3)	.0	Classification:	
Bicarbonate radicle (HCO_3)	252	Chemical character	Na–CO_3.
Sulphate radicle (SO_4)	67	Quality for domestic use	Good.
Chloride radicle (Cl)	44	Quality for boiler use	Bad.
Nitrate radicle (NO_3)	4.9	Quality for irrigation use	Fair.
Total dissolved solids at 180° C	430	Mineral content	Moderate.

[a] Computed.

McVay.—A station on the Atchison, Topeka & Santa Fe Railway about 13.4 miles east of Bouse. There is a railroad well and water tank here, but nothing else. No one stays here except when the well is being pumped. At other times water is not available. The well is 10 inches in diameter and 343 feet deep. Water was struck at 258 feet and rose to a level 253 feet below the surface. The casing is perforated between the depths of 263 and 316 feet. A pumping test of 8 hours made when the well was completed showed a yield of about 11 gallons a minute. The following is a log of the well as reported:

Log of railroad well at McVay.

	Thickness.	Depth.
	Feet.	*Feet.*
Cement gravel (some clay streaks)	265	265
Coarse gravel	65	330
Cement gravel	13	343

Analysis and classification of water from railroad well at McVay.

[Analyzed by M. D. Foster. Collected Mar. 19, 1919. Parts per million except as otherwise designated.]

Silica (SiO_2)	38	Total hardness as $CaCO_3$ [a]	134
Iron (Fe)	.13	Scale-forming constituents [a]	160
Calcium (Ca)	37	Foaming constituents [a]	730
Magnesium (Mg)	10	Alkali coefficient (inches)	7.4
Sodium and potassium (Na + K)	270		
Carbonate radicle (CO_3)	.0	Classification:	
Bicarbonate radicle (HCO_3)	149	Chemical character	Na–SO_4.
Sulphate radicle (SO_4)	273	Quality for domestic use	Fair.
Chloride radicle (Cl)	198	Quality for boiler use	Very bad.
Nitrate radicle (NO_3)	7.4	Quality for irrigation	Fair.
Total dissolved solids at 180° C	924	Mineral content	High.

[a] Computed.

Mexican Mine Tanks.—See Old Mexican Mine Tanks.

Meyers & Wetzel Well.—12 miles southeast of Aguila; 240 feet of water, 275 feet deep; equipped with a gasoline pump.

Middle Well (abandoned).—On the old road from Palomas by way of Castle Dome to Dome and Yuma, 28½ miles from Palomas. Put down originally to supply water for the King of Arizona mine, near Kofa, in the S. H. Mountains. When the mine closed down Abel Figueroa bought the well to use as a watering place for stock. It was 500 feet deep, about 200 feet of which was dug and the rest drilled. The depth to water was 450 feet. This well is now reported to be caved beyond repair, and no water is obtainable here. Mr. Figueroa intends to drill a new well at a site nearer his ranch, which he considers more desirable. The new well is to be some distance east of the old one, and 6 or 7 miles from the present road.

Midway.—On the Arizona & Swansea Railroad, halfway between Bouse and Swansea. A water tank here is kept filled by the railroad. Prospectors frequently camp here. Midway is less than a mile north of the point where the road from Wenden through Cunningham Pass to Parker reaches the railroad.

Morris ranch.—The homestead of G. T. Morris, about a mile north of Agua Caliente and three-fourths of a mile off the main road. It has several buildings and two wells. One of the wells had a hand pump, which was out of order at the time of visit, and the water was said to be undrinkable. The depth was reported as 120 feet, and the depth to water as 45 feet. This well was drilled about 1911. The other well is not used. It has a mine hoist but no pump. It was partly dug and partly drilled; the drilled portion is plugged with wood. The water is undrinkable. The depth is 113 feet, and the depth to water 47 feet. This well is said to have been sunk in 1912 and 1913. Mr. Morris keeps a supply of somewhat salty but drinkable water at his house. He hauls this from a shallow well near Agua Caliente.

Muggins Tank.—There is reported to be a very large natural rock tank in the central part of the Muggins Mountains, east of Dome. This tank is said to have so large a capacity as to be available as a reservoir for water for irrigation. It is not near any road and was not visited during the present investigation, and nothing definite is known regarding it.

New Water Pass.—Between the south end of the Plomosa Mountains and the west end of the S. H. Mountains. Water is reported to occur here and to be available at all seasons. Whether it is in springs or natural tanks is not definitely known. Prospectors frequently camp here. There is a road from Quartzsite to the pass, and a trail from it into the Alamo Spring country, on the north side of the S. H. Mountains.

New Well.—A cattle well belonging to the Flower Pot Cattle Co., in sec. 28, T. 1 S., R. 6 W. It has a horse-operated pump but no facilities for travelers. It is 132 feet deep, and the depth to water is 113 feet. No one lives here, and it is not on a regularly traveled road.

Log of New Well.

	Thickness.	Depth.
	Feet.	*Feet.*
Silt	8	8
Gravel	7	15
Caliche	98	113
Fine white sand (water bearing)	2	115
Mixed caliche, gravel, and white sand	17	132

Norton.—A small settlement on the road between Phoenix and Yuma, 21.8 miles west of Palomas. It has lost its importance since the freight trains that used to pass through it on the way to the mines near Kofa from Mohawk have ceased coming. Somewhat salty but drinkable water can be obtained here from a well that is 22 feet deep (16 feet to water), equipped with a windmill. There are several similar wells on and near the road east of this place.

Old Mexican Mine Tanks.—Reported natural rock tanks 2 miles south and a little east of the Old Mexican mine, which is in the Bighorn Mountains, about 15 miles from Winters Well. These tanks are reliable only during a part of the year.

Old Well.—A cattle well belonging to the Flower Pot Cattle Co., in sec. 19, T. 1 S., R. 7 W. It has a windmill but no facilities for travelers. It is 22 feet deep and yields abundant water from a depth of 16 feet. No one lives here, and it is not on a regularly traveled road. This well is in gravel throughout.

Onemile Well.—One of Thomas W. Bales's cattle wells, in sec. 23, T. 7 N., R. 17 W. It has a windmill but no facilities for travelers. The depth is 60 feet, and the depth to water 40 feet. It is not on any regularly traveled road.

Osborne Well.—A dug well at a mining camp, usually unoccupied, in the Buckskin Mountains, about 1 mile north of the road from Wenden through Cunningham Pass to Parker and 14 miles east of Parker. It is easily reached by branch roads from the highway. The well is equipped with a windlass and buckets and a small gasoline engine. It is 111 feet deep, and the depth to water is 101.9 feet, measured from the curb, which is about 4 feet above the surface of the ground. These measurements were made September 21, 1917. At the time of visit the water had a distinct odor and was probably contaminated with dead animals. This well penetrates calcareous conglomerate for part of its depth, to judge by the material on the dump.

Palomas.—On the road between Phoenix and Yuma, 15.4 miles from Agua Caliente and 85.5 miles from Yuma. Somewhat salty but entirely drinkable water can be obtained at Nottbusch's store here. It comes from a well behind the store equipped with a windmill and small gasoline engine. The well has a depth of 20 feet and a depth to water of 16 feet.

There are two or three small Mexican ranches along the old road from Palomas to Agua Caliente, at which water might be obtained. Among other wells in and near Palomas are J. F. Nottbusch's well, in the NE. ¼ sec. 18, T. 6 S., R. 12 W., depth reported as 54 feet, depth to water in October, 1917, 39 feet; depth to water when first dug (1913), 45 feet; water of good quality; and M. B. Derrick's well, in sec. 7 or 18, T. 6 S., R. 12 W., depth reported as 60 to 65 feet, depth to water 50 feet, equipped with a 15-horsepower gasoline engine, furnishes water to irrigate 30 acres.

Palomas Mountains, tanks in.—There are reported to be a number of natural rock tanks in the Palomas Mountains, some of which are reliable at all seasons. The Land Office plat shows water holes in sec. 21, T. 4 S., R. 14 W.

Palo Verde.—On the road between Phoenix and Yuma, 42 miles from Phoenix, in sec. 8, T. 1 S., R. 4 W. Fairly good water is available here at all times. Data on representative wells in this locality are given below.

Records of wells in the vicinity of Palo Verde, Ariz.

Owner or name.	Location.				Quality of water.	Type of well.	Depth of well.	Diameter of well.
	Quarter.	Section.	Township.	Range.				
							Feet.	*Inches.*
Dr. G. G. Rubel		4	1 S.	4 W.	Good	Drilled	79½	
Harper		4	1 S.	4 W.	Bad	do	150	
Hassayampa ranch of Flower Pot Cattle Co. (Geo. Coke, residence).	SE.		1 S.	5 W.	Good	do	168	

Records of wells in the vicinity of Palo Verde, Ariz.—Continued.

Owner or name.	Aquifers.		Water level below surface.	Method of lift.	Yield.	Use of water.
	Depth to principal aquifer.	Depth to other aquifers.				
	Feet.	*Feet.*	*Feet.*			
Dr. G. G. Rubel	64	....	64	Windmill	Ample	Domestic, irrigation.
Harper	64	150	64	Hand pump and windmill.	......do	Do.
Hassayampa ranch of Flower Pot Cattle Co. (Geo. Coke, residence).	168	[a] 30	30	Windmill	Was slow; improving.	Domestic, stock.

[a] In silt.

Palo Verde mine.—An old mine now used as a watering place for stock by the Harquahala Livestock Co., on the road between Phoenix and Parker, 21.5 miles from Palo Verde, in sec. 36, T. 2 N., R. 8 W. A caretaker lives here, and fairly good water can always be obtained. The old shaft is 194 feet deep. When visited, September 18, 1917, the water stood in it at a depth of 162 feet. The level is reported to rise in wet seasons within 125 feet of the surface. The shaft is equipped with a pump and gasoline engine.

Parker.—The principal town in Arizona on the Parker cut-off road from Phoenix to Los Angeles. It is in sec. 1, T. 9 N., R. 20 W., and sec. 36, T. 10 N., R. 20 W., on the Colorado, where the Atchison, Topeka & Santa Fe Railway crosses the river. There is also a ferry across the river at this point. Good water is always available here. Data on representative wells in this locality are given in the table on page 218. For a discussion of the possibilities of irrigation from the ground water of the river flood plain in the Colorado River Indian Reservation near Parker, see pages 108–117.

The railroad well at Parker is 10 inches in diameter and 225 feet deep. Its water level is 68 feet below the surface. The casing below the depth of 110 feet is perforated. In a pumping test of 10 hours this well is reported by the railroad company to have yielded at the rate of 150 gallons a minute. The following log was furnished by the railroad company:

Log of railroad well at Parker, Ariz.

	Thickness.	Depth.
	Feet.	*Feet.*
Sand and gravel	64	64
Clay (a little water)	46	110
Limestone (probably caliche)	15	125
Cemented gravel and sand (some water)	25	150
Conglomerate	4	154
Cemented gravel and sand (water)	71	225

Records of wells at Parker.

Owner or name.	Location.				Quality of water.	Type of well.	Depth of well.	Diameter of well.	Depth to principal aquifer.	Character of water-bearing material.
	Quarter.	Section.	Township.	Range.						
							Feet.	*Inches.*	*Feet.*	
B. D Flynn	N. ½	32	3 N.	1 E.	Fair	Drilled.	105	10	....	Gravel.
Ice-plant well, Parker Improvement Co.	SE.	32	3 N.	1 E.	Good	Dug	±80	7	72.6	Quicksand.
J. F. Raney	......	5	2 N.	1 E.	...do...	Drilled.	±70	6, 12	68	Gravel.
Atchison, Topeka & Santa Fe Ry.	Rail road station				Fair	...do....	225	10	154	Cemented gravel and sand.

Owner or name.	Depth to which well is cased.	Water level.		Method of lift.	Yield (gallons per minute).	Use of water.	Date of completion of well.
		Below surface.	Date of measurement.				
	Feet.	*Feet.*					
B. D. Flynn	105	60	Sept. 26, 1917	6-horsepower Foos gasoline engine.	20	Town supply.	Mar., 1915
Ice-plant well, Parker Improvement Co.	±80	72.6	.....do.......	American 8 by 36 inch pump.	140	Town supply and ice plant.	1918
J. F. Raney	±70	68	.....do.......	F. M. 9-horsepower gasoline engine.	60	Domestic.	1911
Atchison, Topeka & Santa Fe Ry.	225	68	Sept. 27, 1917	F. M. 12 by 36 inch pump.	150	Railroad.	July, 1916

Analyses and classification of water from wells in Parker.

[Parts per million except as otherwise designated.]

	1	2	3
Silica (SiO_2)	24	29	22
Iron (Fe)	.60	.08	.13
Calcium (Ca)	21	61	52
Magnesium (Mg)	2.1	19	5.2
Sodium and potassium (Na+K)	[a] 249	[a] 94	318
Carbonate radicle (CO_3)	.0	.0	.0
Bicarbonate radicle (HCO_3)	116	175	114
Sulphate radicle (SO_4)	166	119	221
Chloride radicle (Cl)	236	118	363
Nitrate radicle (NO_3)	Trace.	Trace.	Trace.
Total dissolved solids at 180° C	742	534	1,038
Total hardness as $CaCO_3$ [a]	61	230	151
Scale-forming constituents [a]	89	240	180
Foaming constituents [a]	670	250	860
Alkali coefficient (inches)	6.5	16	6.2
Classification:			
Chemical character	Na-Cl.	Ca-Cl.	Na-Cl.
Quality for domestic use	Fair.	Good.	Fair.
Quality for boiler use	Very bad.	Poor.	Very bad.
Quality for irrigation use	Fair.	Fair.	Fair.
Mineral content	High.	High.	High.
Date of collection	Sept. 26, 1917	Sept. 26, 1917	Mar. 25, 1919
Analyst	F. E. Keating	F. E. Keating	M. D. Foster

[a] Computed.

1. Drilled well 105 feet deep, of B. D. Flynn, in N. ½ sec. 32, T. 3 N., R. 1 E.
2. Drilled well about 70 feet deep, of F. J. Raney, in sec. 5, T. 2 N., R. 1 E.
3. Drilled well 225 feet deep, of Atchison, Topeka & Santa Fe Railway.

Peoria.—A station and town on the Santa Fe, Prescott & Phoenix Railroad, about 13½ miles from Phoenix. Water and other supplies are obtainable.

Peroxide Well.—A cattle well owned by the Flower Pot Cattle Co., in sec. 15, T. 1 N., R. 5 W. It has a windmill but no facilities for travelers. It is 88 feet deep, and the depth to water is 34 feet. No one lives here, and it is not on a regularly traveled road.

Log of Peroxide Well.

	Thickness.	Depth.
	Feet.	*Feet.*
Sand and gravel	34	34
Sand	4	38
Red clay	50	88

Peters Well.—An old dug well on the road from Wenden by way of Harrisburg Valley to Phoenix, 1½ miles south of Wenden, in sec. 6, T. 12 N., R. 5 W. The owner is Pete Navarez, who uses it for watering stock. It is equipped with a pump and gasoline engine. A supply of fairly good water is usually kept in the tank. The well is 5 feet in diameter and 126 feet deep. In October, 1917, the water level was at a depth of 83.2 feet.

Analysis and classification of water from Peters Well.

[Analyzed by F. E. Keating. Collected Oct. 1, 1917. Parts per million except as otherwise designated.]

Silica (SiO_2)	15	Total hardness as $CaCO_3$[a]	25
Iron (Fe)	1.8	Scale-forming constituents[a]	37
Calcium (Ca)	6.4	Foaming constituents[a]	910
Magnesium (Mg)	2.1	Alkali coefficient (inches)	2.6
Sodium and potassium (Na + K)[a]	338	Classification:	
Carbonate radicle (CO_3)	29	Chemical character	Na–CO_3.
Bicarbonate radicle (HCO_3)	454	Quality for domestic use	Fair.
Sulphate radicle (SO_4)	77	Quality for boiler use	Very bad.
Chloride radicle (Cl)	144	Quality for irrigation	Poor.
Nitrate radicle (NO_3)	67	Mineral content	High.
Total dissolved solids at 180° C.	919		

[a] Computed.

Phoenix.—The capital of Arizona. An abundant supply of somewhat salty but otherwise good water is obtained from wells. (See p. 152.)

Record of wells of Phoenix Water Department.

No.	Type of well or spring.	Depth of well.	Diameter of well.	Yield (gallons per minute). Pump.	Date of measurement.	Remarks.
		Feet.	*Inches.*			
1		140	12	1,000		
2		180	12	1,000		
3		210	12	1,000		
4		125	16	2,000		
5		125	16	2,000+	Sept., 1914.	Drawdown 14 feet.
6		234	16	[a]2,400	do	Do.
7		420	16	1,800	do	
	Dug	50	180			
	Drilled	160	12			
	Do	180	12			
	Do	212	12			
	Do	150	16			

[a] When pumping 2,400 gallons per minute from well No. 6 water level is lowered about 2 feet in all other wells.

Popper Well.—A drilled well 6 miles west of the Palo Verde mine, owned jointly by the Harquahala Livestock Co. and Richard Popper and used for watering stock. It is uncased and 290 feet deep; the depth to water is 270 feet. The water is reported to be good, but the amount is inadequate, and the well is to be drilled deeper. This well was drilled in 1915.

Quail Springs.—A watering place in the Gila Bend Mountains in Maricopa County. Water is reported to be obtained here eight or nine months of the year. The ground is moist throughout the year.

Quartzsite.—A small town on La Posa Plain, probably in sec. 33, T. 4 N., R. 19 W. Fairly good water is always obtainable at the well in front of the post office. Data on representative wells in this locality are given below.

Records of wells in Quartzsite.

Owner.	Quality of water.	Type of well.	Depth of well.	Diameter of well.	Depth to principal aquifer.	Water level below surface (Oct. 6, 1917).	Method of lift.	Use of water.
			Feet.	*Inches.*	*Feet.*	*Feet.*		
C. V. Kuehn	Good, soft.	Dug	31.5	48		26.8	Windmill.	Domestic.
Fred Kuehn	do	do	38.6	60		35.9	do	Stock.
Do	do	do	46	60	42		do	Domestic.

Red Tanks Well.—A cattle well belonging to the Flower Pot Cattle Co., in sec. 34, T. 1 S., R. 6 W. It has a windmill but no facilities for travelers. It is 116 feet deep, and the depth to water is 33 feet. The supply of water is not large at any time and is unreliable in dry seasons. No one lives here, and it is not on a regularly traveled road. The formations penetrated are similar to those in New Well. Water-bearing strata were encountered at depths of 80 and 116 feet.

Redwater Well.—A cattle well belonging to the Flower Pot Cattle Co., on unsurveyed land in sec. 15, T. 1 S., R. 8 W. It has a windmill but no facilities for travelers. It is 50 feet (?) deep, and the depth to water is 50 feet. No one lives here, and it is not on a regularly traveled road. This well penetrated gravel throughout and encountered water in bedrock at the bottom.

Reed, Cashin Land & Sheep Co.'s wells.—In sec. 7, T. 7 N., R. 11 W. and sec. 2, T. 6 N., R. 12 W. In the former the depth to water is 196 feet. The wells are equipped with gasoline engines. The yield from each well is about 13,000 gallons in 24 hours.

Renada ranch.—Home ranch of the Renada Ranch Cattle Co., in Butler Valley, sec. 2, T. 8 N., R. 14 W. The well at this place furnishes a sufficient supply of good water for domestic use and for watering stock. It is 388 feet deep, and the depth to water is 340 feet. (For description of Butler Well, also owned by this company, see p. 205.)

Reynolds Well.[24]—Between Wellton and Dome, in the SE. ¼ sec. 4, T. 9 S., R. 19 W. Owned by J. F. Reynolds, of Wellton. It is 54 feet deep, 5 inches in diameter, and equipped with a cylinder and 3½-horsepower gasoline engine. The depth to water is 13 feet.

Rogers Well.—A cattle well near the northwest end of the Bighorn Mountains, reported to be reliable at all seasons.

Salome.—A small town and station on the Atchison, Topeka & Santa Fe Railway, in sec. 9, T. 5 N., R. 13 W. Good water is always available at the

[24] Data collected by Kirk Bryan, U. S. Geol. Survey.

store. It comes from the railroad well, which is 10 inches in diameter and 237 feet deep. In this well the first water was struck at a depth of 127 feet, but the principal supply apparently comes from coarse sand at the bottom. The water level in the well is reported to be 125 feet below the surface. When completed the well was tested at 7,300 gallons an hour, or about 120 gallons a minute. The following is the log of the well as reported by the railroad company:

Log of railroad well at Salome.

	Thickness.	Depth.
	Feet.	*Feet.*
Sand and light gravel	55	55
Clay	62	117
Soft sand; first water at 127 feet	14	131
Granite boulders	96	227
Coarse sand	10	237

Analysis and classification of water from railroad well at Salome.

[Analyzed by F. E. Keating. Collected Sept. 30, 1917. Parts per million except as otherwise designated.]

Silica (SiO_2)	22	Total hardness as $CaCO_3$ [a]	50
Iron (Fe)	.25	Scale-forming constituents [a]	63
Calcium (Ca)	11	Foaming constituents [a]	300
Magnesium (Mg)	5.4	Alkali coefficient (inches)	8.8
Sodium and potassium (Na + K) [a]	113		
Carbonate radicle (CO_3)	.0	Classification:	
Bicarbonate radicle (HCO_3)	207	Chemical character	Na–CO_3.
Sulphate radicle (SO_4)	58	Quality for domestic use	Good.
Chloride radicle (Cl)	40	Quality for boiler use	Bad.
Nitrate radicle (NO_3)	9.4	Quality for irrigation use	Fair.
Total dissolved solids at 180° C	361	Mineral content	Moderate.

[a] Computed.

The well of E. S. Jones, in the NE. ¼ sec. 9, T. 5 N., R. 13 W., is drilled 202 feet deep and has a water level about 100 feet below the surface. Mr. Jones reports a seasonal variation of 3 or 4 feet in the water level. The first water was encountered at a depth of 135 feet. When a depth of 202 feet was reached a large supply was obtained and the water rose rapidly to a level 100 feet below the surface. The well has a 6-inch casing and is equipped with a Myers deep-well pump and gasoline engine. It has a yield of about 35 gallons a minute.

Near the road between Salome and Wenden, about 3¼ miles from Salome, is a dug well at an abandoned homestead. It is 3 feet in diameter and 103 feet deep, and the depth to water is 100 feet. A tin can and some wire, by means of which water could be obtained, were found at the time of visit. A mile west of this well is another deserted homestead with a dry well 106 feet deep.

Sand Tank.—On the road between Cibola and Quartzsite, 12 miles south of Quartzsite, near the west border of La Posa Plain. Small amounts of good water can always be obtained by digging a foot or two in the sand of a large wash on either side of the road. When visited in 1918 the most favorable place appeared to be near the north bank of the wash on the east side of the road.

Santo Domingo Tank.—In the mountains 7½ miles northwest of Hot Springs Junction, near the road from Phoenix to Wickenburg. Water is reported to occur at all seasons in the sand of Santo Domingo Wash, about 300 yards downstream from the road. The water flows on the surface in the rainy season.

Southwest Cotton Co.'s wells.—On a large cotton ranch north of Avondale, in Tps. 1 and 2 N., Rs. 1 and 2 W. The company has 15 wells in these townships from which it intends to irrigate. None of these are watering places for travelers, but water could doubtless be obtained at any of them should the need arise. All the wells obtain water in gravel.

Records of drilled wells of Southwest Cotton Co. near Avondale, in T. 2 N., R. 1 W.

Location.		Altitude.	Depth of well.	Diameter of well.	Depth to principal aquifer.	Depth to other aquifers.	Depth to which well is cased.	Water level.		Date of completion of well.
Quarter.	Section.							Below surface.	Date of measurement.	
		Feet.	*Feet.*	*Inches.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*		
W. ½....	12	1,035.7	227	16	56-83	....	....	12.7	Sept. 7, 1917	1912
S. ½.....	28	1,009.71	278	16	103	35.9, 249	....	35.9	.....do........	Aug. 10, 1917
	33	1,009.7	288	16	224	107-124 170-183	....	37.5	.....do........	July 15, 1917
NE.....	14	1,045.4	303	26	55	....	100	25.1	....	July 3, 1917
Center..	34	999.52	209	16	92	66	....	25.6	....	1917
NE.....	14	1,046.8	343	26	40	199	100	22.5	....	1917
SE.. ..	21	1,041.3	160	....	....	....	....	59	....	June 1, 1917
NE.....	34	1,004.4	66	.... ..	....	... .	66	27	July 14, 1917	....
SE......	11	1,043.96	219	16	130	....	....	13.9	....	Apr. 30, 1917
W. ½....	12	1,040.29	189	16	70	42-60 120-130	....	14.5	....	Apr. 13, 1917
SE......	11	1,044.41	202	16	70	167-177	....	16.3	....	....
W. ½....	12	1,051.0	186	16	57	96-110 135-145 157-168	....	9.2	Sept. 8, 1917	....
NE.....	25	....	308	16	....	204-216 244-258	....	67.4	....	Mar. 7, 1917
NE.....	22	1,045.2	124	26	55	40-42 104-115	....	30.3	Sept. 8, 1917	....
NW.....	7	1,112.26	312.5	16	137	98-106 112-118	....	87.46	.....do........	Feb. 12, 1917

Star Well (abandoned).—2½ miles north of Deep Well, in the S. H. Mountains. Put down to supply water for the North Star mine. It is 1,200 to 1,300 feet deep but is now out of repair and no water can be obtained from it.

State Well.—In Loudermilk Wash, in the Gila Bend Mountains, Maricopa County. Also known as Loudermilk Well. It is reached by a road half a mile long from a point on the new road across the Gila Bend Mountains, 20 miles from Agua Caliente. This road formerly returned to the new road near Yellow Medicine Tank and continued to Arlington but is now impracticable beyond State Well. The well is shallow. It is cribbed with planks, and if it were protected from contamination by dead animals the water in it would be very good. On October 30, 1917, the water level was 5 feet below the top of the cribbing, which is 3 feet above the surface of the ground.

Fred Stokes Well.—On unsurveyed land 3 miles east and 6 miles south from Aguila. The depth to water is 265 feet, and the depth of the well is 300 feet. It is equipped with a gasoline engine.

T. B. Stokes Well.—In sec. 32, T. 7 N., R. 8 W. The depth to water is 390 feet, and the total depth 420 feet. The well is equipped with a windmill and gasoline engine.

Surprise Well.—A cattle well of the Flower Pot Cattle Co., on the new road across the Gila Bend Mountains, 14½ miles west of Arlington. This well is 42 feet deep and has a 4-inch casing. It was drilled to bedrock. The drill passed through hard dry caliche to a depth of 41 feet, where water was encountered that rose at once to a level 24 feet below the surface. This is a reliable well for stock and yields good drinking water. There are no facilities for travelers, but water can easily be obtained whenever there is enough wind to operate the windmill.

Analysis and classification of water from Surprise Well.

[Analyzed by C. H. Kidwell. Collected Jan. 12, 1918. Parts per million except as otherwise designated.]

Silica (SiO_2)	55	Total hardness as $CaCO_3$ [a]	346
Iron (Fe)	.13	Scale-forming constituents [a]	330
Calcium (Ca)	68	Foaming constituents [a]	790
Magnesium (Mg)	43	Alkali coefficient (inches)	6.1
Sodium and potassium (Na + K) [a]	293		
Carbonate radicle (CO_3)	.0	Classification:	
Bicarbonate radicle (HCO_3)	363	Chemical character	Na–Cl.
Sulphate radicle (SO_4)	234	Quality for domestic use	Poor.
Chloride radicle (Cl)	306	Quality for boiler use	Very bad.
Nitrate radicle (NO_3)	12	Quality for irrigation use	Fair.
Total dissolved solids at 180° C.	1,248	Mineral content	High.

[a] Computed.

Swansea.—A mining and smelting town in the Buckskin Mountains, one terminus of the Arizona & Swansea Railroad. Water is pumped here from Williams River, 4 or 5 miles distant.[25]

Tenmile Well.—One of Thomas W. Bales's cattle wells, 10 miles southeast of Bouse and about the same distance northwest of Desert Well. It has a windmill but no facilities for travelers. It is 125 feet deep, and the depth to water is 80 feet. The well is not on any regularly traveled road.

Thumb Butte mine.—In the southern part of the Castle Dome Mountains, on a road that was formerly one of the routes between Yuma and Phoenix but is now little used beyond this mine. The mine is 21 miles from Dome. When the mine was visited in October, 1917, no one was found, but there is usually a caretaker at the property. No work was then in progress. Water stood in the shaft at a depth of 228 feet. There is also water in several shallow prospect holes in the immediate vicinity. This is much more accessible than that in the shaft.

Thumb Butte Tank.—In a wash north of the road a quarter of a mile east of the Thumb Butte mine. Water can be obtained by digging in the sand, except in very dry seasons.

Tolladay's Well.—At the southeast end of Harrisburg Valley, near the old dam site 5 miles southeast of Salome. It is the headquarters for the Parker Cattle Co. in this portion of Yuma County. Water is available for travelers at all times. The analysis below shows that it is of good quality. The sample from which this analysis was made was taken from the dug well, which was the only one in existence here when the locality was first visited. Since that time a drilled well has been completed a few yards from the old one. The dug well is 4 feet in diameter and is equipped with hand pump and gasoline engine; the depth to water is 30.6 feet. The new drilled well is 82 feet deep.

Log of new Tolladay Well.

	Thickness.	Depth.
	Feet.	*Feet.*
Soil	7	7
Gravel	69	76
Granite	6	82

[25] Bancroft, Howland, Reconnaissance of the ore deposits in northern Yuma County, Ariz.: U. S. Geol. Survey Bull. 451, p. 59, 1911.

Analysis and classification of water from Tolladay's dug well.

[Analyzed by C. H. Kidwell. Collected Oct. 2, 1917. Parts per million except as otherwise designated.]

Silica (SiO_2)	44	Total hardness as $CaCO_3$ [a]	181
Iron (Fe)	.18	Scale-forming constituents [a]	210
Calcium (Ca)	43	Foaming constituents [a]	420
Magnesium (Mg)	18	Alkali coefficient (inches)	7.1
Sodium and potassium (Na + K) [a]	155		
Carbonate radicle (CO_3)	.0	Classification:	
Bicarbonate radicle (HCO_3)	404	Chemical character	Na–CO_3.
Sulphate radicle (SO_4)	100	Quality for domestic use	Good.
Chloride radicle (Cl)	58	Quality for boiler use	Bad.
Nitrate radicle (NO_3)	.45	Quality for irrigation	Fair.
Total dissolved solids at 180° C	630	Mineral content	High.

[a] Computed.

Torrance Well.—In the SW. ¼ SW. ¼ sec. 12, T. 7 N., R. 8 W. Owned by Clay Torrance. Depth to water 430 feet, total depth 510 feet.

Tub Spring.—In the mountains east of Wickenburg. Tub Spring Wash contains water in the sand both above and below the road at all seasons. Water flows on the surface during the rainy season. This place is reached by roads leading off the main road between Wickenburg and Phoenix, both east and west of it, accommodating travelers in both directions. The eastern road forks off the main one 7 miles from Hot Springs Junction and is 1¼ miles long. The other fork is 10 miles from Wickenburg, and the distance to the wash from the fork is three-fourths of a mile.

Tule Tank.—A natural tank in the central part of the Gila Bend Mountains in Maricopa County midway between the two roads that cross the range. Water can be obtained here eight or nine months out of every year, and the ground is moist throughout the year.

Twentymile Well.—One of Thomas W. Bales's cattle wells, 4 miles southwest of Desert Well, in the Ranegras Plains, 0.7 mile from the office of the Shamrock Mining Co. on the north side of the Bear Hills, and 2.6 miles east of a fork on the Quartzsite-Vicksburg road, marked by a Geological Survey sign. The roads leading to it are difficult for automobiles because of high centers, and the well should be used as a watering place by travelers only in an emergency. No facilities for travelers are provided, but the well is equipped with a windmill and tank. It is 256 feet deep, and the depth to water is 216 feet.

Uster Well.—In the SW. ¼ SE. ¼ sec. 21, T. 7 N., R. 9 W. Owned by Frank Uster. Depth to water 362 feet, total depth 372 feet. The well is equipped with a windmill.

Van Hagen Well.—One of the Flower Pot Cattle Co.'s wells, on unsurveyed ground in sec. 19, T. 2 S., R. 6 W., near the old road across the Gila Bend Mountains. Although it is equipped with a windmill, there are no facilities for travelers and it is an unsatisfactory watering place. It had to be shot before any water was obtained, and the supply is now intermittent and unreliable. It is 40 feet deep, and the depth to water is 28 feet. It is bottomed in bedrock.

Analysis and classification of water from Van Hagen Well.

[Analyzed by C. H. Kidwell. Collected Oct. 28, 1917. Parts per million except as otherwise designated.]

Silica (SiO_2)	81	Total hardness as $CaCO_3$[a]	172
Iron (Fe)	.20	Scale-forming constituents[a]	220
Calcium (Ca)	36	Foaming constituents[a]	330
Magnesium (Mg)	20	Alkali coefficient (inches)	6.1
Sodium and potassium (Na+K)[a]	123		
Carbonate radicle (CO_3)	.0	Classification:	
Bicarbonate radicle (HCO_3)	468	Chemical character	$Na-CO_3$.
Sulphate radicle (SO_4)	14	Quality for domestic use	Good.
Chloride radicle (Cl)	28	Quality for boiler use	Bad.
Nitrate radicle (NO_3)	.16	Quality for irrigation use	Fair.
Total dissolved solids at 180° C	535	Mineral content	High.

[a] Computed.

Vicksburg.—A station on the Atchison, Topeka & Santa Fe Railway 20 miles east of Bouse, in sec. 30, T. 5 N., R. 14 W. There is no well here, but the railroad company keeps a supply of water in the cistern at the section foreman's house, which is available for travelers. The railroad company drilled a 10-inch hole here to a depth of 238 feet in 1910 without obtaining any water. The first 200 feet was in gravel and sand and the last 38 feet in granite.

Vinegaron Well.—One of Thomas W. Bales's cattle wells, about 13 miles south of Harquahala and 6 miles west of the pass through which the Harquahala road crosses the Eagletail Mountains. It has a windmill but no facilities for travelers. It is 357 feet deep, and the depth to water is 332 feet. No one lives here, and it is not on a regularly traveled road. This well is also called Coyote Well.

Volcanic Well.—A cattle well belonging to the Flower Pot Cattle Co., on unsurveyed ground in sec. 8, T. 1 S., R. 8 W. It has a windmill but no facilities for travelers. It is 99 feet deep, and the depth to water is 88 feet. No one lives here, and it is not on any regularly traveled road. Water-bearing strata were encountered at depths of 68, 88, and 99 feet. The lowest stratum contained a small supply of bitter water, and consequently the casing was pulled back to 88 feet, where sufficient water is now obtained.

Log of Volcanic Well.

	Thickness.	Depth.
	Feet.	*Feet.*
Caliche (some water at 68 feet)	88	88
White sand (water bearing)	1	89
Red clay	11	100
White sand (water bearing).		

Vulture mine.—An old and well-known mine 13.7 miles by road south of Wickenburg. It is not now being worked, but a caretaker lives at the property, and water can usually be obtained. There is a drilled well here, said to be 2,000 feet deep, but it is not in use.

Vulture Well.—A cattle well belonging to the Flower Pot Cattle Co., in sec. 36, T. 4 N., R. 5 W. It has a windmill but no facilities for travelers. It is 162 feet deep and penetrates sand and gravel, with boulders throughout.

The depth to water is 138 feet. No one lives here, and it is not on a regularly traveled road.

Webb Well.—In a wash just north of the old road across the Gila Bend Mountains, 12¼ miles from Arlington. It was dug in 1917 to supply water for testing the ores of the Arizona Gold Hill Mining Co. When visited in January, 1918, it was 32 feet deep, and the depth to water was 28.8 feet. Of the total depth, 5 feet was in rock (agglomerate). It was the intention of the owners to sink still deeper in the hope of obtaining a larger supply of water. The drawdown in the well was 3.5 feet when pumping 5 gallons a minute. The analysis below shows that the water contains a small quantity of total solids; it is a very good drinking water.

Analysis and classification of water from Webb Well.

[Analyzed by M. D. Foster. Collected Oct. 28, 1917. Parts per million except as otherwise designated.]

Silica (SiO_2)	46
Iron (Fe)	1.7
Calcium (Ca)	51
Magnesium (Mg)	15
Sodium and potassium (Na + K)[a]	30
Carbonate radicle (CO_3)	.0
Bicarbonate radicle (HCO_3)	284
Sulphate radicle (SO_4)	6.1
Chloride radicle (Cl)	11
Nitrate radicle (NO_3)	.20
Total dissolved solids at 180° C	291
Total hardness as $CaCO_3$[a]	189
Scale-forming constituents[a]	220
Foaming constituents[a]	81
Alkali coefficient (inches)	28

Classification:

Chemical character	Ca–CO_3.
Quality for domestic use	Good.
Quality for boiler use	Poor.
Quality for irrigation use	Good.
Mineral content	Moderate.

[a] Computed.

Wellton.—A town and station on the Southern Pacific Railroad 38½ miles east of Yuma. Water is obtainable here at all times but is not of the best quality. The Southern Pacific Co. has drilled four wells here. The deepest one was finished in 1904. It is 1,120 feet deep, and the water stands 58 feet below the surface. The supply is reported to be abundant, but the quality is bad. For the logs of these wells see pages 80–81.

Wenden.—A small town and station on the Atchison, Topeka & Santa Fe Railway about 57 miles from Parker. Good water is available at all times from the schoolhouse well. Data on representative wells in this locality are given below. The town water supply comes from a deep well at the schoolhouse.

Records of wells in the vicinity of Wenden, T. 6 N., R. 12 W.

Owner or name.	Location.		Quality of water.	Depth of well.	Depth to water.	Yield.	Use of water.
	Quarter.	Section.					
				Feet.	*Feet.*		
	NW.	32		98.8	94		
Mrs. Crowder	NE.	30	Bad	210	120	Ample	Domestic.
Old town well		31	do	105.5	49		
Schoolhouse well		29	Good	777	100	Ample	Town supply.

Analysis and classification of ground-water supplies at Wenden.

[Analyzed by F. E. Keating. Parts per million except as otherwise designated.]

	1	2		1	2
Silica (SiO_2)	21	13	Scale-forming constituents [a]	40	73
Iron (Fe)	1.4	1.7	Foaming constituents [a]	280	2,500
Calcium (Ca)	5.6	13	Alkali coefficient (inches)	8.9	1.8
Magnesium (Mg)	1.8	13			
			Classification:		
Sodium and potassium (Na+K) [a]	103	923	Chemical character	$Na-CO_3$.	Na-Cl.
Carbonate radicle (CO_3)	4.8	11	Quality for domestic use	Good.	Bad.
Bicarbonate radicle (HCO_3)	181	157	Quality for boiler use	Bad.	Very bad.
Sulphate radicle (SO_4)	49	592	Quality for irrigation use.	Fair.	Poor.
Chloride radicle (Cl)	23	918			
Nitrate radicle (NO_3)	6.2	39	Mineral content	Moderate.	Very high.
Total dissolved solids at 180° C	351	2,702	Date of collection (1917)	Oct. 1.	Oct. 2.
Total hardness as $CaCO_3$ [a]	21	86			

[a] Computed.

1. Deep well at schoolhouse.
2. Old town well, dug 105½ feet deep.

White Tanks, Maricopa County.—Reported to be a reliable series of rock tanks in the northern part of the White Tank Mountains in Maricopa County, west of Agua Fria River. Probably other rock tanks occur in this range also.

White Tanks, Yuma County.—Reported to be a reliable series of large tanks in the White Tank Mountains northwest of the Palomas Mountains in Yuma County, accessible by trail from Palomas. The same name is sometimes applied to a series of tanks in the Castle Dome Mountains, farther west.

Wickenburg.—A town and station on the Santa Fe, Prescott & Phoenix Railroad, in Maricopa County. In 1920 the population was 572. Water is obtained from wells and is available at all times.

Willow Spring.—In the Eagletail Mountains, about 1 mile south of Courthouse Rock, on an old road, now used only by an occasional horseman. In November, 1917, the water level was reported to be 10 feet below the curbing.

Willow Tanks.—Natural tanks on the new road across the Gila Bend Mountains, 25 miles from Arlington. There are three tanks, two about 50 yards west of the road and visible from it and one in a small side wash just off the large wash about 200 yards east of the road. All three hold water most of the year but are dry after protracted drought. They are rock tanks, but those west of the road are partly filled with sand. As the tanks are unprotected the water in them is usually so dirty as to be unsatisfactory for human consumption.

Wilson Well.[26]—A dug well between Dome and Yuma, in sec. 34, T. 7 S., R. 22 W. Owned by John Wilson. It is 4 feet square and 14.5 feet deep and is equipped with a windmill and galvanized-iron tank having a capacity of 7,500 gallons. The depth to water is 11.5 feet.

Winters Wells.—On the cattle ranch of E. H. Winters, of Phoenix, on the Parker cut-off, 15 miles from Palo Verde. There are three wells at the home place, where water is available for travelers at all seasons. Eight other wells are scattered over the ranch. Data on all these wells are given in the table below. The data were furnished from memory by E. R. Beedle, ranch foreman, and the locations of some of the wells may not be accurately given. The wells are equipped with windmills, and Mr. Beedle states that at times the lack of

[26] Data collected by Kirk Bryan, U. S. Geol. Survey.

wind is a serious inconvenience. Rarely for six weeks at a time there may not be sufficient wind to operate the windmills.

Records of wells belonging to E. H. Winters.

	Location.				Quality of water.	Type of well or spring.	Depth of well.	Diameter of well.
	Quarter.	Section.	Township.	Range.				
							Feet.	*Inches.*
1	NE.	7	1 N.	6 W.	Good	Drilled	185	6,4
2	NE.	7	1 N.	6 W.	do	Dug	95	96
3	SE.	25	1 N.	7 W.	do	Drilled	160	4
4	SW.	35	1 N.	7 W.	do	do	130	6
5	SW.	32	1 N.	6 W.	do	do	170	4
6	SE.	18	1 N.	6 W.	do	do	150	6
7		14–15	1 N.	6 W.	do	do	88	4
8		35, 36	1 N.	6 W.	do	do	160	4
9	NW.	17	1 N.	6 W.	do	do	160	4
10	Unsurveyed.	10	3 N.	8 W.	do		21	
11	do	10	3 N.	8 W.	do	Dug	11	

	Aquifers.		Depth to which well is cased.	Water level below surface (Sept. 17, 1917).	Method of lift.	Use of water.	Date of completion of well.
	Depth to principal aquifer.	Character of material.					
	Feet.		*Feet.*	*Feet.*			
1	185		20	70	Windmill		*a* 1916
2		Cement	20 cement; 20 pipe.	70	Windmill and 4-horsepower gasoline engine.		*a* 1888
3			20	100±	Small windmill	Stock	*a* 1912
4				100	10-foot windmill	do	July 4, 1915
5			20	170±	do	do	1915
6					12-foot windmill	do	*a* 1913
7		Sand	16	75	10-foot windmill	do	*a* 1914
8		Gravel	20	140	12-foot windmill	do	*a* 1914
9		do	20	120	14-foot windmill	do	*a* 1914
10				6–7			*a* 1914
11				4			*a* 1914

a Approximate.

Analyses and classification of water from E. H. Winters's wells in NE. ¼ sec. 7, T. 1 N., R. 6 W.

[Analyzed by C. H. Kidwell. Collected Dec. 5, 1917. Parts per million except as otherwise designated.]

	1	2		1	2
Silica (SiO_2)	32	37	Total hardness as $CaCO_3$ *a*	49	65
Iron (Fe)	.60	.10	Scale-forming constituents *a*	77	100
Calcium (Ca)	13	19	Foaming constituents *a*	540	530
Magnesium (Mg)	4.0	4.2	Alkali coefficient (inches)	6.3	6.4
Sodium and potassium (Na+K) *a*	202	196	Classification:		
Carbonate radicle (CO_3)	56	.0	Chemical character	Na-Cl.	Na-Cl.
Bicarbonate radicle (HCO_3)	27	169	Quality for domestic use	Good.	Good.
Sulphate radicle (SO_4)	70	67	Quality for boiler use	Very bad.	Very bad
Chloride radicle (Cl)	211	200	Quality for irrigation use.	Fair.	Fair.
Nitrate radicle (NO_3)	.18	.85	Mineral content	High.	High.
Total dissolved solids at 180° C.	627	631			

a Computed.

1. Drilled well, 185 feet deep, 6 inches in diameter. Temperature reported to be 81.5° F.
2. Dug well, 95 feet deep, 8 feet in diameter. Temperature reported to be 78° F.

Wood Well.—At a mountain seep 8 miles north of Aguila. Owned by Herbert Wood. This well is 18 feet deep. It waters 50 cattle in winter and 5 in summer.

Woodchopper Tank.—A natural rock tank on the north flank of the Bighorn Mountains. Water is available here for most of the year. A short distance to the north is a very large natural tank used for watering sheep and said to be reliable at all seasons.

Woolsey Tank.—An old and well-known watering place and camp ground on the old road across the Gila Bend Mountains 16 miles southwest of Arlington. (See Pl. XVII, *B*.) The camp ground is about 100 yards off the main road, and the tank is in the wash a few yards from the camp ground. It is a natural rock tank partly filled with sand and reliable at all seasons. As it is unprotected from contamination the water in it is fit only for stock. However, in the same wash a few yards away, visible from the natural tank and also from the camp ground, is a prospect hole belonging to the Flower Pot Cattle Co. and known as the Perhaps mine. This hole is only 10 feet deep and contains drinkable water at all seasons. The owners were contemplating resuming development of the prospect in 1918. Possibly this development, if carried out, will destroy the value of this hole as a watering place.

Analysis and classification of water from prospect hole known as Perhaps mine.

[Analyzed by M. D. Foster. Collected Jan. 10, 1918. Parts per million except as otherwise designated.]

Silica (SiO_2)	70	Total hardness as $CaCO_3$ [a]	242
Iron (Fe)	.34	Scale-forming constituents [a]	270
Calcium (Ca)	54	Foaming constituents [a]	180
Magnesium (Mg)	26	Alkali coefficient (inches)	13
Sodium and potassium (Na+K) [a]	66		
Carbonate radicle (CO_3)	.0	Classification:	
Bicarbonate radicle (HCO_3)	398	Chemical character	$Ca-CO_3$.
Sulphate radicle (SO_4)	14	Quality for domestic use	Good.
Chloride radicle (Cl)	29	Quality for boiler use	Poor.
Nitrate radicle (NO_3)	2.5	Quality for irrigation use	Fair.
Total dissolved solids at 180° C	446	Mineral content	Moderate.

Yellow Medicine Tank.—A small rock tank of the plunge-pool type 75 yards south of the road and a short distance east of the old convict camp on the new road across Gila Bend Mountains, 28 miles west of Arlington. The water in it is good if clean but is usually dirty, because the tank is unprotected. The tank dries up in long dry spells.

Yellow Medicine Well.—A shallow well on the east side of Yellow Medicine Wash in the Gila Bend Mountains, about a mile south of Yellow Medicine Tank. (See Pl. XVI, *B*.) The depth to water was 88 feet September 9, 1917. The well is equipped with a loose-fitting trap door, a block and tackle, and an old powder can in which to draw up the water. At the time of visit the water was so contaminated with dead rats as to be undrinkable.

Yuma.—A city at the junction of Gila and Colorado rivers, 197 miles from Phoenix. There are numerous wells in and near it, and much land in the vicinity is irrigated by the Yuma project. (See p. 164.) Water is available here at all seasons.

RECENT CHANGES IN ROADS.

In order to bring the information regarding the roads in the lower Gila region as nearly up to date as possible letters of inquiry were sent in April, 1923, to a number of persons and organizations in the

[a] Computed.

region. The following data were furnished by H. B. De Long, of the Automobile Club of Arizona; W. L. Ellison, county engineer of Yuma County; C. M. Hindman, of Wellton; and the Arizona Highway Department:

The principal change in routes of travel since the field work for this report was done appears to be in the route from Phoenix to Yuma. The present route is from Phoenix to Arlington, thence south to Gillespie dam, where Gila River is crossed on the apron of the dam, thence to Gila Bend, and west to Yuma. This road is now a State highway, and plans have been made to give it a gravel surface. The distance from Phoenix to Yuma by this route is about 198 miles. The road through the Gila Bend Mountains and Agua Caliente, which in 1918 was the main route to Yuma, is now little used and not recommended. The washed-out concrete bridge at Antelope Hill on this road has been temporarily repaired with pile trestles. Logs of the part of the road from Phoenix to a point just beyond Arlington will be found on pages 126–127, 131–132, and a description on pages 152–155. The route has probably not been greatly changed, so that many of the distances and directions given are still correct, but there are a number of changes in the character of the road, and the country it passes through is more densely populated than in 1918. The road from Phoenix to Buckeye is now reported to be paved, and there is now a bridge all the way across Agua Fria River, although part of it is a temporary structure. From Buckeye to Arlington the road is in fairly good condition, but from Arlington south to the Gillespie dam it is rough. The Gillespie dam is at the site of Enterprise dam, shown on Plate V. From Gillespie dam to Gila Bend the road is now in good condition. The character of the country along this stretch can be learned from the description of the road from Buckeye to Gila Bend on page 155. From Gila Bend west along the line of the Southern Pacific Railroad there is a good highway for about 8 miles. From this point nearly to Colfred the road contains chuck holes and is sandy in places, and detours are necessary on account of construction work. From Colfred to Yuma there is a gravel-surfaced road, in good condition. From Gila Bend to a point near Blaisdell the route is essentially the same as that in use in 1918. Logs and a description of the part of the road from Wellton west are given on pages 128–130, 163–164, and logs of the part between Gila Bend and Wellton have been published in Water-Supply Paper 490–D.[27] From a point near Blaisdell to Yuma the route has been changed. It now leads along the north side of the railroad from Blaisdell to a point just east of Araby, about 2 miles, then south half a mile, then west 6½ miles on a section-line road, then north to Yuma. There is now a railroad well between Pembroke and Mohawk and a water tank at Colfred, in addition to the water supplies mentioned by Bryan;[28] also several wells put down for irrigation between Mohawk and Yuma.

The route from Phoenix to Wickenburg is still essentially that given in the logs on pages 139–142, except that the road from Marinette to Phoenix is now paved.

The road from the east boundary of Yuma County through Wenden, Salome, and Bouse to Parker is reported to have been improved in part and the remainder is now under construction. When finished it is to be a good graded road, with gravel surface where necessary.

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[27] Bryan, Kirk, Routes to desert watering places in the Papago country, Ariz.: U. S. Geol. Survey Water-Supply Paper 490–D, pp. 339–340, 385–386, 1922.

[28] Idem, pp. 339–340.

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