THE SALTON SEA REGION, CALIFORNIA

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

BY

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The desert region of the United States has a peculiar fascination. Its solitude and silence are soothing to the man who comes to it from a busy life and much human contact. It contains almost or entirely uninhabited areas that are as large as some of the smaller Eastern States. The visitor to the desert may travel all day without meeting a human being and almost without hearing a sound except that made by his own vehicle. It is a country of distant views and grand panoramas, visible not only from the mountain tops but also from the extensive alluvial slopes. These great distances and magnificent landscapes tend to enlarge and ennoble the human mind. It is a land of abundant bright sunshine, of pure, bracing air, free from debilitating sultriness. Its nights are characterized by invigorating cold, with a sky overhead that is so intensely starry that it inspires awe and reverence.

Thus, when all is well, this desert region seems so wholesome and congenial that the visitor almost laughs at his preconceived fears. But if he comes at the end of a long day, with a tired and thirsty team of horses, to an isolated watering place that has gone dry, or if his automobile breaks down many miles from the nearest water or human aid, or, worse still, if he loses his bearings and the ever present panorama assumes a strange and bewildering aspect—then his feeling toward the desert undergoes a sudden change. He recognizes it at once as a stern and awful reality that cannot be trifled with. Its grand scenery and cheery sunshine seem to become a monstrous mockery.

To the man who has lived a long time in the desert region all these features, which impress the tenderfoot so strongly, seem perfectly commonplace, and he is likely to smile at the idea that the desert is dangerous. Yet it can be observed that this experienced traveler in the desert habitually takes precautions that would not occur to the inexperienced, and if the tenderfoot proposes to make a trip into the desert without adequate information and equipment the old-timer will be quick to warn him of the danger.

The desert region appeals strongly to the imagination of people in all parts of the country. Hence it has been the subject of numerous stories and popular descriptive articles. Some of these portray the
region very faithfully and accurately, but many either magnify the horrors of the desert or else go to the opposite extreme and give the erroneous impression that the desert is rapidly disappearing and will soon be largely under irrigation. The result has been somewhat confusing to those who have attempted to gain a conception of the desert region by reading about it.

For a number of years the United States Geological Survey has carried on investigations of the water resources of the arid part of the country. The water supplies of this, as of most other arid regions occur largely below the surface. Investigations of these hidden supplies have consisted chiefly of reconnaissance surveys and have resulted in water-supply papers of a rather distinctive type in which the geography, geology, and hydrology of large parts of the desert are systematically described. (See PI. I.) The purpose in preparing these papers was not primarily to entertain the reader, but rather to present in plain and clear language a large amount of reliable information about the areas covered. The geographic and geologic descriptions are essential for the adequate presentation of the hydrology, but they have also resulted in making the ground-water papers valuable as geographic reports.

In 1916 a survey of desert watering places was authorized by Congress, and in 1917 the sum of $10,000 was appropriated for carrying out this survey. The authorization reads as follows:

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the Secretary of the 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 question immediately arose as to what part of the continental United States may be considered the desert region, or, more properly, what part is so arid that a stranger can not safely travel through it without directions as to the location of watering places. This question was approximately answered by drawing the heavy red line shown in Plate I.

The region thus outlined forms a great triangle whose base, 800 miles long, is the Mexican border from the Peninsular Mountains, in southern California, to the mouth of Pecos River, in Texas, and
whose apex is in north-central Oregon. The west side of this huge desert triangle is the mountain wall formed by the Peninsular Mountains, the Sierra Nevada, and the Cascade Range; the east or north-east side is a less definite line extending from north-central Oregon through Salt Lake City and Santa Fe to the mouth of Pecos River. Its area is about 500,000 square miles, or about one-sixth of the area of the United States.

This region is by no means devoid of natural resources or human activity. It contains prosperous cities, fertile agricultural districts, forest-clad mountains, a large aggregate number of watering places, rich mines, and an unknown wealth of mineral deposits yet to be discovered and exploited. But the localities that have water supplies comprise widely separated oases in a vast expanse of silent, changeless, unproductive desert whose most impressive characteristic is its great distances and whose chief evidences of human occupation are the long, long roads that lead from one watering place to another. In the future existing oases will be enlarged, others will be created, and the mineral and agricultural products of the region will be greatly increased. But in spite of all that man can do, this large region will remain essentially a desert, and large tracts will remain uninhabited and devoid of water supplies. Travelers in most of this region must depend for water on isolated springs, wells, and "tanks," which are not uncommonly separated from one another by a hard day’s journey with team and wagon.

It was obviously not possible with the funds available from the appropriation to cover more than a small part of the half a million square miles included in the arid region. The area that was selected lies in southeastern California and southwestern Arizona (Pl. I) and occupies about 60,000 square miles, or somewhat more than one-tenth of the entire arid region. It is an area larger than the State of Illinois and nearly as large as all of New England. It is the hottest and most arid part of the United States, and, until the watering-place survey was made, it was also one of the least explored and most poorly mapped areas. Over large parts of the area the average annual rainfall is less than 5 inches. The slight rainfall and the high temperature together produce a high degree of aridity for most of the area. The high temperature also adds greatly to the danger of perishing from thirst.

It was at once recognized that by combining funds available for the Geological Survey’s regular ground-water work with the small appropriation for the desert watering-place survey a number of valuable reconnaissance ground-water papers could be produced and at the same time the desert survey could be extended farther than if the two lines of work were carried on separately. The area was divided into four parts—the Salton Sea region, the Mohave Desert region, the
lower Gila region, and the Papago country. Four capable young
geologists were selected for this project—John S. Brown, David G.
Thompson, Clyde P. Ross, and Kirk Bryan. Each was given a Ford
automobile, a plane table, other necessary equipment, and a non­
technical helper and was assigned to a vast expanse of desert country,
with instructions to map the roads and watering places, sketch the
relief, collect samples of the water, erect signposts directing to water­
ing places, and get as much information as possible in regard to the
geography, geology, and hydrology of each area, with special reference
to the possibilities of developing additional water supplies. The
field work was begun in the fall of 1917 and was completed, for the
most part, during the following winter.

The results that were obtained testify to the energy, enthusiasm,
and capacity of the men who did the work. Maps were prepared
covering the entire area of about 60,000 square miles, showing the
relief and the location of watering places, roads, and other features.
(See Pls. II and III, in pocket.) 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 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. Exploratory geologic maps of the area were made, and much
information was obtained concerning its geography, geology, and
ground-water conditions. Four guides to watering places, with de­
tailed maps, have been published, and four comprehensive water­
supply papers have been prepared for publication, of which the
present volume is one. Several short papers have also resulted from
this work.

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 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 shad­
ing was done by John H. Renshawe, from information furnished by

1 Brown, J. S., Routes to desert watering places in the Salton Sea region, Calif.: U. S. Geol. Survey
Water-Supply Paper 490-A, 1920. Thompson, D. G., Routes to desert watering places in the Mohave
desert watering places in the lower Gila region, Ariz.: U. S. Geol. Survey Water-Supply Paper 490-C,
1922. Bryan, Kirk, Routes to desert watering places in the Papago country, Ariz.: U. S. Geol. Survey
Water-Supply Paper 490-D, 1922.

Ross, C. P., Geology of the lower Gila region, Ariz.: U. S. Geol. Survey Prof. Paper 120, pp. 183-107,
Thompson, D. G., Some features of desert playas (unpublished).
the geologists who did the field work. Mr. Renshawe brought to this task not only the skill and esthetic appreciation of an artist but an intelligent understanding of desert forms resulting from long experience as a topographer in the West. The 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 Salton Sea region, described by John S. Brown in the present volume, covers about 10,000 square miles and has a number of features of unusual interest. More than any other area it has the character of a genuine desert—the hot climate, the great tracts of drifting sand, the palm-tree oases—all of which suggest the typical deserts of the Old World. It contains the Salton Sea, which lies far below sea level and whose unique history is one of the most fascinating of geologic stories. It also contains the famous Imperial Valley, which constitutes one of the largest irrigation districts in the country and one of the most important encroachments upon the desert that man has made. It is bordered by Colorado River, one of the largest rivers in the United States, which furnishes water in abundance to Imperial Valley but which in 1905 broke through its barriers and poured its great flood into the Salton Basin, with destructive results and menacing possibilities.

The question of primary importance in the region outside of the districts irrigated by Colorado River is that of the water supplies available. The present report describes the existing supplies and discusses the prospects of developing additional supplies in all parts of the region. In general, the ground-water supplies are meager and unsatisfactory, but Coachella Valley contains one of the most productive artesian basins in the West, which yields much water for irrigation. This artesian basin was described in detail by W. C. Mendenhall in Water-Supply Paper 225, but the present paper gives the first adequate description of the water supplies and ground-water conditions in the region as a whole.

The delay in publishing this paper has been due chiefly to the inadequate appropriations for printing. Mr. Brown began the field work in October, 1917, and completed it in March, 1918. He entered the military service in July, 1918, and received his discharge in January, 1919. He completed this paper in October, 1919, but because of lack of funds for printing, it was not sent to the Government Printing Office until April, 1923.
THE SALTON SEA REGION, CALIFORNIA.

By John S. Brown.

INTRODUCTION.

METHODS AND SCOPE OF WORK.

The field work for this report was carried on from October, 1917, until March, 1918, during the time of the year when the climate of this region is most favorable for outdoor work. The party consisted of one geologist and a nontechnical assistant and was equipped with an automobile and camping outfit, only such stops at towns or settlements being made as were necessary for procuring supplies and gathering information. Most of the time and attention of the party was given to the uninhabited desert country. A plane-table map was made of all roads traveled, distances being measured by an accurately registering odometer and triangulation carried along on mountain peaks or other prominent landmarks. Careful notes were made on topography, geology, and water supplies. An effort was made to get all the information possible in regard to watering places. Samples from 55 sources were analyzed in the water-resources laboratory of the United States Geological Survey, and 5 analyses were obtained from other laboratories.

The region is so large that to cover every part of it was manifestly impossible. The data for the parts of the area not covered by plane-table mapping are compiled from other available sources, chiefly topographic maps of the United States Geological Survey and maps of the General Land Office. The maps in this report are believed to afford the most complete and accurate representations of the entire region yet published. Not every watering place was found, and probably not all were even heard of, but certainly few of those utilized by the public on any of the desert roads have escaped observation. There will always be places known only to prospectors or chance explorers where water is obtainable at certain seasons. The desert is a lonely place, where the passing of one or many human beings is soon forgotten, and some of its mountain canyons and byways will ever remain undiscovered country, new even though men have passed them many times.
ACKNOWLEDGMENTS.

The writer is indebted to many people for assistance in the field and office work. Particular credit is due to Mr. B. W. Broderson and Mr. W. C. Vaubel, both of Los Angeles, for their very efficient help as assistants in the field work. The Automobile Club of Southern California cooperated freely with information and assistance. Business men, well drillers, miners, prospectors, and farmers of the region gave invaluable information and assistance, for which it is impossible to thank them all individually but which is none the less appreciated.

GENERAL FEATURES OF THE REGION.

LOCATION.

The Salton Sea region is in southeastern California. It reaches the international boundary between the United States and Mexico on the south and extends eastward to Colorado River, which here forms the boundary between California and Arizona. The northern boundary of the area shown on the map is the thirty-fourth parallel, but certain areas north of this boundary are described in order to connect routes of travel with important places slightly beyond it. The western boundary is the meridian of 116° 40', but there is a considerable belt of territory along this border that belongs physiographically and climatically to the mountain region of California, and the information given concerning this region is confined chiefly to routes of travel along certain irregular westward extensions of the desert. As thus defined, the region is roughly a square, with sides about 100 miles in length.

NAME.

Many names have been applied in many ways to this region. Blake originally applied the name Colorado Desert to the low basin whose center is now occupied by Salton Sea and whose origin is directly the work of Colorado River. He defined it practically as the area which lies within the old beach that encircles the Salton Sea. (See Pls. II and III.) The name has persisted better than any other suggested but has been loosely used by many writers to include much more than Blake intended. Unfortunately persons unfamiliar with this region associate the name Colorado Desert with the State of Colorado. The term Mohave Desert has been loosely applied in a similar way to a region north of this in San Bernardino County, and efforts to make the two terms cover all of southeastern California and define the boundary between them usually result in a line drawn from San Gorgonio Pass to any point on Colorado River that suits the whim

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of the person who wishes to set up the definition. Physiographically, the mountainous area east of the Salton Basin belongs with the area farther north. and the only satisfactory dividing line to be suggested lies along the ranges that bound the basin on its northeast side. Nevertheless, Colorado Desert is the name most frequently applied in literature to the larger part of this area.

The name Salton seems originally to have been that of a small station on the Southern Pacific Railroad that is still in existence, but it has come to be universally and unquestionably applied to the lake known as Salton Sea, which now occupies the center of this region. There is a tendency to expand the application of this name by using such terms as Salton Basin and Salton Sink, which are applied to the whole trough corresponding to Blake's Colorado Desert. Blake has preferred in later days to call this region the Cahuilla Basin or Cahuilla Valley, but Cahuilla is an Indian name probably related to Coachella, and Coachella has come to be generally accepted as the name for only the northern part of this valley—that part north of Salton Sea. It therefore seems best to use the name Cahuilla only for the ancient lake whose shore lines, stretching from the Mexican border north to Indio, were first recognized and carefully described by Blake.

The name Salton Sea region is here adopted because the Salton Sea lies near the center of the region and is well known.

With the rapid development of certain parts of this region since 1900 there has arisen a much greater necessity for naming and designating places. Most of the irrigated tracts are in lowlands known as valleys, such as Coachella Valley, Imperial Valley, Palo Verde Valley, Yuma Valley. Higher and more generally unreclaimed uplands are called mesas, as the Palo Verde Mesa and Yuma Mesa. A gradual separation and definition of the desert mountains is going on but is not yet entirely established.

HISTORY.

EARLY SPANISH EXPLORATION AND DEVELOPMENT.

The earliest accounts and maps containing information about this part of California are those of Spanish explorers of the sixteenth and succeeding centuries. Ulloa in 1539 and Alarcón in 1540 commanded small expeditions that reached the head of the Gulf of California but did little exploring. An erroneous idea prevailed, even for nearly two centuries after these discoveries, that the Gulf of California was a long strait and the land of California an island. Various early maps show the degrees of information, or lack of information, upon which early explorers based their ideas of California. Some excellent reproductions of these antique maps are given by Godfrey Sykes in a recent book on various features of the lower
Colorado Valley region. One of these maps is of particular interest because it shows Colorado and Gila rivers flowing into a lake separate from the Gulf of California and furnishes a suggestion that at that time the Salton Sea may have received some drainage from these rivers.

The early Spanish explorations during the period of the conquest of Mexico were all inspired by the hope of finding gold or treasure or lands of wondrous wealth. But the realities of the desert in Arizona and California were in strange contrast to the visions of the explorers, and the chimerical Seven Cities of Cibola proved as elusive as the mirage of the forbidding desert beyond which they were reported to exist, so that the fruitless search of Alarcón and others was abandoned.

About 1700 some Spanish missionaries, notably Padre Kino, a Jesuit, succeeded in establishing missions in Sonora and about the mouth of the Gila, and a vestige of culture was introduced into the country. Succeeding padres maintained the work of Kino, and there was at least some slight communication with settlements on the Pacific coast, for which it was necessary to cross the desert here considered by trails known only to the missionaries and the Indians.

Later explorations.

In the period from 1800 to 1850 American explorers began to take interest in the region of the lower Colorado, and hunting and trapping parties led by James O. Pattie, R. W. H. Hardy, and others explored the delta below Yuma to the Gulf of California.

The real history of this region begins, however, approximately with the discovery of gold in California, in 1848. In that year Lieut. W. H. Emory led a party of soldiers on a military reconnaissance from Fort Leavenworth, Mo., to the coast, passing through this region, from the junction of the Gila and Colorado to San Diego, by a trail which was apparently well known to the Spanish and the Indians and which was the main road used by succeeding travelers for three decades. This road ran from the present site of Yuma westward on the north side of Colorado River, south of Pilot Knob and the Sand Hills, across Mexican territory, turned northward along the channel of Alamo River, thence westward up the valleys of Carrizo, Vallecito, and San Felipe creeks to the Warner ranch, and led on to San Diego or other coast points.

5 Cibola was a place of wealth and magnificence, commonly rumored to exist somewhere north of Mexico, and the object of much painful search by Alarcón, Díaz, and other early Spanish explorers. George Wharton James (Our American wonderlands, pp. 138-144, 1915) states that the pueblos of the Zuni Indians in Arizona, which he describes carefully, were the real cities of Cibola.
6 Emory, W. H., Notes of a military reconnaissance from Fort Leavenworth in Missouri to San Diego in California, Washington, 1848.
GOLD SEEKERS.

The discovery of gold gave a great impetus to travel into California, and nearly every possible route was utilized. On the south around Cape Horn or across Panama and on the north by the Salt Lake routes gold seekers poured into California by thousands, and not a few from the United States and many from Mexico went by a southern route following Emory's trail. Guinn states that in 1849-50 10,000 people crossed the Colorado at the mouth of Gila River. Nevertheless, the desert was so forbidding and their haste so great that little was added to the permanent knowledge of the country by these transient wayfarers.

In 1850 John L. Le Conte visited the lower part of the Salton Basin with a party led by Major Heintzelman, who was commandant at the military post of Fort Yuma for several succeeding years. Le Conte recognized the fact that the lake, now known as the Salton Sea, was fed by the overflow of Colorado River through New River channel. He gives a brief account of some active mud volcanoes which it was the object of the expedition to explore.

PACIFIC RAILROAD EXPLORATIONS.

The first accurate knowledge of this region was obtained in 1853, by the Williamson expedition, the members of which, in their search for a practicable railroad route to the Pacific Ocean, explored all the promising passes of the Sierra in southern California and were the first white men to discover the San Gorgonio Pass, now utilized by the Southern Pacific Railroad. This expedition was equipped with adequate transportation facilities and surveying apparatus and gathered also much valuable geologic and scientific material. Williamson's party explored the region from San Gorgonio Pass through Coachella Valley, passing the places now known as Palm Springs, Indian Wells, Fish Spring, and McCain Spring, and thence on to the "emigrant road," or Emory's trail, at New River. They then took this trail to the Warner ranch and later crossed the desert to Yuma from that place, finally returning to the coast over the same road. A detailed account of this expedition is found in volume 5 of the Pacific Railroad reports. Immediately after the Williamson expedition, in 1855, a more extended examination of the Warner Pass route was made by Lieut. John G. Parke, whose observations, recorded in volume 7 of the Pacific Railroad reports, included a traverse of the unusual route through San Felipe Canyon and the Narrows.

3 Blake, W. P., Geological reconnaissance of California, New York, 1858.
COLORADO RIVER EXPLORATION.

Several expeditions by boats in the years immediately following 1850 added to the knowledge of Colorado River, but little was learned of the country beyond the vicinity of the river and its delta at the gulf. In 1858 Lieutenant Ives\(^{10}\) ascended the river in a steamboat called the *Explorer* as far as Black Canyon, somewhat above the present Nevada line. Captain Johnson with a steamboat called the *Colorado* accomplished practically the same thing as Ives at the same time. Other steamers traversed portions of the lower Colorado in succeeding years, but these trips added nothing to the knowledge of the geography of the country.

OLD STAGE ROADS.

The development of the mining industry and the rapid increase in settlement of the coastal region of California made imperative some system of communication overland, and the stage roads that have so long figured in the story and romance of the early West became numerous. Several of these roads crossed the desert of southeastern California. At first communication was more or less irregular and consisted of official trips between the military post at Fort Yuma and the coast towns. In 1857 an overland mail route maintained by relays of stages was placed in operation between San Antonio and San Diego, following the "emigrant road," or Emory's trail, from Yuma to San Diego by way of the Warner ranch. This route was replaced in 1858 by the Butterfield stage, which operated more or less continuously for several years.\(^{11}\) The adobe stage stations at Carrizo and Vallecito are relics of this interesting past. At some time later, of which no exact record has been found, a stage line operated from Ehrenberg Ferry westward through San Gorgonio Pass to Los Angeles. Lieutenant Bergland\(^{12}\) followed this route in the return trip from one of his Colorado expeditions. He says: "From Ehrenberg we followed the old stage road to Chuckawalla, thence to Dos Palmas, Los Torres, Agua Caliente [now Palm Springs], Whitewater, through San Gorgonio Pass." This quotation shows that a stage had been operated and fallen into disuse along this trail prior to 1876. This stage route was revived in 1876. Lieutenant Bergland in describing a second visit states that the Southern Pacific Railroad was completed as far as Whitewater (from the west) and that from that point two express companies were operating stages by way of Ehrenberg across Arizona and New Mexico.\(^{13}\)

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11 Guinn, J. M., History of California, California Hist. Soc., 1907. See also Bancroft, H. H., History of California, vol. 7, pp. 143-146, for a discussion of mail and express service in the period immediately following the discovery of gold.
12 Bergland, E. C., Geographic surveys west of the 100th meridian, Chief Eng. Ann. Rept. 1876, p.113
13 Idem ,p. 114.
SOUTHERN PACIFIC RAILROAD.

The completion of the Southern Pacific Railroad line connecting Yuma with the coast along its present route through the Salton Basin, in 1879, made it comparatively easy and safe to cross the desert, and overland travel by team across this region nearly ceased. Previously nearly all who entered the region did so only in order to reach more inviting places on its other side; they did not tarry long for exploration or acquaintance. For a long time after the railroad was built through the region its visitors aside from those who wished to travel across it were confined mainly to prospectors and explorers who hoped to develop some source of wealth hidden in its desolate spaces. As the railroad, in addition to freight service, supplies water at all its stations it has been a material help in rendering travel more easy and decreasing danger along its right of way.

MINING.

Mining was for many years the only important industry of this part of California. Prospectors have frequented its mountains in search of gold ever since the days of 1849, and before that time Indians and Spanish explorers probably had produced small amounts of gold.

Mining has been carried on in the Picacho district almost continuously since 1857, when, according to Newberry, mines were in operation. In the Cargo Muchacho Range mining has been done on a large scale at various times since 1879. These two districts were favored by their proximity to Colorado River at Yuma. On the west side of the region some promising gold mines were opened at Julian in 1870 and have been worked almost continuously since. Mines have existed in the Chuckwalla Mountains since 1890 or earlier, as indicated by the descriptions given by C. R. Orcutt.

Lack of transportation, fuel, and water have always greatly hindered development in this region, except at a few points that are easily accessible by rail. The extension of railroads and the development of agriculture are gradually improving this condition, and mining will undoubtedly benefit thereby.

An enumeration of mineral products of the region and notes on their occurrence are given on pages 60-63.

AGRICULTURE.

Since 1900 many parts of this region, once considered so useless and so hopeless of development, have been reclaimed by irrigation.

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The reclaimed areas are widely separated, the chief ones being
Imperial Valley, south of Salton Sea; Coachella Valley, or the Indio
region, north of Salton Sea; and Palo Verde and Yuma valleys,
along Colorado River. Numerous projects in other places have failed,
either through lack of natural resources or inadequate development.
Only a few of the minor projects survive. The greatest increase in
development and productivity will come in the extension of the areas
named, which have the greatest natural advantages of soil and water
supplies.

Within the irrigation districts towns have grown up rapidly; rail­
roads are being extended, and roads suitable for all communication
are rapidly being built. The following table gives some idea of the
amount of development that has taken place and may be expected.

**Irrigation in southeastern California.**

<table>
<thead>
<tr>
<th>Locality</th>
<th>Date</th>
<th>Area irrigated (acres)</th>
<th>Area irrigable (acres)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Imperial Valley:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>United States</td>
<td>1920</td>
<td>415,000</td>
<td>885,000</td>
</tr>
<tr>
<td>Mexico</td>
<td>1920</td>
<td>190,000</td>
<td>235,000</td>
</tr>
<tr>
<td>Palo Verde Valley</td>
<td>1920</td>
<td>35,000</td>
<td>78,000</td>
</tr>
<tr>
<td>Yuma Valley in California</td>
<td>1922</td>
<td>11,705</td>
<td>15,000</td>
</tr>
</tbody>
</table>

* Problems of Imperial Valley and vicinity: 67th Cong., 2d sess., S. Doc. 142, p. 48, 1922. Irrigable
  area in Imperial Valley as given includes 72,000 acres in Coachella Valley. Irrigable area in Mexico as
given is that of Imperial Irrigation District only. Possible extensions give a total irrigable area in
Mexico of 800,000 acres.

Unpublished figures supplied by U. S. Reclamation Service. Of this total, 1,945 acres was Indian
land farmed by Indians and 5,030 acres was Indian land farmed by whites.

In addition to the larger projects a number of small areas are being
developed largely by individual enterprise. Among these are Borego
Valley, the Coyote Wells region, San Felipe Valley, Mason Valley,
and other small valleys lying mostly at the foot of the western
mountains, from which they receive a small supply of water. These
areas will doubtless be fully developed at some time; but their total
possibilities are insignificant compared to those of the projects
already under way, and their present addition to the productivity of
the region is negligible.

In reflecting on the startling changes that have taken place in this
region in the course of two decades one is likely to become oversan­
guine as to the future; and there is a common impression in the lay
mind that at some time this entire desert may be reclaimed and made
productive. There are only two possible sources of water for irriga­
tion in this region—Colorado River and the rainfall within the region
itself, including several small drainage basins in California that extend
beyond the area mapped. It is generally conceded that even with
absolutely complete utilization of all flood water and normal stream
flow of the Colorado the river can never supply all the so-called
irrigable lands—lands lying at an elevation favorable for irrigation by gravity or small pumping lifts—of the lower river valley. The annual rainfall within the area averages approximately 3 inches, of which much evaporates. When it is considered that an average depth of 5 feet of water is used yearly on every acre irrigated in this region, the inadequacy of this supply for extensive reclamation is obvious. Nevertheless, complete utilization of the water available from both sources will greatly extend the areas now irrigated and add other garden spots in many places.

IMPERIAL VALLEY.

EARLY SCHEMES FOR RECLAMATION.

Imperial Valley is a portion of that broader physiographic unit sometimes called the Colorado Desert or more properly the Salton Sink, and its existence and something of its nature have been known throughout the United States since about 1850, when several parties of explorers and numerous caravans of gold seekers found their way across its dreaded wastes into the more alluring parts of California. Prof. W. P. Blake, of the Williamson expedition in 1853, was probably one of the first to recognize the potential agricultural value of its land and stated in his reports that portions of this region, which he had named the Colorado Desert, would, if supplied with water, be wonderfully fertile. Indeed, Blake even suggested that it might be possible to supply water from Colorado River by deepening the channel of New River, very much as was actually done nearly 50 years later.

Soon after Blake’s visit to the Colorado Desert Dr. O. M. Wozen-raft became interested in the possibility of irrigating the desert by water taken from Colorado River and went so far as to have surveys made by which a route for a canal practically identical with that now used was chosen. In 1859 the State Legislature of California petitioned the United States Government to cede to that State 3,000,000 acres of land for reclamation, but the plan was not generally regarded as feasible and fell through.

In 1875-76 a party in charge of Lieut. Eric Bergland, Corps of Engineers, made an examination of the lower Colorado River to determine sites where the river water could be diverted for irrigation. This party reported favorably upon a canal location passing through Mexican territory along practically the same route as was later adopted.
IRRIGATION DEVELOPMENTS.

Nothing came of these recommendations immediately, but the project of reclaiming the present Imperial Valley was finally undertaken by the California Development Co., organized in 1896. As this company could get no concessions from the Government of Mexico for the construction of canals in that country it was necessary also to organize a Mexican company to take care of the problems involved in transferring water across the border and back again.

Work began in 1900, and in the next year water was turned into the main canals. Separate companies were organized to colonize the land, and the name Imperial Valley was deliberately chosen as being more alluring to investors and settlers than the forbidding terms sink and desert. Development was rapid, particularly as the practical results of irrigation were very encouraging, and by 1905 the valley had a population of about 12,000.

ENGINEERING PROBLEMS.

The problem of leading water from Colorado River into Imperial Valley seemed to be very simple. For many years the Colorado during its summer floods had spilled over its banks and wasted its excess water into the Salton Sink by way of two fairly well defined channels known as Alamo and New rivers. The natural gradient from the river toward the sink is considerably greater than that toward the Gulf of California, and the general plan of diversion was, as was later discovered, all too easy. The California Development Co. constructed its intake near Pilot Knob, an isolated mountain about 10 miles west of Yuma, on the west bank of the river. The main feature of the diversion was a gap made in the side of the river through which the water might be led by canal to the irrigable lands.

It was found practicable to utilize a large part of the old channel of Alamo River, thereby avoiding considerable excavation for the canal.

The water was diverted at a point in United States territory just north of the international boundary and was led across into Mexico, thence southward and westward and finally back northward into the United States. It would, of course, have been highly desirable to construct this canal entirely in the United States, but the engineering difficulties involved were considered insuperable with the means at hand. A canal wholly on the north side of the boundary would have required a cut more than 100 feet deep for a distance of 25 or 30 miles and a closed conduit several miles long beneath the Sand Hills.

The plan of diversion adopted worked satisfactorily at first, but with the growth of the valley and the increased use of water great difficulty was found in keeping the main and branch canals open to the desired extent because of the continual deposition of silt on their
HISTORY.

beds. During seasons of the year when the river was low this difficulty was very troublesome, especially in the first few miles of the main canal below the intake. Accordingly in 1904 it was thought advisable to open an intake on Mexican territory which would have a more satisfactory grade. A canal was cut leading from the river to the former canal at a point several miles farther south, and this admitted freely all the water needed for the water users in the valley.

FLOOD DANGERS OF 1905-1907.

Unfortunately the danger of these diversions of the river was not realized, and no adequate preparation was made to control the Colorado in flood seasons. Probably no one is directly culpable for the catastrophe which followed and which placed Imperial Valley among the sensational subjects of national interest in the next two years. A graphic description of these events was given by George Kennan, an unbiased summary of all the engineering difficulties by H. T. Cory. A brief but excellent account is also given by Mendenhall. It will be sufficient here to sketch the flood briefly, acknowledging indebtedness to the above-named authors for some of the substance of this account.

Several unusual floods that occurred in the spring of 1905 greatly widened the artificial breach in the river bank made to admit extra water into the canals. These floods also carried out the dams built to seal off this inlet, so that when the annual summer flood season approached conditions were alarming because too much water was being diverted toward the valley. During the high-water season of this year much water flowed through the canal and over its banks and wasted into the basin at the bottom of Salton Sink, where it formed the beginning of the present Salton Sea. Meanwhile the California Development Co. had become involved in financial troubles and placed itself under obligations to the Southern Pacific Co., so that the Southern Pacific engineers took charge of the work of river control at first in an advisory capacity and then completely. Strenuous efforts were made to dam up the intakes, but flood followed flood, and one after another the structures were carried away.

The Salton Sea grew day by day until it had compelled the Southern Pacific Co. to remove its main line to higher ground a dozen times and threatened to engulf all the irrigable land of the valley. Finally the whole flow of Colorado River was pouring through an opening hundreds of feet wide (Pl. IV, A and B). This water on its way to the Salton Sea ate great canyons in the soft silt of the valley (Pl. V,

19The Salton Sea, Macmillan Co., 1917.
20The Imperial Valley and Salton Sink, San Francisco, John J. Newbegin, 1915.
A and B). These canyons are followed by the present channels of New and Alamo rivers.

The amount of dirt removed in the excavation of these channels is given by Cory as 400 to 500 million cubic yards, or four times the volume of excavation in the Panama Canal. The loss of property and land was great. However, it is expected that this loss will ultimately be compensated by the fact that the erosion of these channels provides the basis for a future drainage system that will be imperatively needed throughout the valley.

The problem finally became so serious that Congress and the President were called upon for aid, but the international complications made this a difficult matter, and the Southern Pacific Co. finally succeeded, at great expense, in closing the break on November 4, 1906. However, another flood in December caused a breach in one of the levees protecting the canal, and all the work had to be done over again. But with the aid of previous experience this was more easily accomplished. The total cost to the Southern Pacific Co. of its various attempts to control the runaway river is given by Kennan as nearly $3,000,000.

PROSPECTS FOR THE VALLEY.

Since the unfortunate experiences just narrated effective measures of river control have been applied, and the danger of a recurrence of such experiences in the near future is not particularly great, though never absent. The valley has survived its troubles and is at present probably the largest and most prosperous unit of reclaimed land under irrigation in the United States. The population of the valley is variously estimated at 35,000 to 50,000, of which possibly one-fifth is in Mexican territory. Many schemes are on foot for the expansion of the irrigated area, which is constantly being increased. The ultimate amount of irrigable land in the United States portion of Imperial Valley is about 1,000,000 acres, of which probably half is now under cultivation. There is considerable local agitation for a canal wholly upon United States soil, but the building of such a canal would involve many serious financial and political considerations. Undoubtedly the present development of the valley is sufficient to assure the use of every possible means of maintaining and increasing its prosperity.

CLIMATE.

The climate of this region has a wide range if the high-mountain province on its western border is regarded as a part of it. That of the low-lying desert basins and ranges, however, is typically arid and is characterized by extreme heat and dryness. The center of Salton

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22 See All-American canal in Imperial Valley, Calif.; Hearings before H. R. Comm. on Irrigation of Arid Lands, 66th Cong., 1st sess., 1919.
Basin is the hottest part of the United States and one of the hottest desert regions of the world. The following table summarizes some records, made chiefly by the Southern Pacific Co., of the climate of certain desert stations prior to 1900:

Precipitation and temperature in Salton Basin.

<table>
<thead>
<tr>
<th>Station</th>
<th>Altitude above or below sea level.</th>
<th>Length of record.</th>
<th>Mean annual temperature.</th>
<th>Mean annual precipitation.</th>
<th>Month of greatest precipitation.</th>
<th>Month of least precipitation.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indio</td>
<td>–20</td>
<td>23</td>
<td>76</td>
<td>2.43</td>
<td>January (0.87 inch)</td>
<td>June (trace)</td>
</tr>
<tr>
<td>Mammoth Tank</td>
<td>+237</td>
<td>23</td>
<td>76</td>
<td>1.51</td>
<td>December</td>
<td>June</td>
</tr>
<tr>
<td>Ogilby</td>
<td>+354</td>
<td>11</td>
<td>6</td>
<td>1.10</td>
<td>February</td>
<td>June (0)</td>
</tr>
<tr>
<td>Palm Springs</td>
<td>+354</td>
<td>12</td>
<td>6</td>
<td>3.53</td>
<td>December</td>
<td>June (0)</td>
</tr>
<tr>
<td>Salton</td>
<td>–263</td>
<td>12</td>
<td>76.9</td>
<td>2.56</td>
<td>December</td>
<td>June</td>
</tr>
<tr>
<td>Volcano</td>
<td>–220</td>
<td>12</td>
<td>1.59</td>
<td></td>
<td>December (0.43 inch)</td>
<td>June (0)</td>
</tr>
</tbody>
</table>

The records at Mammoth Tank showed that July was the hottest month, with an average temperature of 98.5° F., and January the coldest, with an average of 53.9° F. The highest recorded temperature was 130° F.; the lowest 22° F. The maximum annual precipitation was 5.48 inches, and the minimum only a trace. The maximum temperature recorded at Salton was 126° F.; the minimum 20° F. The month of June seems to have been practically rainless at all stations near Salton Sea, as shown both here and in subsequent records. The greatest rainfall occurs in December, January, and February.

More complete data taken chiefly from the yearly reports of the United States Weather Bureau are embodied in the following table. The Weather Bureau data include the year 1917.

Temperature and precipitation in southeastern California.

<table>
<thead>
<tr>
<th>Station</th>
<th>Altitude above or below sea level.</th>
<th>Length of record.</th>
<th>Mean annual temperature.</th>
<th>Mean annual precipitation.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beaumont</td>
<td>+2,600</td>
<td>16</td>
<td>70.2</td>
<td>19.02</td>
</tr>
<tr>
<td>Cabezon</td>
<td>+1,779</td>
<td>11</td>
<td>70.5</td>
<td>11.60</td>
</tr>
<tr>
<td>Campo</td>
<td>+2,189</td>
<td>46</td>
<td>70.1</td>
<td>20.15</td>
</tr>
<tr>
<td>Calexico</td>
<td>0</td>
<td>13</td>
<td>70.2</td>
<td>3.28</td>
</tr>
<tr>
<td>Indio</td>
<td>–20</td>
<td>40</td>
<td>73.9</td>
<td>2.68</td>
</tr>
<tr>
<td>Julian</td>
<td>+4,219</td>
<td>28</td>
<td>70.7</td>
<td>26.30</td>
</tr>
<tr>
<td>Mecca</td>
<td>–181</td>
<td>12</td>
<td>70.7</td>
<td>3.62</td>
</tr>
<tr>
<td>Palm Springs</td>
<td>+354</td>
<td>12</td>
<td>70.1</td>
<td>4.36</td>
</tr>
<tr>
<td>Yuma, Arizona</td>
<td>+141</td>
<td>37</td>
<td>72.5</td>
<td>3.10</td>
</tr>
</tbody>
</table>

In the last few years more or less complete records have been kept at Blythe, Brawley, and Warner Hot Springs. The following data were obtained from the United States Weather Bureau:
Temperature and precipitation at Blythe, Brawley, and Warner Hot Springs, 1914–1917.

<table>
<thead>
<tr>
<th>Year</th>
<th>Blythe (altitude 268 feet)</th>
<th>Brawley (altitude -105 feet)</th>
<th>Warner Hot Springs (altitude 3,165 feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>°F.</td>
<td>Inches.</td>
<td>°F.</td>
</tr>
<tr>
<td>1914</td>
<td>67.7</td>
<td>5.92</td>
<td>70.3</td>
</tr>
<tr>
<td>1915</td>
<td>68.5</td>
<td>3.88</td>
<td>70.7</td>
</tr>
<tr>
<td>1916</td>
<td>69.8</td>
<td>1.82</td>
<td>70.8</td>
</tr>
<tr>
<td>1917</td>
<td>68.8</td>
<td>1.82</td>
<td>70.7</td>
</tr>
</tbody>
</table>

The data given are sufficient to indicate the general range of yearly temperature and rainfall. The temperature decreases and the rainfall increases with increasing altitude. The mean annual temperature shows a very close agreement in all the records at any station, but the rainfall is extremely erratic in both yearly and monthly distribution. Much of the rainfall occurs in violent storms at widely separated times. In most of the desert the average yearly precipitation is probably less than 5 inches, and in much of it less than 3 inches. The higher valleys of the Peninsular Mountain region (see p. 22) have an average of 20 to 30 inches, and the extreme summits of the mountains much more. A rainfall of 57 inches was recorded at Julian in 1916, but this was very exceptional. In the regions above an altitude of 3,000 feet snow occurs nearly every winter and increases in amount as the altitude increases. San Jacinto and San Gorgonio peaks frequently wear snow caps until early summer.

Little is known as to the effect of altitude on precipitation in the desert ranges. There is undoubtedly a considerably heavier precipitation in the Little San Bernardino Mountains than in the desert at Indio, for the vegetation in these mountains is similar to that found at altitudes of 3,000 feet or more in the mountains on the western border of the region. The Piñon district, in the Little San Bernardino Mountains, receives its name from the considerable growth of piñon, which, though hardly to be described as forest, is still markedly different from the vegetation of the ranges farther east. In January, 1918, a snowfall that descended to altitudes of about 4,000 feet on the Santa Rosa Mountains barely capped the summits of the Little San Bernardino Mountains. The extreme barrenness of such ranges as the Palen, Chuckwalla, and Chocolate mountains, however, indicates that they receive little more precipitation than the surrounding valleys.

The subjoined table, taken from the monthly reports of the United States Weather Bureau, gives the direction of the prevailing winds

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for each month at several places in the region. The records at Blythe, Brawley, and Calexico are incomplete for many of the months. The data indicate that the direction of the prevailing winds differs at different places but is much the same from year to year at any particular station. Thus at Indio more than 80 per cent of the prevailing winds are from the northwest. At Brawley more than 90 per cent are from the southwest. At Calexico the winds are rather variable, but more than two-thirds are from the north, northwest, or west.

There is a very marked seasonal variation at Blythe and Yuma. At Blythe 90 per cent of the prevailing winds from October to March are from the north and 98 per cent from April to September are from the south or southwest. At Yuma over 80 per cent of the prevailing winds from October to March are from the north, and during the rest of the year 100 per cent are from the southwest or west.

Direction of prevailing winds in Imperial County and eastern Riverside County, Calif., and at Yuma, Ariz., 1914-1918.

[Observations are incomplete at some stations. The figures indicate the number of times for each month, considered as a whole, that the prevailing wind was in the direction stated.]

<table>
<thead>
<tr>
<th>Month</th>
<th>Blythe</th>
<th>Brawley</th>
<th>Calexico</th>
<th>Indio.a</th>
<th>Yuma, Ariz.</th>
</tr>
</thead>
<tbody>
<tr>
<td>January</td>
<td>N. 4</td>
<td>SW. 2</td>
<td>NW. 2, N. 1</td>
<td>NW. 3, SE. 1</td>
<td>N. 4, NE. 1</td>
</tr>
<tr>
<td>February</td>
<td>N. 5</td>
<td>SW. 1</td>
<td>N. 1, NW. 1</td>
<td>NW. 4</td>
<td>N. 4, W. 1</td>
</tr>
<tr>
<td>March</td>
<td>N. 3, SW. 1, S. 1</td>
<td>NW. 2, N. 1</td>
<td>NW. 3, SE. 1</td>
<td>N. 5</td>
<td>W. 4, SW. 1</td>
</tr>
<tr>
<td>April</td>
<td>S. 4, N. 1</td>
<td>SW. 2</td>
<td>N. 1, W. 1, NW. 1</td>
<td>NW. 4</td>
<td>W. 4, SW. 1</td>
</tr>
<tr>
<td>May</td>
<td>S. 2, SW. 2</td>
<td>SW. 2</td>
<td>W. 2, NW. 1</td>
<td>NW. 4</td>
<td>SW. 4, W. 1</td>
</tr>
<tr>
<td>June</td>
<td>S. 3, SW. 1</td>
<td>SW. 1</td>
<td>SE. 2</td>
<td>NW. 4</td>
<td>SW. 4, W. 1</td>
</tr>
<tr>
<td>July</td>
<td>S. 4, SW. 1</td>
<td>SE. 1</td>
<td>SE. 2, SW. 1</td>
<td>NW. 3, SE. 1</td>
<td>SW. 4, W. 1</td>
</tr>
<tr>
<td>August</td>
<td>S. 3, SW. 2</td>
<td>SE. 1, SW. 1</td>
<td>SE. 2, SW. 1</td>
<td>NW. 2, SE. 2</td>
<td>SW. 4, W. 1</td>
</tr>
<tr>
<td>September</td>
<td>S. 4, SW. 1</td>
<td>SW. 1</td>
<td>NW. 1, SE. 1</td>
<td>NW. 2, SE. 2</td>
<td>SW. 3, W. 2</td>
</tr>
<tr>
<td>October</td>
<td>N. 4</td>
<td>SW. 3</td>
<td>N. 1, NE. 1</td>
<td>NW. 3, SE. 1</td>
<td>N. 3, W. 1, SW. 1</td>
</tr>
<tr>
<td>November</td>
<td>N. 4</td>
<td>SW. 4</td>
<td>NW. 1, W. 1</td>
<td>NW. 4</td>
<td>N. 4, SW. 1</td>
</tr>
<tr>
<td>December</td>
<td>N. 4, S. 1</td>
<td>SW. 4</td>
<td>NW. 1, N. 1</td>
<td>NW. 4</td>
<td>N. 5</td>
</tr>
<tr>
<td>Total</td>
<td>N. 25, S. 22</td>
<td>SW. 24, SE. 2</td>
<td>NW. 10, SE. 7, N. 6, W.4,SW.1,NE.1</td>
<td>NW. 40, SE. 8</td>
<td>N. 25, SW. 19, W. 15, NE. 1</td>
</tr>
</tbody>
</table>

*Observations at Indio are complete for 4 years, 1914-1917.

The reason that the winds at Indio blow so persistently in one direction undoubtedly lies in the fact that cool air from the coast rushes in through San Gorgonio Pass to replace the ascending heated air of Coachella Valley. A similar cause probably produces the uniform southwest winds at Brawley, the cool air of the mountains on the west having a tendency to flow down into Imperial Valley, particularly along channels such as the valleys of Carrizo and San Felipe creeks.

A complete record for the years 1914-1918 of the direction of the storm winds, or the highest winds recorded each month, at Yuma and their maximum velocities is given in the following table, which indicates that more than 40 per cent of the high winds are from the north, about 25 per cent from the northwest, west, or southwest, and the remainder from the south or east. These data have an important bearing on the subject of sand-dune formation. (See pp. 27-32.) The
Direction and velocity, in miles per hour, of highest winds at Yuma, Ariz., 1914–1918. [See also Fig. 1, p. 28.]

<table>
<thead>
<tr>
<th>Month</th>
<th>1914</th>
<th>1915</th>
<th>1916</th>
<th>1917</th>
<th>1918</th>
</tr>
</thead>
<tbody>
<tr>
<td>January</td>
<td>W.30</td>
<td>S.28</td>
<td>S.30</td>
<td>N.21</td>
<td>N.30</td>
</tr>
<tr>
<td>February</td>
<td>NW.34</td>
<td>SE.28</td>
<td>N.33</td>
<td>N.23</td>
<td>N.25</td>
</tr>
<tr>
<td>March</td>
<td>N.31</td>
<td>N.31</td>
<td>N.28</td>
<td>N.30</td>
<td>N.34</td>
</tr>
<tr>
<td>April</td>
<td>NE.30</td>
<td>N.31</td>
<td>N.28</td>
<td>N.34</td>
<td>SE.30</td>
</tr>
<tr>
<td>May</td>
<td>SW.26</td>
<td>W.30</td>
<td>W.27</td>
<td>W.27</td>
<td>S.37</td>
</tr>
<tr>
<td>June</td>
<td>S.21</td>
<td>N.19</td>
<td>E.35</td>
<td>S.37</td>
<td>SE.38</td>
</tr>
<tr>
<td>July</td>
<td>N.30</td>
<td>SE.22</td>
<td>S.26</td>
<td>S.46</td>
<td>SE.36</td>
</tr>
<tr>
<td>August</td>
<td>S.34</td>
<td>SE.40</td>
<td>NW.26</td>
<td></td>
<td></td>
</tr>
<tr>
<td>September</td>
<td>S.23</td>
<td>W.30</td>
<td>NW.25</td>
<td>S.37</td>
<td>S.18</td>
</tr>
<tr>
<td>October</td>
<td>W.22</td>
<td>N.19</td>
<td>NW.20</td>
<td>N.20</td>
<td>S.27</td>
</tr>
<tr>
<td>November</td>
<td>N.24</td>
<td>N.33</td>
<td>N.33</td>
<td>N.18</td>
<td>NW.33</td>
</tr>
<tr>
<td>December</td>
<td>N.30</td>
<td>N.36</td>
<td>N.27</td>
<td>N.31</td>
<td>SW.26</td>
</tr>
</tbody>
</table>

Number of months for each direction: 1914, N. 4, S. 3, W. 2, NW. 1, SW. 1, NE. 1; 1915, N. 6, SE. 4, W. 2; 1916, N. 4, W. 3, NW. 2, SW. 1, S. 1, E. 1; 1917, N. 8, S. 4; 1918, SE. 4, N. 3, S. 2, NW. 1, SW. 1, E. 1. Summary for 5 years: N. 25, S. 10, SE. 8, W. 7, NW. 4, SW. 3, E. 2, NE. 1.

FLORA.

NATURE OF DESERT FLORA.

The flora of this and of all other desert regions is made up largely of plants that are highly specialized and adapted to the unusual conditions under which they live. The xerophytes are by far the most numerous class. They are distinguished from the plants of more humid regions by their small amount of leaf surface exposed and by the shedding of leaves in dry seasons or (in perennials) the death of the whole upper portion of the plant. Some of them, such as the cacti, have no leaves. Storage organs for retaining water are characteristic of some plants like the barrel cactus. Thick waxy skins on stems or leaves are common. Great root development is one of their characteristics. The halophytes, which are adapted to resist extreme salinity of soil or of water supply, are another widely represented class. Individual species are largely restricted to ranges of soil, temperature, and water supply favorable to them; so that certain plants occur mainly in zones controlled either by moisture, or altitude, or character of soil. As all these factors have a very wide range in this region, it follows that between the high, well-watered mountains and
A. FLOODING OF SOUTHERN PACIFIC RAILROAD NEAR SALTON.
Photograph by W. C. Mendenhall.

B. END OF PROTECTIVE LEVEE DESTROYED BY BREAK IN DECEMBER, 1906.
Photograph by W. C. Mendenhall.
A. ARROYO CUT IN IMPERIAL VALLEY BY FLOOD WATERS OF 1904-1907.
Photograph by W. C. Mendenhall.

B. CUT BANKS OF NEW RIVER FORMED DURING FLOODING OF IMPERIAL VALLEY.
Photograph by W. C. Mendenhall.
A. SALT GRASS (DISTICHILIS SPICATA) AND MESQUITE (PROSOPIS) AT MESQUITE SPRING, SAN BERNARDINO COUNTY.

The calf has died recently in the pool of water.

B. THE OCATILLA (FOUQUIERIA SPLENDENS).

A typical inhabitant of the detrital slopes. Cactus and ironwood in the background. South border of Cottonwood Mountains.
BADLANDS OF UPPER CARRIZO VALLEY

Carved in soft Tertiary beds. View looking northwest from Carrizo Mountain. Photograph by W. C. Mendenhall.
the arid lowlands there is a great diversity in types of vegetation. Another factor to be considered is the gradual transition from moderately humid climate of the coast to the excessively hot rainless climate of the interior. For convenience in a nontechnical discussion of plant forms the region may be divided into various areas characterized by rather similar physical features and close resemblance in plant life.

VEGETATION OF VALLEYS THAT CONTAIN GROUND WATER.

In the Salton Basin, along Colorado River, around Palen Dry Lake, and in certain small mountain valleys there are lowlands with a fine clay or sandy soil that is kept moist by the upward percolation of ground water confined under slight pressure or lying within a few feet of the surface. A portion of the land in the center of such a basin may be so heavily impregnated with residual alkali left by evaporation that it supports no vegetation. The plants that grow nearest the borders of these barren areas are certain salt bushes (Atriplex), which cover extensive areas in Coachella Valley and along Colorado River, and salt grass (Distichlis spicata). (See Pl. VI.)

Farther back and more or less mingling with the salt bushes are the mesquites (Prosopis odorata, or the screw bean, and Prosopis juliflora). These plants occupy soil ranging from rather tight clay to fine sand and prefer areas that are not water-logged or incrusted with alkali but are well supplied with water at depths probably less than 50 feet (pp. 114–117). They have an extensive development both above and below the ground surface and a very dense, slow-growing woody tissue. They are excellent for firewood, and the beans they bear are often used, at least by Indians, for human and animal food. The mesquites extend in places where conditions of water supply are favorable to altitudes of at least 3,500 feet. They cover many square miles in the Salton Basin and on the Colorado River flood plain and occur at scattered springs and along streams over all the region except in the high mountains.

A class of plants dependent entirely on an abundant supply of ground water is common to small areas around springs and near streams. The plants are important as indicators of ground water and are discussed individually under vegetation indicative of water (pp. 112–118). They include the palm (Neowashingtonia filamentosa), the rushes (Juncus), the sedges or tules (Scirpus), arrow weed (Pluchea sericea), and some others. Black willows (Salix nigra) are a common associate of these plants near springs and form dense thickets along Colorado River in places subject to overflow. The cottonwood (Populus) is more rare on the desert but is found at a number of springs and along mountain streams where there is an abundance of good water. Sycamores (Platanus) also occur in such associations.
There is a general group of plants common to the dry detrital slopes, or so-called mesas. Closely associated with them are the plants, chiefly trees, that grow in the dry washes of these arid plains. The most abundant of these plants are creosote bush (*Larrea tridentata* or *mexicana*), ocatilla (*Fouquieria splendens*), ironwood (*Olneya tesota*), palo verde (*Cercidium torreyanum*), several varieties of cactus, and an unknown tree, probably *Parosela spinosa*. Spanish bayonet or yucca is also an associate of these plants in places. All these plants depend on the intermittent desert rains for moisture, though some are confined almost wholly to drainage courses where flood water is most abundant.

Creosote bush, commonly but improperly called greasewood, occupies many square miles of sandy, gravelly, or stony plains. It occurs usually in dense clumps, which are fairly well separated from one another. Although it inhabits the driest soils, it thrives more luxuriantly in places having a liberal supply of moisture, where it often grows to 6 or 8 feet in height with stems an inch in diameter. The plant is notably waxy and has an oily stench that has suggested the names greasewood and creosote bush. Ocatilla (*Pl. VI, B*) is a widespread inhabitant of dry detrital slopes and is known throughout the region, though largely confined to isolated localities. Both it and the creosote bush extend in a few places to the rocky mountain slopes.

The ironwood forms a thin but persistent forest over large areas in Salton Basin and Chuckwalla Valley and is also present in nearly all the dry washes. Its wood is very dense and excellent for firewood. The tree grows slowly, and the dead wood lasts almost indefinitely, as is common with many trees in the desert, so that it is a fruitful source of firewood for campers. The palo verde and the *Parosela spinosa* are confined largely to dry washes in the desert. The palo verde (Spanish for green wood) is so named for its pale-green bark, which is especially conspicuous in winter. The *Parosela spinosa* grows in clumps of several trunks and in winter presents a grayish or silvery-white appearance. It has innumerable little spines that approach thorniness in character. All three of these trees grow to heights of 15 or 20 feet in favorable localities, and one palo verde tree 50 feet high was seen. All these trees are legumes.

The desert willow (*Chilopsis linearis*) is also a common tree in the dry washes of the desert and unfortunately ruins the reputation of willows in general as indicators of water, for it apparently has no connection with permanent ground water.

On the ironwood, palo verde, mesquite, and some other trees appear bunches of mistletoe (*Phoradendron californicum*), a great tangled parasite that is always green.
Several varieties of cactus are common in places, but their distribution is much more restricted than is popularly believed. Cactus is the dominant type of vegetation in a few localities, chiefly the very rocky slopes near mountain borders. It occurs in greatest abundance in the Devils Garden, an area of a few square miles north of the Southern Pacific Railroad between Whitewater and Palm Springs Station. Extensive areas are overgrown with cactus at the foot of the Laguna Mountains, at the south base of the Eagle Mountains, and elsewhere. But there is probably a larger area where cacti are absolutely unknown than where they are present even in small numbers. The giant cactus, so common in parts of Arizona, was not seen in this region. The chief varieties of cactus are the *Opuntia*, the barrel cactus (*Echinocactus cylindraceus*), some *Mammillaria* and *Cerei*. Cholla, which grows to a height of 2 or 3 feet, is perhaps the most common of all and one of the most unpleasant to approach, for its thorny tufts stick out on the tip of every sprangling branch.

**MOUNTAIN VEGETATION.**

On the higher parts of the western mountain ranges there is an abrupt and marked change in the character of vegetation. Sagebrush of various kinds is thick in a belt of moderate aridity above the area containing the more desert-like vegetation of the Salton Basin; this gives way at higher altitudes to shrubbery including the juniper, live oak, manzanita, and numerous bushes 10 to 15 feet in maximum height. Along watercourses there are forests of cottonwood, oak, and sycamore. Above altitudes of 3,000 or 4,000 feet are extensive forests of oak, which grade into pine on the higher summits.

In the desert ranges the vegetation characteristic of mountains is almost absent. In the Little San Bernardino Mountains there is a stunted growth of manzanita, juniper, and piñon on the crest of the range, suggesting an incipient stage of true mountain vegetation. Numerous high areas in this region are characterized by creosote, bunch grass, and Mormon tea (*Ephedra californica*), an association marked by the absence of many more truly desert plants.

**SEASONAL CHANGES IN VEGETATION.**

The flora of the desert usually appears dry and often almost dead, but it has its periodic variations. After the annual rains the plants often flare up in great brilliancy of leaf and flower and for a few days change the somber appearance of the region to one of many brilliant hues and great diversity of color.

**FAUNA.**

To appearances at least the animals of the desert are less conspicuous than the plants. The traveler may go for miles, sometimes for
days, and see not more than two or three animals. Nevertheless, the region contains a large variety of mammals, reptiles, insects, and even birds.

The largest wild animals are the deer, antelope, mountain sheep, mountain lion, and coyote. All but the last are rarely seen except by hunters. The deer are said to be mostly of the black-tail species. They are of large size and exist in considerable numbers in the desert ranges and basins, where they are occasionally seen even by tourists on the automobile roads. Mountain sheep are found in all the ranges of the region. Antelope are rare but are present in the desert mountains. All these animals feed on grasses and browse the bushes of the desert valleys and mountain canyons. In the open season they are killed by prospectors and miners, and the meat is "jerked" and preserved for food.

The mountain lion is confined largely to the high western ranges, which are forested and afford a considerable pasturage for his prey. He is reported sometimes, however, to wander through the desert ranges and along the Colorado River jungles. His small cousin, the wildcat, is known over all the region.

The coyote is the commonest predatory animal of the desert. A certain amount of civilization seems to agree with him, for he finds the extra food afforded by domestic fowl and by dead cattle very acceptable. Indeed, he is the scavenger of the desert and promptly clears away all carcasses of other animals. Coyotes are frequently seen by the roadside and even near towns, though they usually maintain a respectful distance. Their howls and cries at night furnish music of a sort for desert campers, and they often approach very near a camp at night but have never been known to attack persons. They are much more numerous in Imperial and Coachella valleys and the western mountains and along Colorado River than in the more barren places.

Jack rabbits are seen nearly everywhere in the desert, and a trip across it in any direction is usually enlivened by the sight of one to a dozen of them. Cottontails are known in the more settled communities. The smallest common animal is the kangaroo rat, a little animal that flits about like a flash and hides in burrows in the sand. He is a thievish visitor around camps or buildings. Other kinds of rats are said also to exist.

Birds are rather uncommon in the most truly desert regions, except for quail. "Desert quail" and other quail flock in large coveys and are frequently seen both in settled communities and in the open desert, but in the desert they are found most commonly near the springs or watering places, where insects and plant food are abundant. Persistent hunting has considerably reduced their numbers at some places.
A very common bird is the road runner, which often appears to make a pastime of allowing itself to be chased along a road. It runs very swiftly and is remarkable for a long tail, light body, and tufted crown.

Since the filling of Salton Sea large numbers of aquatic birds have inhabited it and are sometimes so numerous as to make the water look black from a distance. They formerly nested in great numbers on the obsidian islands at the south end of Salton Sea. Since these islands have emerged, it is not known what is their preference as to nesting grounds. The varieties include ducks, geese, and many pelicans.

The term desert reptiles immediately suggests the rattlesnake, but it is remarkable that in this entire field investigation only one baby rattler was seen. In the winter season, however, they are probably not much in the open. There are several kinds of rattlers, but the commonest are the diamondback and sidewinder. Their bites are poisonous. The Gila monster, a large lizard that is very rare in California, is also generally reputed to have a venomous bite.

Lizards of numerous kinds are the commonest reptiles of the desert and are of various sizes, the largest several inches in length. The chuckwalla is a very famous one in this locality and has impressed his name upon mountain ranges and other places in the desert. He is said to have been an important part of the Indians’ bill of fare in times not long gone by. Horned toads and desert tortoises, or land turtles, are other common reptiles.

Insects are numerous in summer, particularly near springs or other water. Mosquitoes are common the year around, though they cause no great inconvenience in sleeping in the open in winter. Moths and various other winged creatures are often pests about a fire at night but are rarely seen in daytime. Scorpions and tarantulas are found in the desert. The tarantula is a hairy black spider with a spread of 3 to 6 inches in his long legs. He is especially feared for his poisonous bite. Centipedes and scorpions are also sometimes found. The sting of the scorpion is very painful.

Fish are abundant in Salton Sea, it is said; the chief variety is a mullet that is known in both salt and fresh water. Fish have long lived in Fish Springs, to which they gave the name. There are also numerous varieties of fish in Colorado River. Remains of dead fish are a feature of many of the overflow lakes of the Colorado Delta and would doubtless be abundant in Salton Sea should it entirely evaporate.

**PHYSIOGRAPHY.**

**DIVISIONS OF THE REGION.**

Physiographically the Salton Sea region presents many striking contrasts. From lofty mountains with forests of large trees, heavy
winter snows, and an annual precipitation of 30 inches or more, there is an abrupt transition to low desert ranges and plains that are nearly devoid of vegetation, where summer temperatures prevail the year around and where there may be entire years practically without rain. Diagonally across the region, from southeast to northwest, extends a great trough whose lowest point is nearly 300 feet below sea level. (See Pls. II and III.) On the west side of this deep trough rise the great Peninsular Mountains, whose culminating points are 10,000 feet above sea level. On the east side is a desert containing irregular ranges and undrained basins ranging in altitude from a few hundred feet to 5,000 feet or more. The eastern border of the territory is formed by Colorado River, whose turbid, silt-laden waters meander through a low valley and finally spread out over a huge delta as they enter the Gulf of California.

The region may be separated into three main divisions that lie in three different physiographic provinces—the Peninsular Mountains, the desert basins and ranges, and the Salton Basin. A fourth division is made to include Colorado River valley, some features of which deserve separate treatment.

**PENINSULAR MOUNTAINS.**

The Peninsular Mountains lie in the southwestern part of the region but extend westward beyond its limits. They include the San Jacinto, Santa Rosa, Vallecito, and Laguna mountains. Along the summit of the Peninsular Mountains are numerous gently rolling tracts floored by residual soil and sculptured into local relief of only a few hundred feet. Such are Piñón Flat, Montezuma Flat, and large tracts in the Laguna Mountains and in the vicinity of Jacumba. They undoubtedly are in part the remnants of the surface of this region before it was uplifted to form the present mountain chain.

East of these gently rolling tracts there is a belt characterized by extremely rough and deeply dissected surface. On the slopes of the San Jacinto Mountains are some of the steepest stream courses in the United States. This rugged belt along the east side of the Peninsular Mountains is apparently the result of a great uplift of the present mountain mass in comparatively recent time. The topography and drainage are here very much influenced by the structure of the rocks, especially by faults. The intersection of faults and the lifting of fault blocks across stream courses has produced, on the eastern mountain slope, several notable triangular valleys that are completely surrounded by high mountains except for narrow canyon outlets. (See pp. 52-53.) Moreover, there are deep, straight canyons that apparently follow fault lines—for example, Carrizo Gorge, Palm Canyon, Banner Canyon, Grapevine Canyon, and many of less promi-
nence. Many of the smaller streams, however, are but little influenced by faults and merely plunge down the steep declivities by the shortest routes.

The mountains give rise to many small perennial streams of which the largest are Snow, Tahquitz, and Palm creeks, in the San Jacinto Mountains, and Coyote, San Felipe, Vallecito, and Carrizo creeks, farther south. These streams are fed by the rainfall in the highest parts of the mountains. Toward the east the precipitation dwindles rapidly, becoming scant and erratic. The small streams often sink into the gravel of their beds long before they reach the desert. They may reappear in narrow rocky canyons only to be lost again a little farther down; but all of them disappear a short distance from the mountains. Occasional floods furnish sufficient water for these streams to reach Salton Sea. These floods are the chief erosive agents in the mountains and the chief depositional agents at the mountain borders, where great alluvial slopes are built up of the materials they transport. Such slopes are most notable on the east side of the Santa Rosa and San Jacinto mountains, on the west wall of Borego Valley, and on the east slope of the Laguna Mountains.

DESERT BASINS AND RANGES.

The desert basins and ranges lie northeast of a nearly straight line extending from the north tip of Coachella Valley southeastward to the Laguna dam, in Yuma Valley, 5 to 10 miles northeast of and parallel to the Southern Pacific Railroad. This part of the region has much similarity, though also some dissimilarity, to the region east of Colorado River in Arizona. On the north it is continuous with the desert region generally known as the Mohave Desert.

This area is of a somewhat modified basin and range type and is part of a large physiographic subdivision known to geographers as the Sonoran Desert, which includes land farther north in California and farther southeast in Arizona and Mexico. Its mountains and valleys probably originated by block faulting, but so much erosion of the mountains and filling of the valleys has taken place that it is difficult to trace the outlines and geologic structure of the original blocks. The region is characterized in this part of California by great waste-filled basins, which separate the mountains. The deposits of waste have grown so high upon the borders of the mountains as to obliterate much of the evidence as to their origin and continuity. Many of the basins have no outlets for surface water, and in this respect the region is like the Mohave Desert on the north but unlike the region east of the Colorado, which contains no closed basins but whose drainage lines all lead to either Colorado River or Gila River.

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A strip along the eastern edge of the Salton Sea region also drains into the Colorado.

The mountains of this part of the region include the Little San Bernardino, Cottonwood, Eagle, Pinto, Orocopia, Chuckwalla, Little Chuckwalla, Chocolate, Palo Verde, Coxcomb, Palen, Maria, Little Maria, and McCoy ranges, as well as a few smaller scattered groups. All these mountains are more fully described in the route descriptions. In general there is a decrease in altitude of mountain summits from west to east. Thus, the Little San Bernardino Mountains rise more than 5,000 feet above sea level, and the Eagle and probably the Chuckwalla mountains about 4,000 feet, whereas the Maria, McCoy, and Palo Verde ranges and the eastern part of the Chocolate Mountains do not reach higher than 3,000 feet. There is a little timber on the highest part of the Little San Bernardino Mountains, but the other ranges when viewed from a distance appear utterly barren and on closer observation are seen to have only a meager growth of desert shrubs in the arroyos. There are a few mountain springs but not a single perennial stream in any of these ranges.

The sides of the mountain are cut by deep gorges, and many of the crests are knifelike in their acuteness. There is, however, a wide difference in the topography of different ranges, due in part to differences in the kind of rock and in the rock structure and in part to differences in the stage of the erosion cycle. Thus, the Eagle Mountains present at many places the well-rounded outlines of a homogeneous granite mass, the Palo Verde Mountains show the domination of flat-lying or tilted volcanic beds, and the Palen and Maria mountains have scarps resulting from the erosion of intensely folded and faulted metamorphic sediments.

The desert valleys are flooded by outwash from the mountain ranges. At the sides their slopes are steep, for the rare rains produce floods in the mountain canyons that carry away enormous quantities of rock débris, which is deposited at the mountain border, where the water sinks or becomes sluggish. These alluvial slopes are found on the margins of all the valleys. They are composed of a great number of coalescing alluvial fans, the largest of which are at the mouths of the largest canyons that drain the highest and most extensive mountain areas.

The lowest parts of the closed desert basins receive the storm waters from the tributary uplands that are not dissipated by seepage or evaporation on their way thither. Consequently these low tracts occasionally become covered with thin sheets of muddy water that persist a few days or rarely several weeks, until the water is removed by evaporation, leaving behind the salts which it contained in solution and the clay or silt which it held in suspension. By repetition of this process of flooding and desiccation during many centuries,
these low tracts have received considerable deposits of alkaline clay that supports practically no vegetation and have become almost level and exceedingly smooth, except for the very minor irregularities produced by crystallization of the salts and cracking of the clay when it dries. These barren clay flats are called playas or "dry lakes." The name lake does not refer so much to the very ephemeral lakes which at long intervals occupy depressions in the flats as to the resemblance of the smooth, glistening level surface of the alkaline clay to the surface of a real lake.

The principal playas in this region are Palen Dry Lake, Ford Dry Lake, and Clark Dry Lake. Besides these there are a number of very small ones. Before 1904 a very large playa existed in Salton Basin in the bed of the present Salton Sea.

This region of desert basins and ranges may be subdivided into three parts, each containing closely related physiographic and geologic features. One subdivision includes the Little San Bernardino, Cottonwood, and Eagle mountains and some territory farther north in the vicinity of Dale. Its mountain masses consist of granitic and metamorphic rocks, similar to those of the Peninsular Mountains. Its boundaries are probably fault lines, and prominent cross faults dissect it into a number of ranges and basins, but its general nature is that of a high plateau of plutonic rocks. Its summits are in many places rounded and inconspicuous. Many of its peaks are nearly buried in their own débris. Portions of the interior of this subdivision form parts of extensive little-dissected plains.

The second subdivision forms a large triangle including the Oro­copia, Little Chuckwalla, Chocolate, Palo Verde, and Mule mountains and perhaps the Chuckwalla Mountains, which, however, appear to consist chiefly of granites similar to those of the Eagle Mountains. Part of this subdivision is described as the Arroyo Seco valley. (See p. 106.) This subdivision as a whole is characterized by mountains of highly metamorphosed schist and ancient granite covered by great masses of rhyolite, andesite, and basalt of much later origin. Chimneys, scarps, and buttes chiseled out of flat or tilted beds of this volcanic material are dominant in many places in the mountains and appear unexpectedly in the plains veneered with recent gravel. The entire subdivision is drained to points outside its borders. In its rock formations and resulting mountain forms and in the character of its drainage it is closely related to parts of western Arizona.

A third subdivision may be made to include the Chuckwalla Valley and the Coxcomb, Palen, Maria, and McCoy mountains. It comprises sharp-crested ranges of a highly faulted complex of igneous and sedimentary metamorphic rocks separated by broad undrained

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basins. It is continuous with a similar territory farther north in San Bernardino County.

SALTON BASIN.

LOCATION AND GENERAL CHARACTER.

The remaining major physiographic division of the region is the Salton Basin, which lies between the two divisions already described. It is a continuation of the great trough in which lies the Gulf of California, which is believed to be a sunken fault block that subsided as the land on both sides was elevated. Where Colorado River formerly discharged into the Gulf of California it built near the border of the United States and Mexico a very large delta which finally extended across the gulf and isolated the northern part, creating a lake not connected with the ocean. This lake eventually dried up and left a desert, much of which is below sea level.

Topographically the Salton Basin does not differ materially from other closed desert basins except that it is larger than most of them and lies at an unusually low level. The surface of its central portion is very even and nearly flat; about its borders are alluvial slopes such as border the other basins. In a number of places rock masses protrude above the even surface of the basin as rocky islands project out of the sea. Such island-like features are formed by Borego, Superstition, and Carrizo mountains, the Indio Hills, the Cargo Muchacho Mountains, Pilot Knob, and a number of volcanic buttes, 100 to 200 feet high, south of Salton Sea.

BADLANDS.

Badlands constitute an important feature of the physiography of Salton Basin. Badlands originate in regions where rocks of greater or less hardness but all fairly soft are exposed at long intervals to heavy rains such as are characteristic of an arid climate. The result is that the soft rocks, unprotected by vegetation, suffer rapid erosion and in the earlier stages of the erosion cycle are deeply and intricately dissected.

Along the borders of Salton Basin are extensive badlands in soft sandstone and clay. Because so much of the material thus eroded is soft clay and resembles dried mud the local residents usually refer to the badlands as mud hills. The largest areas of badlands are in the Mecca and Indio hills; south of the Santa Rosa Mountains, around Seventeen Palms; and in the valley of Carrizo Creek. Smaller areas of badlands occur along Salt Creek, in Iris Pass in the Chocolate Mountains, north of the Palen Mountains, east of the Maria Mountains, and at the borders of a few other ranges. (See Pls. VII–IX.)

The drainage courses in the badland areas are locally called canyons, or arroyos, or dry washes, without much effort at distinction.
The word "canyon" implies greater size than the other two, which are applied to any dry watercourse, however small. The shape of these drainage courses varies in cross section according to the structure of the rocks, which may also greatly modify the direction of drainage. Where the rocks lie nearly horizontal, as in the northeastern half of the Mecca Hills or at places along Carrizo Creek, the washes are rectangular in section. The floor of the wash is flat, and the sides rise vertically, in places to heights of 100 or 200 feet. (See Pl. IX, A.) This shape is probably due to the fact that the infrequent rains are very violent, and great quantities of flood water, with an enormous erosive power, are carried by the wash during brief intervals. The water does not penetrate deeply into the adjacent soil and rarely causes landslides in the steep walls of the washes.

A peculiar feature resulting from erosion in the flat-lying beds of the Mecca Hills is shown in Plate IX, A. Flood waters pouring over the vertical walls of the deeper washes cut these semicircular vertical chasms. At the bottom of the chasm is a talus pile of boulders too large to be carried away by the flood waters. This talus pile grows rapidly in height, while at the same time erosion cuts down at the top, and the chamber-like reentrant is thus converted first into a wash of steep gradient and later into an ordinary flat-floored wash.

At some places where the strata lie nearly level, flat-topped hills are left as remnants of erosion. Two large hills of this sort, known as the Table Mountains, constitute prominent landmarks in the valley of Carrizo Creek (Pl. VIII). These hills are capped by layers of fairly hard, resistant sandstone, which protects them from erosion.

In areas of folded rocks the topography and drainage are greatly modified. Many of the dry washes follow the outcrops of soft layers and run for long distances parallel to the strike of the beds. This is particularly true in the Indio Hills and in the belt of close folding at the southwest side of the Mecca Hills. (See p. 55.) The edges of harder layers on either side form the divides, some of which are so narrow that it is impossible to walk along their crests. The bottoms of the washes have a V shape, instead of the rectangular outline common in regions of horizontal beds.

SAND DUNES.

Wind erosion and deposition play an important part in the production of the surface forms of the desert, although wind is not nearly so effective a sculpturing agent as water. Some of the sand deposits have a maximum thickness of a few hundred feet, but there are water-laid sediments many hundred feet thick. In the badlands, where innumerable deep washes trench the surface, the wind has eroded only little potholes and caverns a few inches or a foot or two in depth in the arroyo walls. In places like San Gorgonio Pass,
where canyons hundreds of feet deep have been cut in the mountains, the wind has merely polished jutting points of rock until the garnets and harder minerals stand out in conspicuous relief. Nevertheless sand dunes are prominent surface features in the region, particularly in Salton Basin.

The Sand Hills east of Imperial Valley (Pl. X) constitute the largest belt of dunes in this region and one of the largest in the United States. (See Pl. III.) They extend southeastward from the vicinity of Amos and terminate a few miles beyond the Mexican boundary, forming a veritable mountain range 40 miles long and 2 to 6 miles in width. The crests of some of the dunes rise in places 200 to 300 feet above the land on either side, and the general impression from a distance is that of a low and nearly buried mountain range.

This enormous accumulation of sand was undoubtedly produced by the action of the wind in a region containing sand in abundance. Of the stations included in the table on page 15 giving the directions of the prevailing winds in this region, those nearest the Sand Hills are Brawley, Calexico, and Yuma. The prevailing wind at Brawley is from the southwest about 90 per cent of the time; at Calexico it is from the north or west nearly 70 per cent of the time; and at Yuma the winter winds are nearly all from the north and the summer winds from the southwest or west. It seems safe to assume that the prevailing winds at the Sand Hills are chiefly from the southwest, west, or northwest.

It should be remembered, however, that a gentle wind continuing in one direction for many days will move much less sand than a violent storm of a few hours. On page 16 is another table which shows the direction and velocity of the highest wind for each month for a period of five years at Yuma, Ariz., and the same data are given graphically in Figure 1. If the relatively small differences in velocity of the winds are neglected, the combined resultant is a force from the northwest acting in a direction S. 15° E., more or less parallel to the axis of the Sand Hills. It is probable that similar observations at Brawley or Calexico
would show a resultant of more nearly westerly direction. The most significant fact in the table for Yuma is that the direction of the maximum winds corresponds somewhat closely with that of the prevailing winds for the same months.

The conclusion that the Sand Hills have probably been built by winds from the southwest, west, and northwest accords with the observation in the field. West of the Sand Hills and east of the beach line of the ancient lake referred to on page 32 is a nearly level plain from 3 to 20 miles in width. The surface of this plain is covered practically everywhere with sand, which at some places forms areas of small dunes. Over most of the plain, however, there is a thin surface coating of gravel consisting of pebbles of about the size of peas, which appears to be a residuum too heavy for the wind to carry. The land northeast of the sand dunes has a very smooth surface but rises at about 50 feet to the mile toward the mountains on the northeast. The soil is usually clayey and hard, and the surface is coated with large pebbles an inch in diameter at many places, a residuum left by water rather than by wind. The conclusion appears justified that the dune sand has been gathered from the west, and probably most of it originated by wave action when the old beach was formed. In fact it is very likely that the Sand Hills originated when the beach was forming and the supply of sand was being constantly augmented. They may have traveled eastward to their present position either at that time or later. It is certain that the Sand Hills in their larger features have changed but little recently, for the land surveys of 1856 indicate that their shape and position then were practically the same as now.

There appears to be some movement of the dunes toward the southeast. The topographic map of surveyed portions of the Sand Hills shows steeper slopes on the south and east. Blake describes the sand as wasting over an embankment at the southeast extremity of the belt of dunes and being swallowed up by the lowland of Colorado River, where the annual floods and the resulting growth of vegetation serve either to carry away the sand or to fix it in place. The embankment he refers to is a continuation of the terrace bluffs along Colorado River. (See pp. 33–35.)

In Coachella Valley, above Indio, there are extensive areas of shifting sand, but large dunes are confined to a small area around Indian Wells. These dunes are formed by strong winds blowing from the northwest down San Gorgonio Pass into the heated lowland. In the pass itself great sand drifts are piled on the east sides of all the rocky spurs that project from the San Jacinto Mountains. The

effect of sand erosion in this region is minutely described by Blake and by Mendenhall, who writes of telegraph poles protected at the base by rock piles and of tin cans that show a bright polish due to the sand blast.

Southwest of Salton Sea, between McCain Spring and Kane Spring, there is a territory where crescentic dunes, called barchans, are common. Figure 2 shows a barchan in plan and section. The tips of the crescent are called horns. Barchans are believed to originate in regions where there is a strong wind blowing in practically a uniform direction. The horns of the barchan extend to leeward—that is, in the same direction in which the wind progresses—and the barchans travel in that direction.

The barchans near Salton Sea are evidently formed by winds from the northwest which sweep down the valley of San Felipe Creek. Their supply of sand comes chiefly from the old beach, which lies west of them. They are of various sizes, some as small as 300 feet from horn to horn, others probably 1,000 feet or more. Two of the largest are near McCain Spring and form a useful landmark visible for several miles. These dunes have remained practically stationary for the last 10 or 15 years, indicating that they do not travel rapidly. This observation accords with that of Captain McMahon in Persia. The same authority notes that barchans are apparently confined to regions of firm, hard soil and do not occur in extensive areas of deep sand.

This is true of the barchans near Salton Sea, which are found on a relatively smooth clay plain formed by Lake Cahuilla at the time the old beach was created. Except for the barchans themselves there is practically no sand in the vicinity.

In San Felipe Valley, in the same general region in which the barchans occur, there are also spring-formed dunes. Dunes of this type occur in Tularosa Basin, N. Mex., and elsewhere and are described by Meinzer. They are formed in sandy regions where a rising seep of water promotes a growth of vegetation in which sand

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[Figure 2: Plan and section of barchan dune such as is found southwest of Salton Sea.

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\(\text{Op. cit., p. 92.}\)


\(\text{Cornish, V., and others, On the formation of sand dunes: Geog. Jour., March, 1897, pp. 279-309.}\)

\(\text{Mendenhall, W. C., Some desert watering places in southeastern California and southwestern Nevada: U. S. Geol. Survey Water-Supply Paper 224, p. 84, 1909.}\)

\(\text{Cornish, V., and others, op. cit., p. 309.}\)

\(\text{Meinzer, O. E., Geology and water resources of Tularosa Basin, N. Mex.: U. S. Geol. Survey Water-Supply Paper 343, p. 52, 1915.}\)
begins to collect. The sand may pile up so high that the water can
not rise through it, and the spring then becomes completely sealed
over. The core of the dune is a mass of black mucky soil and decayed
vegetation. Kane Spring (Fig. 3) is a good example of such a spring
in this region. It occupies a mound about 30 feet high and several
hundred feet in diameter. The mound is somewhat elongate from
west to east, the prevailing winds being westerly. On the top of the
mound is a sunken marshy area, an acre or two in extent, from
which water seeps eastward, maintaining a considerable plot of grass.
A well has been dug in the marsh at the top and a pipe line laid to a
reservoir west of the mound.

Sometimes a sealed spring of this sort breaks out at one side of
the dune and the process is partly repeated. Barrel Spring was
probably formed in this way. It consists of a little pool of water on
the side of a belt of high sand dunes which are partly fixed by a
growth of mesquite.

Sand deposits of a type somewhat related to the spring-formed
dunes are developed around clumps of vegetation, rock piles, and
other obstructions. Such deposits occur most commonly around
clumps of mesquite in this region and are 2 to 10 feet in height
and 5 to 30 feet in diameter. Thousands of them were leveled in
preparing Imperial Valley land for irrigation, and they can still be
seen where the land is unimproved.

Peculiar dunes occur on the surface of Superstition Mountain.
They are elongated parallel to the length of the mountain, which
extends from northwest to southeast. Some of them are almost
serpentine in narrowness and sinuosity. They are found on both
sides of the mountain and apparently shift back and forth over its
crest to some extent as the wind changes. Frequently they block
up canyons draining north or south and create temporarily inclosed
depressions. The sand consists of nearly pure white quartz grains
and is very fine. Its position at altitudes of 400 to 700 feet above
sea level indicates that the wind which deposited it evidently had
remarkable carrying power, if, as seems possible, the source of the
sand is the old beach 2 or 3 miles to the northwest, which lies near sea level.

The only other dunes seen in this region are some relatively small ones in Chuckwalla Valley southeast of Ford Dry Lake and Palen Dry Lake. Their supply of sand probably comes from the outwash from neighboring mountains. They have probably been formed by the action of winds from the northwest, for they occupy the southeast sides of their respective basins.

Shore Lines.

One of the most interesting features of the Salton Basin is the old beach (Pls. II and III) which lies 40 to 50 feet above sea level and encircles the Imperial Valley, the Salton Sea, and that part of Coachella Valley south of Indio. It is a continuous topographic feature throughout the region here described and extends also somewhat to the south in Mexican territory. Its relations in Mexico are more fully described in connection with certain terraces along Colorado River that seem to be more or less connected with it in origin. (See p. 34.)

On the west side of Salton Basin and throughout Coachella Valley the old beach consists at most places of a sand ridge usually not more than a few feet in height. Its character varies somewhat with the nature of the rocks on which it is formed. (See Pl. XI.) Where the land is nearly level the beach is low and wide. Thus on the Carrizo-Imperial road and the Warner-Brawley road west of Imperial Valley it has a width of half a mile or more, and the sand throughout this distance is deep and soft. South of McCain Spring the beach is cut in the soft Tertiary strata of badlands that rise considerably above it, and there is a tendency to cliff formation. Farther north in Coachella Valley the sandy beach is a few hundred feet wide and is built on Quaternary valley fill. Along with sand deposits of the beach there are found great numbers of small shells in an excellent state of preservation.

Near Fish Spring the water of the lake that formed the beach washed directly against granitic rocks, and instead of a beach the old shore is marked by a deposit of travertine, at places several feet thick, which borders the granite of the Santa Rosa Mountains and forms a conspicuous white line that is visible for 2 or 3 miles along the Coachella-Brawley road near Fish Spring.

On the east side of Imperial Valley and as far north as Frink Spring the beach is marked by an almost continuous wave-cut cliff from 10 to 30 feet in height. Sand is less prevalent in this part of the beach, but the Quaternary sediment in which the cliff is cut is soft and sandy, so that roads that ascend the cliff are very bad. At the crossing of the bench east of Niland on the Yuma road the
TABLE MOUNTAIN AND BADLANDS ON NORTH SLOPE OF CARRIZO MOUNTAIN.

Photograph by W. C. Mendenhall.
A. DETAIL OF EROSION IN THE MECCA HILLS.
Vertical wall of Shaver Canyon in horizontal conglomerate beds. Flood waters from the bordering uplands erode hanging valleys like the one in the center.

B. BADLANDS NEAR SEVENTEEN PALMS.
Carved in Tertiary strata south of the Santa Rosa Mountains. Photograph by W. C. Mendenhall.
SAND HILLS NEAR AMOS.

Photograph by W. C. Mendenhall.
A. EAST OF NILAND.
Showing wave-cut cliff and terrace.

B. AT FOOT OF SANTA ROSA MOUNTAINS, WEST OF TORO.
Showing sand beach.
OLD BEACH OF LAKE CAHUILLA.
Photographs by W. C. Mendenhall.
traveler has a good view of the cliff that marks the old shore line in that region.

The significance of the old beach was first pointed out by Blake, who described the beach and the travertine deposit and gave the name Lake Cahuilla to the ancient lake by whose waves it was formed. Since that time numerous other writers have published accounts of it, and all agree that geologically the old beach is one of the most recent features of the desert, some even contending that the lake that formed it has disappeared only within the last 500 or 1,000 years. The shells found in the beach deposits indicate that the water was fresh or very nearly fresh, and the logical conclusion is that the lake was sustained by Colorado River, which must at that time have discharged into the Salton Basin instead of the Gulf of California, as at present, perhaps overflowing into the gulf. The age and origin of Lake Cahuilla are treated more fully in the section on geologic history (pp. 57–60).

Some evidence of former shore lines at higher altitudes than that of the old beach is afforded by faint lines in granitic and metamorphic rocks on Superstition Mountain and Carrizo Mountain, but these lines have not been studied carefully enough to ascertain their true nature and meaning. Several strand lines have been formed by Salton Sea during its recession since 1907, but they will probably disappear almost as quickly as they were formed, for they are only a few feet in height and the material in which they are cut is very soft.

COLORADO RIVER VALLEY.

GENERAL FEATURES.

Colorado River borders this part of California on the east, and its valley constitutes a more or less distinct physiographic division adjacent to the division of desert ranges and basins. The valley is hemmed in by scattered mountain ranges both in Arizona and in California; the largest ranges near the river in California are the Maria, McCoy, Palo Verde, and Chocolate mountains. The width of the river valley varies greatly according to the distance of the limiting ranges from the river, being at some places 20 or 25 miles and at others only 2 or 3 miles. As the rainfall in the region is insufficient to sustain permanent streams, the tributary valleys are small and unimportant. That of the Arroyo Seco, a dry streamway in the northeastern part of Imperial County, is the largest in this region and has a length of 40 or 50 miles. Elsewhere alluvial divides connect the mountains that are adjacent to the valley and form inclosed basins that do not drain into the Colorado.
At nearly all points the valley of the Colorado is separated into two parts at different levels by a conspicuous bluff 50 to 100 feet in height, which has been formed by the process of stream terracing. There is thus a lowland, or flood plain, near the river, and a bench, or terrace, locally called a "mesa," between the lowland and the mountains. The width of both features varies greatly, but as a rule the terrace is widest where the lowland is widest. Thus at Blythe the lowland, known as Palo Verde Valley, is 7 or 8 miles wide, and the terrace, called the Palo Verde Mesa, is nearly as wide. The same relation is shown by Yuma Valley and the Yuma Mesa, near Yuma. On the other hand, at Laguna dam, north of Yuma, in the Chocolate Mountains, the river occupies a narrow pass and the terrace is very narrow or absent altogether. This general relation between lowland and terrace continues for a considerable distance up the Colorado, toward the Grand Canyon, beyond the region under consideration.

The lowland is very nearly level, having at most places a slight slope away from the river and being lowest at the foot of the bordering bluff, owing to the building of natural levees by the river along its banks. The soil is a very fine sand or silt such as is being carried by the river and deposited along its banks at the present time. A great part of the lowland is covered during summer floods unless protected by artificial levees. Numerous old channels and oxbow lakes over its surface show the location of abandoned stream channels. A very large one near Palo Verde known as the Laguna apparently receives a considerable amount of ground water and flows sluggishly throughout the year.

The terrace above the lowland usually constitutes a narrow and nearly level plain a few miles in width. At a few places its surface is broken by bluffs that divide it into more than one level and convert the single terrace into a series of terraces; for example, west of Blythe, on the Palo Verde Mesa, where there is a second bench 30 or 40 feet higher than the first. At most places, however, there is but one level to the terrace. The surface of the terrace is usually sandy or gravelly, the underlying sediment apparently being rather fine in texture. Where good exposures are visible in the escarpment that separates it from the flood plain the material is usually sand or gravel. Near the mountain borders, however, the terrace rises sharply and merges with the alluvial slopes at the mouths of mountain canyons. The surface material on these slopes is coarse and bouldery.

The bluff that separates the terrace from the lowland is very straight and regular in general outline and has an abrupt slope. Its minor details, however, are greatly modified by erosion, all the dry washes that cross it having cut down to the level of the lowland where they cross the bluff, thus giving it a notched appearance. Although the writer's observations were confined to the California...
side of the river, the terrace bluff on that side has its counterpart on the Arizona side. Both are well shown on the topographic maps of the river made by the United States Geological Survey in 1903. The terrace bluff on the Arizona side is modified by Gila River at its junction with the Colorado, the Colorado River bluff merging into a similar one along either side of the Gila and extending up that river for at least 50 miles. It is probable that the terrace bluffs of the two rivers are similar in age and origin.

Another notable feature of the Colorado terrace bluff west of the river is that it bends westward at Pilot Knob, near the international boundary, passes south of the Sand Hills in Mexican territory, and then turns northward and merges into the old shore line of Lake Cahuilla (see p. 32), which is marked by a prominent escarpment for many miles northward. This feature was noted by Blake and Antisell in their early reports on the region and has appeared on a number of recent maps made by irrigation surveys, in which the terrace bluff of the Colorado west of Yuma is shown to be continuous with the old shore line. Cory has described that portion of the bluff which he calls the "edge of the mesa," west of Pilot Knob, as follows:

The edge of the latter [mesa] runs southwest for 4 miles [from Pilot Knob]; then it turns directly west for 25 miles. Then again it turns sharply to a little west of north for 50 miles, the latter edge forming the east side of the cut-off portion of the gulf, Lake Cahuilla.

There is less available information as to the terrace bluff east of the Colorado below Yuma. The topographic maps show that it continues to the international boundary 20 miles southwest of Yuma, diminishing gradually in height. The best maps and descriptions available indicate conclusively that it is continuous also to the head of the Gulf of California, but in Mexican territory it probably diminishes still more in height.

CAUSES OF STREAM TERRACES.

Stream terraces originate wherever a river that has formed a flood plain, either by lateral planation or by filling its valley, cuts down to a lower level. Such a change from deposition to erosion may be brought about in various ways. A very common cause is uplift of the stream valleys due to movements in the earth's crust. If a valley that is occupied by a sluggish stream which deposits sediment along its course is suddenly elevated its grade becomes steeper, the velocity of the stream is increased, and the stream can carry more sediment. It also has a greater eroding power and so cuts away some of the

Cory, H. T., Imperial Valley and Salton Sink, p. 1230, San Francisco, 1915.
filling it has deposited and lowers its valley. Any portions of the old flood plain not cut away are left standing at the side of the valley and constitute terraces. The same effect may be produced by an increase in the volume of the stream from increased rainfall or other causes. To form extensive terraces, the changed conditions must be long continued, as might result from a marked change in climate. A third factor in forming terraces is the amount of sediment the river collects in its upper course, where it is usually always eroding. A river, like a train, can carry only a certain load. If too much load is supplied as sediment the surplus is deposited. If, however, the load of a stream that has been carrying a great deal of sediment suddenly diminishes, the stream becomes able to erode some of the material already deposited, thus forming terraces. Extensive forest planting on the headwaters of a stream in regions previously barren might cut down the supply of sediment so as to produce this result.

Lee37 has described the valley of the Colorado below the Grand Canyon and given a summary of its history. The terrace bluffs here considered were formed during the third epoch of canyon cutting described by Lee. Canyons were cut at that time through the Chocolate Mountains and at some other places farther north, outside the region here considered. No theory is advanced by Lee as to the cause of this erosion, though climatic changes are suggested as a factor of possible importance.

SUGGESTED HYPOTHESIS FOR FORMATION OF COLORADO RIVER TERRACES.

The terrace bluffs along Colorado River show a remarkable resemblance to the bluffs left as a result of the erosion of the New River and Alamo River channels during the recent overflow of the Colorado into the Salton Basin (Pl. V). At that time the two rivers eroded gorges 50 feet deep and nearly a quarter of a mile in average width for many miles along their courses in Imperial Valley. The bluffs on both sides of the small streams that now occupy these channels are similar to the bluffs along Colorado River. Furthermore, there is a very marked resemblance between the old shore line east of Imperial Valley and the terrace bluff along the river—in fact, it is impossible to tell where one ends and the other begins. These facts suggest that the beach and the terrace bluffs may perhaps have originated at the same time from related causes, the explanation of both features possibly being found in the diversion of Colorado River into the Salton Basin and the consequent creation of the ancient Lake Cahuilla.

Colorado River from Yuma southwestward flows over a broad delta that slopes both toward Salton Sea and the Gulf of California, which

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are about equally distant from Yuma. The building of this delta has been the chief factor in isolating the Salton Basin from the gulf, with which it was once continuous, the delta having been built higher than sea level all the way across to the Cocopah Mountains, on the west side of the basin in Mexico. At various times in the past the Colorado has discharged into the Salton Basin, as is proved by the presence of fresh water in Lake Cahuilla indicated by fresh-water fossils on the old beach. At other times, as at present, it has flowed into the gulf.

As the bottom of the Salton Basin is about 275 feet below sea level the natural gradient for the river is much steeper in that direction than it is toward the gulf. Thus, if the basin were dry and the river suddenly broke into it the fall of the river would be increased temporarily by 275 feet, a change that would affect the erosion of the river valley in the same way as an uplift of the land of 275 feet. As was demonstrated in the recent outbreak in Imperial Valley, this would cause the river to erode its valley rapidly, the only check to its erosive action being the fact that the Salton Basin would gradually fill up with water and sediment, thus restoring the former gradient.

The danger to agricultural interests of allowing Colorado River to flow unchecked into Salton Sea has been recognized fully by engineers engaged in the work of reclamation in that region. This effect of the deepening of the river channel was emphasized by F. H. Newell, Director of the United States Reclamation Service, and was elaborated by C. E. Grunsky, an engineer closely associated with the work of the Reclamation Service. Grunsky points out that if Colorado River should continue to flow into Imperial Valley it would not only inundate 20,000 square miles of the best land in the Salton Basin, but a great deepening of the river channel would occur which would probably extend 400 miles upstream. In addition to simple deepening of the channel lateral cutting of the river banks would be very great, and the valuable agricultural land in Yuma Valley and Palo Verde Valley would probably be eaten away and carried down to the delta.

It is evident that the process of erosion above described is exactly identical with that by which terraces are formed. The uncertain element is the time required for the erosion of a given depth and volume of the river valley and for the filling of the basin sufficiently to reduce the river's grade and cause it to resume deposition.

As the river would erode its bed much more slowly in rock-bottom canyons than where it flows on valley fill, such erosion as might be

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Footnotes:

2 Grunsky, C. E., Colorado River in its relation to Imperial Valley: 65th Cong., 1st sess., S. Doc. 103

1917
caused by a temporary diversion of the river into Salton Sea probably would not cause much deepening above the first rock-floored portion of the valley. Soundings made for dam sites and other purposes indicate that bedrock is 100 or 200 feet below the bed of the river in all canyons of the Colorado below Black Canyon, which is about 250 miles north of Yuma. Below Black Canyon there are several canyons where the river occupies a narrow channel through the bordering mountains. Between these canyons there are broad lowlands, such as Palo Verde Valley, between the inclosing terrace bluffs. In the following table these lowlands and canyons are listed in geographic order, and most of the areas are taken from official reports of the Reclamation Service and Geological Survey relating to irrigation problems.

Area of lowlands and canyons along Colorado River below Black Canyon, in acres.

<table>
<thead>
<tr>
<th>Area</th>
<th>Acres</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cottonwood Valley</td>
<td>7,000</td>
</tr>
<tr>
<td>Pyramid Canyon, 8 miles.</td>
<td></td>
</tr>
<tr>
<td>Mohave Valley</td>
<td>53,000</td>
</tr>
<tr>
<td>Needles Canyon, 12 miles.</td>
<td></td>
</tr>
<tr>
<td>Chemehuevis Valley</td>
<td>28,000</td>
</tr>
<tr>
<td>Aubrey Canyon, 20 miles.</td>
<td></td>
</tr>
<tr>
<td>Great Colorado Valley (four divisions):</td>
<td></td>
</tr>
<tr>
<td>Calzona Valley</td>
<td>18,000</td>
</tr>
<tr>
<td>Colorado River Indian Reserve</td>
<td>122,000</td>
</tr>
<tr>
<td>Palo Verde Valley</td>
<td>100,000</td>
</tr>
<tr>
<td>Cibola Valley</td>
<td>19,000</td>
</tr>
<tr>
<td>Chocolate Canyon, 30 miles.</td>
<td></td>
</tr>
<tr>
<td>Yuma Valley</td>
<td>90,000</td>
</tr>
</tbody>
</table>

Total area of valleys ......... 437,000
Total area of canyons (length 70 miles, average width 1½ miles) . 60,000
Total area inclosed by terrace bluffs below Black Canyon. 497,000

The table shows that along Colorado River nearly 500,000 acres of land was eaten away below Black Canyon at the time the terraces were formed. Along Gila River also a large area was excavated, though to a less depth than that along the Colorado. A liberal estimate would probably be to allow 140,000 acres additional for excavation along the Gila, thus making the total area 640,000 acres, or 1,000 square miles. The average depth of this excavation was probably between 50 and 150 feet. The present terraces do not average more than 75 feet, probably nearer 50 feet, and the depth to rock in the canyons precludes a depth greater than 200 feet in the river bed. A depth of 100 feet may be taken as a reasonable basis for calculation. On this basis the total volume of earth removed was 100,000 square mile feet.

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A basis for calculating the rate of earth removal is afforded by the figures for erosion during the overflow in 1904-1907. Cory gives the volume of earth removed along Alamo and New rivers in nine months as 450,000 cubic yards, which is equivalent to 578 square mile feet a year. In Alamo River a waterfall 30 feet or more high and 250 to 300 feet wide was formed and retreated headward for many days at a rate of 1 foot a minute, a rate of excavation amounting to about 400 square mile feet a year. The Arizona Experiment Station publishes figures showing that the sediment normally carried by the Colorado at Yuma amounts to 435 square mile feet of mud annually, but the river is depositing at that point under present conditions and would carry much more if it were eroding. MacDougal estimates the filling deposited during the recent flood as one-third of a cubic mile and states that “It is obvious that all the alluvial fill in the basin might be accounted for by the floods of the last few hundred years and that all of the main events of its history might have occurred within recent times.”

If Cory’s estimate of 578 square mile feet a year is taken as the average rate of erosion, the time necessary to carve out the lowland now existing between the terrace bluffs would be 100,000 divided by 578, or 173 years.

There remains the question of the time required to fill the Salton Basin. The basin could not be filled above the level of the old beach that delimits the extinct Lake Cahuilla (42 feet above sea level), as it would then overflow into the Gulf of California. In fact, the altitude of the divide between the Salton Sea and the gulf appears at present to be only about 30 feet above sea level. The area inclosed by the old beach is approximately 2,100 square miles, and its maximum depth is 273 feet below sea level. This added to 30 gives a total depth of 303 feet. If the average depth is about one-third the maximum, or 100 feet, the volume of the basin is about 210,000 square mile feet. More careful computations made by separating the basin by horizontal planes along contour lines and calculating the volume of each part as the frustum of a cone show the actual volume up to 30 feet above sea level to be 264,500 square mile feet.

The volume of water annually discharged by the Colorado at Yuma, according to measurements by the United States Geological Survey, averages about 16,700,000 acre-feet, or 26,000 square mile feet. At this rate of inflow the time required to fill the basin to 30 feet above sea level would be 264,500 divided by 26,000, or about 10 years. However, the rate of filling would be greatly retarded by evaporation as the area of water in the lake grew large. The best

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41 Cory, H. T., Imperial Valley and Salton Sink, p. 1324.
figures available indicate that in this region an open body of water suffers an annual loss of about 6 feet through evaporation. On an area of 2,100 square miles this would amount to more than 8,000,000 acre-feet, or half the volume of the Colorado River discharge at Yuma. However, even in spite of this high rate of evaporation, the Salton Sea, it appears, would overflow in less than 20 years.

The discrepancy between the time that would probably be required to fill the Salton Basin (10 to 20 years) and the time estimated as necessary to erode the present valley of the Colorado below Black Canyon (173 years or more) makes it appear improbable that the terrace cutting of the Colorado can be accounted for in this manner. Nevertheless several features of the evidence strongly suggest a relation between the the formation of Lake Cahuilla and the terraces, chief of which is the continuity of the terrace bluff and the beach. Moreover, if the terrace cutting is to be explained by uplift of the region about the head of the Gulf of California, it appears that there should be evidence of this uplift in the form of sea beaches elevated at the same time. These beaches might be expected to encircle the Salton Basin. The old beach of Lake Cahuilla can not represent such a sea beach, for its fossils furnish evidence that the lake was fresh.

Climatic changes may of course explain the fluctuations of the Colorado between periods of erosion and deposition. But a climatic variation that would cause the Colorado’s annual discharge to drop below 8,000,000 acre-feet, half of its present volume, would make it possible for evaporation to exceed inflow should the river be diverted into the Salton Basin, and in that event erosive action started by the diversion of the river might continue until the lake was filled with sediment, a task which at the estimated rate of erosion would require 300 or 400 years. In this connection it must be remembered that at the beginning of inflow into Lake Cahuilla the basin was deeper and larger than at present by a volume equal to the amount of sediment deposited on the bottom of the old lake, which was doubtless considerable. The question is also pertinent, though probably not easily answered, How long may the erosive activity of a river continue by head-end erosion after the cause that incited the change from deposition to erosion is removed?

DRAINAGE.

Seventeen separate drainage basins have been recognized in this region (see Pl. XII), and there are undoubtedly a number of others that are very small and escaped notice, but the total area of the undiscovered basins is insignificant. The drainage basins fall into three...
groups—the western, comprising the area draining westward to the Pacific Ocean; the central, including the Salton Basin and all the remaining closed basins; and the eastern, draining directly into Colorado River and thence to the Gulf of California.

The following table shows the location and approximate area of the drainage basins within the region. Several of these, notably the Salton Basin, receive some drainage from areas outside this region. Others contribute all their run-off to outside areas, as the Pacific drainage system. The Salton Basin is the most extensive single unit, occupying more than 50 per cent of the total area.

<table>
<thead>
<tr>
<th>Drainage system</th>
<th>Location or center of desert basin</th>
<th>Area.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Salton Basin</td>
<td>Salton Sea</td>
<td>5,800</td>
</tr>
<tr>
<td>Colorado River</td>
<td>East side of territory</td>
<td>1,500</td>
</tr>
<tr>
<td>Pacific slope</td>
<td>West side of territory</td>
<td>800</td>
</tr>
<tr>
<td>Ford Dry Lake</td>
<td>T. 6 S., R. 19 E.</td>
<td>675</td>
</tr>
<tr>
<td>Palen Dry Lake</td>
<td>T. 5 S., R. 17 E.</td>
<td>640</td>
</tr>
<tr>
<td>Sand Hills</td>
<td>East side of Sand Hills</td>
<td>500</td>
</tr>
<tr>
<td>Pinto Basin</td>
<td>T. 3 S., R. 12 E.</td>
<td>375</td>
</tr>
<tr>
<td>Blythe Junction Basin</td>
<td>T. 1 S., R. 21 E.</td>
<td>180</td>
</tr>
<tr>
<td>Clark Dry Lake</td>
<td>T. 9 S., R. 7 E.</td>
<td>140</td>
</tr>
<tr>
<td>Hayfields</td>
<td>T. 6 S., R. 19 E.</td>
<td>125</td>
</tr>
<tr>
<td>Near Vallecito Mountains</td>
<td>T. 12 S., R. 6 E.</td>
<td>65</td>
</tr>
<tr>
<td>Pleasant Valley</td>
<td>T. 3 S., R. 9 E.</td>
<td>60</td>
</tr>
<tr>
<td>Near Cottonwood Mountains</td>
<td>T. 4 S., R. 11 E.</td>
<td>35</td>
</tr>
<tr>
<td>Eastern San Felipe Valley</td>
<td>T. 13 S., R. 5 E.</td>
<td>25</td>
</tr>
<tr>
<td>Copper Mountain</td>
<td>San Bernardino County drainage area here in T. 2 S., R. 8 E.</td>
<td>30</td>
</tr>
<tr>
<td>Blair Valley</td>
<td>T. 13 S., R. 6 E.</td>
<td>6</td>
</tr>
<tr>
<td>Near Borrego Mountain</td>
<td>T. 12 S., R. 8 E.</td>
<td>4</td>
</tr>
</tbody>
</table>

* Receives drainage from areas outside the region.
* Contributes drainage to areas outside the region.

Of the 17 recognized drainage systems 7 occupy less than 1 per cent each of the total area. The Palen Dry Lake and Ford Dry Lake are so poorly separated topographically as to be grouped under the one heading Chuckwalla Valley, and as such they constitute a large and important unit of the area of interior drainage. The basin east of the Sand Hills is shut off from the Salton Basin only by the barrier of sand drifts across its natural slope. It probably includes a number of separate and poorly defined drainage basins that end in imperfect playas at the northeastern border of the dunes.

**GEOLOGY.**

No detailed study of the geology of the region was possible, observations being confined chiefly to routes of travel, the vicinity of watering places, and a few points where special investigation was possible. Most of the information gained is discussed in detail in the route descriptions (pp. 194–279) under headings of local geology. As so little
connected work has been done on the geology of southeastern California, a summary based on extensive but hasty observations and a liberal use of the data gathered by others in detailed studies of small areas will be given here. The most useful references on the geology of the region are Blake’s original description of the Salton Basin, called by him the Colorado Desert, recently revised for use in several books on the Imperial Valley; Mendenhall’s papers on Coachella Valley and Carrizo Creek; Fairbanks’s Geology of San Diego County; Harder’s bulletins on the iron ores of the Eagle Mountains and the gypsum of the Palen Mountains; and Lee’s and Bancroft’s papers on western Arizona. All these works are listed in the bibliography on pages 125–128, which also includes shorter publications of interest. A reconnaissance geologic map of the region based on all available data forms Plate XII.

GENERAL ROCK SECTION.

As shown on Plate XII, the rocks of this region are divided according to age into three groups, each of which comprises rocks of igneous and sedimentary origin. Rocks of Quaternary and Tertiary age make up the two youngest groups, but because the amount of igneous rock that is definitely known to be Quaternary is so small all the igneous rocks of Tertiary and Quaternary age are shown together on the map. The third group includes sedimentary and igneous rocks of many different ages, none of which, however, have been studied carefully enough to permit their separation into units. Accordingly they are here referred to merely as pre-Tertiary.

In the following general section for the rocks of southeastern California, given by Harder,44 the youngest formations are listed at the top:

9. Unconsolidated desert deposits.
8. Basalt, slightly tilted.
7. Partly consolidated shale, sandstone, and conglomerate, horizontal.
6. Trachytic, andesitic, and rhyolitic flows, tilted and broken.
5. Red and brown sandstone, shale, and conglomerate, tilted.
4. Intrusive granite, syenite, monzonite, and diorite and their porphyritic phases in sills, dikes, and irregular batholiths.
3. Quartzite, crystalline limestone and dolomite, and conglomerate.
2. Purple and gray slate, shale, sandstone, and quartzite.
1. Schist, crystalline limestone and dolomite, gneiss, and granite.

PRE-TERTIARY ROCKS.

According to most geologists who have worked in this region the oldest three series in the above section are probably of pre-Cambrian age. This opinion is based mainly on the facts that these rocks are

clearly the oldest in the region, having suffered the greatest metasomatism and being intruded or overlain by all the other series; that they are similar to the pre-Cambrian rocks of the Grand Canyon and other parts of Arizona; and that, although vast thicknesses of the sedimentary beds are exposed in places, no fossils have ever been found within them. These rocks occur mainly in the desert mountains in the region between the Salton Basin and Colorado River. They are commonly flanked by Tertiary or later sediments about the mountain borders, and in large areas they are covered or intruded by Tertiary volcanic rocks.

The rocks that can most certainly be referred to the oldest series (No. 1) consist of granite and granite gneiss. In this series probably belong the granite and schist that compose most of the Cargo Muchacho Range; the granite, slate, and schist that form the basements of the Picacho Hills and the eastern part of the Chocolate Mountains; and the granite that forms the basements of the Mule Mountains, Chuckwalla Mountains, and Black Hills. In addition it is likely that the lowest rocks of the Maria Mountains, the granite at the north end of the Palen Mountains, known also as Granite Mountain, and the schist and granite gneiss of the Coxcomb and Eagle mountains belong to this series.

It is less feasible to differentiate the next two series (Nos. 2 and 3), and, indeed, their separation from the first series is exceedingly indefinite. Bancroft \(^45\) states that the lower part of the two series in the nearest adjacent portions of Arizona includes most of the limestone, quartzite, and dolomite, and the upper part is chiefly argillite, argillaceous shale, and fine-grained schist. Harder apparently places most of the limestone, dolomite, and quartzite in California above the argillaceous and arenaceous rocks. These two series, closely associated with the first, make up the remaining masses of the Maria, McCoy, Palen, Coxcomb, and Chuckwalla mountains except for some granitic, dioritic, and porphyritic intrusives that are probably of Mesozoic age. They also occur over large areas in the northern part of the Eagle Mountains and include a great body of schist in the Orocopia Mountains and in the basement of the Mecca Hills. Possibly the black biotite schist of the Little San Bernardino Mountains and the arenaceous schist and shale of the Hexie Mountains, around Pleasant Valley, belong to one of these series.

No rocks of known Paleozoic age are found in the region covered by this paper, but further studies may indicate that some of the formations that have been described as probably pre-Cambrian are really younger. On the western border of the desert in Carrizo Mountain and on top of Fish Mountain, in the Carrizo Creek region,

there are beds of marble with some schist and sandstone, which have tentatively been referred by Mendenhall and Fairbanks to the Paleo­zoic with a suggestion that they may be Carboniferous. Marble, schist, and gneiss of undetermined age in scattered localities in the east wall of the San Jacinto and Santa Rosa mountains may belong to the same series as the rocks of the Carrizo Mountain district.

Along the crest of the Peninsular Mountains, from Jacumba to Julian and extending northwestward for many miles, is a belt of arenaceous schist, argillaceous slate, shale, and other metamorphosed sedimentary rocks in which Fairbanks found fossils that he regarded as Carboniferous but which he believed to comprise also older and younger rocks. Merrill states that the fossils on later study are considered Triassic.

Sedimentary rocks of Mesozoic age have not been identified in this region, but some of the metamorphic rocks mentioned above as occurring in the Peninsular Mountains may be Mesozoic.

The fourth series of rocks in Harder’s section is represented in the Eagle Mountains. It probably includes the great mass of igneous rocks to the north and west of that range and thus makes up the bulk of the Cottonwood and Little San Bernardino mountains, extends eastward into the Pinto Range, and underlies nearly all the upland to the north between these ranges and the road to Dale. It is intruded into minor masses of metamorphic rocks of undetermined age, mostly schistose or gneissic. This series also is generally considered as making up the mass of the San Bernardino Mountains and the Peninsular Range and is widespread in the mountain region west of the Salton Basin, in the San Jacinto, Santa Rosa, Vallecito, and Laguna mountains.

**TERTIARY SEDIMENTARY DEPOSITS.**

Sedimentary beds believed to be of Tertiary age occupy extensive areas along the southwest and northeast sides of the Salton Basin and presumably underlie practically the entire basin. The largest and best-known exposures southwest of Salton Sea are in the Carrizo Creek valley, around Yuha Well, south of the Santa Rosa Mountains, and northeast of Superstition Mountain. Fringes of the same rocks are found around Superstition Mountain and Borego Mountain and on the north side of Fish Mountain. At the northeast side of the Salton Basin similar beds are exposed in the Indio Hills and Mecca Hills, which form a nearly continuous belt along the northeast side of the Salton Basin.

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48 Merrill, F. J. H., Geology and mineral resources of San Diego and Imperial counties, p. 10, California State Min. Bur., December, 1914.
of that part of the basin known as Coachella Valley. These hills, except for a few outcrops of crystalline bedrock, are composed entirely of the Tertiary rocks. A small exposure exists several miles southeast of the Mecca Hills near Durmid. Along Salt Creek between the Orocopia and Chocolate mountains and in the Chocolate Mountains at Iris Pass Tertiary beds are well exposed.

Within the boundaries of the old beach on either side of Salton Sea are some large areas where the Tertiary strata occur persistently in the beds of the dry washes at depths usually less than 20 feet, being generally covered by a thin deposit of silt and clay laid down on the ancient lake bed.

North of the Palen Mountains is a small area of sedimentary rocks that closely resemble the Tertiary beds and have provisionally been mapped as such. A few other areas in the northeastern part of the region may contain rocks of this division, but it is not possible to designate them.

The Tertiary beds consist of soft, poorly consolidated conglomerate, sand, and clay, containing in places a large amount of gypsum and some other saline materials. Usually the salts occur only as thin seams or as scattered crystals, but here and there they form thick layers interstratified with the mechanical sediments. The conglomerate occurs as a basal member wherever the Tertiary beds rest on older rocks and usually consists of fragments of the underlying bedrock. As a rule the conglomerate grades laterally into sand and clay away from the crystalline bedrock. This gradation is well exhibited in Shaver Canyon, where the conglomerate is coarse at Shaver Well but much finer 2 or 3 miles away. Doubtless there is also a vertical gradation, the strata at the bottom near the bedrock surface being much coarser than succeeding strata above. Beds of sand of varying fineness and of clay make up the larger part of the Tertiary where exposed at distances of a mile or more from the mountains. The sand is seldom pure in quality, being usually an arkosic mixture of quartz and feldspar fragments with a considerable amount of mica, the alteration of which leaves a brown iron stain on the exposed surfaces.

Part of the Tertiary beds in the region are marine and part terrestrial. Marine beds cover large areas in the Carrizo Creek region, where they contain an abundant marine fauna and are represented around Carrizo Mountain and north of Fish Mountain by chemical deposits such as gypsum and strontianite, which were evidently deposited in water. The small amount of gypsum found at other localities probably indicates merely conditions of aridity similar to

those now prevailing in this region, where incrustations of salts are common on the playas of the desert.

Because the Tertiary beds vary greatly in character within short distances and contain no beds that are recognizable over extensive areas it is very difficult to estimate their thickness. Mendenhall estimates the thickness in the Mecca Hills as 4,000 to 5,000 feet. Several wells drilled in prospecting for oil southwest of Salton Sea have penetrated 1,000 feet or more in the Tertiary beds, according to report. It is probable that the Tertiary in this region includes several thousand feet of sedimentary material.

The age of the beds referred to the Tertiary seems to be reasonably well fixed as late Tertiary, although further study may place part of them in the Quaternary. The marine fauna of Carrizo Creek was originally considered Miocene, but the latest opinion is that it is Pliocene. As the marine beds directly overlie the basal conglomerate they must represent very nearly the oldest rocks of the group. The general character of the beds indicates that they were deposited in and around a basin which somewhat resembled that existing at present and which was occupied for at least a considerable time by salt water. The separation of the Tertiary from the Quaternary is based largely upon the structural and lithologic characteristics and apparent continuity, the Tertiary beds being at nearly all places sharply folded and faulted and exhibiting marked angular discordance with the later Quaternary deposits.

The most abundant fossils in the Carrizo region are corals and mollusks, particularly pectens, which may be gathered by the wagonload around Carrizo Mountain or Yuha Well. They are of large size, many reaching 6 inches in diameter. Some fossils that may possibly be of Tertiary age were found near Colorado River at the south base of the Palo Verde Mountains on the Blythe-Glamis road, in sec. 18 or 19, T. 10 S., R. 27 E. They occur in a thin-bedded arenaceous limestone that overlies volcanic rock, presumably Tertiary. The limestone is covered at most places by Quaternary gravel. The fossils are very small and consist of Corbicula, according to W. H. Dall, of the United States Geological Survey, who examined the specimens together with similar fossils collected by C. P. Ross in Arizona. If these are marine Tertiary they indicate a considerable extension of the sea up the present valley of Colorado River in Tertiary time.

The Tertiary as here grouped includes No. 5 and No. 7 of Harder's general section.

51 Vaughan, T. W., op. cit., p. 367.
TERTIARY AND QUATERNARY VOLCANIC ROCKS.

The volcanic rocks of southeastern California differ somewhat in age but are probably mostly Tertiary; some of them are Quaternary. They occur as flows interbedded with sedimentary beds in the Carrizo region, around Superstition Mountain, and in Iris Pass. In Iris Pass there are also large bodies of volcanic material overlain by sediments. Around Jacumba occur great flows of basaltic lava, and in the mountains east of that place there are exposures of lava and tuff resting on the granitic rocks. The lavas are most prominent, however, in the triangle occupied by the Orocopia, Chuckwalla, Chocolate, and Palo Verde mountains. The Palo Verde Mountains are entirely volcanic, so far as known, being chiefly a mass of andesitic or rhyolitic flows. The Chocolate Mountains from one end to the other exhibit a great mixture of andesitic and rhyolitic flows with possibly syenite and trachyte in the west end. The Orocopia Mountains are to a large extent composed of eruptive andesite and trachyte which extend westward and at places reach into the Mecca Hills. The eastern part of the Chuckwalla Mountains contains extensive flows; the Black Hills consist of lava capping granite; and the Arroyo Seco valley contains innumerable hills of volcanic rock, probably remnants of a buried lava surface.

The fact that the volcanic rocks are in many places interbedded with the Tertiary sediments, show a similar degree of disturbance, and are overlain, like the sediments, by Quaternary formations seems clearly to indicate their general equivalence in age. This is also the most reasonable assumption on the basis of a correlation with the widespread Tertiary volcanic rocks in Arizona and other adjacent areas.

The only volcanic material of unquestionably Quaternary age in this region is found in the vicinity of the mud volcanoes southeast of Salton Sea, where three or four small buttes of black obsidian protrude through the Quaternary silt. The age of the volcanic rocks of the rest of the region is subject to at least as much doubt as the age of the Tertiary sedimentary rocks. Basalts of Quaternary age are found in western Arizona and in San Bernardino County, Calif., only a little north of this region. Harder does not mention any occurrence of his No. 10, which is undoubtedly Quaternary, within the region here described.

QUATERNARY DEPOSITS.

The Quaternary deposits immediately underlie nearly all the lowlands and have the largest areal extent of all the rock formations. They underlie the larger part of the Salton Basin and practically all of Chuckwalla Valley, the Colorado River valley, and many smaller valleys and basins. As valley fill they consist of sand, gravel, and
clay washed down from the mountains and hills and more or less stratified by water. Their composition varies widely with the nature of the rock from which they were eroded. Thus, in the Peninsular Mountain region they are usually composed of boulders and fragments of granite; near the Orocopia Mountains they contain a great proportion of flat fragments of black micaceous schist; near the Palo Verde Mountains they consist mainly of fragments of volcanic rocks. In texture the valley fill varies greatly according to its distance from its source, being very coarse and bouldery at the base of the mountains and becoming fine and clayey in the centers of valleys and on the playas, where water sometimes stands and evaporates. The Quaternary delta deposits of Colorado River, at the southeast end of Salton Sea, consist of very fine sand or clay and constitute the fertile agricultural soil of Imperial Valley. Many other valleys underlain by the Quaternary contain large areas of good agricultural land.

The thickness of this Quaternary valley fill is highly variable. At the mountain borders it thins to the vanishing point, but in the larger valleys it reaches a thickness of at least several hundred feet. The Hopkins well (p. 242), near the center of Chuckwalla Valley, penetrated sand and gravel and reached bedrock at 1,200 feet. Much of this material was doubtless Quaternary, though Tertiary beds similar to those found elsewhere in this region would probably be indistinguishable from the Quaternary in drilling and may be present beneath the Quaternary at that place. A considerable number of wells in Coachella Valley exceed 1,000 feet in depth, and, so far as reported, none of them reached bedrock. A part of this depth, however, may be in Tertiary material. Numerous wells in the Holtville region (see p. 83) are 500 to 800 feet deep and end in sand or gravel that may be either Tertiary or Quaternary.

It is probable that lake beds of Quaternary age occur in the Borego and San Felipe valleys. A prominent fault line bounds each of these valleys on the northeast (see p. 51), and it is likely that the valleys were converted into closed basins for some time by the elevation of fault blocks across their outlets. No careful search was made for strand lines, but it is believed that they might be found. A shallow well in Borego Valley penetrated beds of calcareous material that was doubtless deposited in water. The extreme smoothness of Borego Valley and its very fine, silty soil suggest deposition in quiet water or under conditions similar to those of the present-day playas. A considerable thickness of well-stratified fine sand occurs along the banks of San Felipe Creek in San Felipe Valley. In the Salton Basin much of the silt and mud deposited within the area marked by the old beach was laid down in the bodies of water that have occupied the basin during Quaternary time, and this material may be regarded as lake beds.
THE QUATERNARY deposits in the Colorado River valley consist of fine sand, clay, and gravel, which are usually exposed along arroyos that descend from the terraces along the valley to the level of the present flood plain. An excellent exposure occurs on the road to Yuma (see p. 209) about 6½ miles from Yuma and consists of fine, clean sand overlain by a layer of coarse pebbles. Lee has separated the Quaternary deposits of the contiguous region along Colorado River in western Arizona into the Temple Bar conglomerate and the Chemehuevis gravel.

In addition to ordinary water-laid alluvial materials the Quaternary deposits include considerable bodies of dune sand. (See pp. 27–32.)

STRUCTURE.

FAULTING.

Faulting has been one of the most effective agents in producing the present topography of this region. The origin of the Salton Basin is generally ascribed to block faulting, and many of the smaller valleys to the southwest of this basin doubtless originated in the same manner. The Peninsular Mountains are a product of uplift along several fault lines, and it is likely that some of the ranges in the region farther east originated in the same way. Much information as to the nature and location of faults in California is given in the report of the commission that investigated the San Francisco earthquake.

The evidence of faulting in this region is in most places furnished by topography; in only a few places is adequate stratigraphic evidence available. Igneous and metamorphic rocks, such as compose the mass of the mountain ranges, are so homogeneous that it is often impossible to determine differences in the rocks exposed on either side of a fault, and the Quaternary material that fills most of the valleys has been deposited since the faulting occurred and obscures the faults in many places. In the following sections an effort is made to present the field evidence from which the presence of faults is inferred.

FORMATION OF SALTON BASIN.

Fairbanks points out the fact that the Salton Basin, essentially continuous with the Gulf of California, is a depression due to crustal movements and may be described as a great dropped fault block, or


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graben. The basin is approximately wedge shaped, narrowing almost to a point at San Gorgonio Pass, on the northwest. The mountains that border this wedge-shaped lowland increase in height as the wedge narrows, until at the pass there is 8,000 feet of relief within a few miles on either side.

**FAULTS NORTHEAST OF SALTON BASIN.**

*San Andreas rift.*—Along the north side of San Gorgonio Pass and extending eastward into the basin is a fault known as the San Andreas rift, which has long been recognized by geologists and which extends many miles to the northwest. Prior to this work it had been traced only as far southeast as Whitewater River 2 or 3 miles north of Whitewater.\(^*\) The fault is probably continuous with one which extends through this region along the northeast side of the Indio and Mecca hills and for which the name Indio fault is tentatively proposed.

*Indio fault.*—The Indio fault was observed for several miles in the region immediately north of Indio along the road to Pinyon Well, in the Mecca Hills east of Shaver Well, and at a point about 2 miles west of Dos Palmas. The Indio and Mecca hills consist of a long and nearly continuous belt of folded sedimentary strata of Tertiary age along the northeast border of the Salton Basin. They have originated apparently by uplift along the line of the Indio fault, which produced a belt of low hills rising from the basin floor and separated from the higher granitic mountains to the northeast by a series of valleys and saddles. North of Indio the northeast wall of the Indio Hills is very steep and abrupt, though probably nowhere more than 200 or 300 feet high. It constitutes the most clearly defined fault scarp observed in this region. To the east of the scarp is a small valley which parallels it and which is underlain by Quaternary sand and gravel. Northeast of the Mecca Hills the fault scarp is much less conspicuous where observed but still constitutes a very well defined ridge. In the region west of Dos Palmas the scarp consists only of a low bluff along the eastern border of a point of clay hills. Although this fault has not been traced continuously throughout the region, the evidence obtained appears to justify the belief that it extends northwestward to the San Andreas rift, passing north of certain low hills that protrude from Coachella Valley near Palm Springs Station. To the southeast it probably extends at least as far as the small hill of Tertiary material near Durmid, which was probably uplifted in the same manner as the hills farther north. It is possible that the fault may continue as far as the Mud Volcanoes, southeast of Salton Sea, which are sometimes thought to be associated with deep-seated faults; but this is largely a matter of speculation.

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It should be noted that the throw of this fault is opposite to that of the San Andreas rift, and also to that of the original displacement by which the Salton Basin must have been formed. Such reversals of throw along prominent fault lines are, however, neither impossible nor uncommon.

FAULTS SOUTHWEST OF SALTON BASIN.

The faults along the southwest side of the basin are apparently of two ages and trend in somewhat different directions. The intersection of the two fault systems has caused the present irregular outline of the basin, in which great mountain salients, such as the Santa Rosa Mountains, the Vallecito and Fish Mountain spur, and the mountainous projection along the Mexican boundary, are separated by reentrant valleys, such as San Felipe Valley and the Carrizo Creek valley.

If this inference is correct, the older of these two fault systems strikes about N. 10° W. and is represented by three notable escarpments. One lies along the east base of the San Jacinto Mountains, passing up Palm Canyon. Another is at the west side of Borego Valley. The third extends from Agua Caliente Springs southward up Carrizo Gorge, along the east face of the Laguna Mountains.

Evidence of a fault along the northeast and east face of the San Jacinto Mountains was obtained near Whitewater. Just west of Whitewater Point the mountain face is composed of pink and gray granite and grayish marble. The marble and granite are arranged in layers turned on edge with a strike about N. 20° W. and a dip of 75° or more to the northeast. The marble is much less abundant than the granite but constitutes a considerable part of the mountain mass, in layers ranging from a few inches to 50 feet in thickness. The alternation of rocks is well exhibited in a prospect tunnel in sec. 23, T. 3 S., R. 3 E., where the material penetrated has the appearance of a gigantic fault breccia and the contact surfaces are abundantly slickensided. This intimate mixture of different rocks probably resulted from step faulting consisting of successive breaks along many parallel lines. Associated with this prominent fault is the warm spring at Palm Springs, whose water by analysis (p. 283) closely resembles that of other springs in granitic rocks, such as Jacumba, Cottonwood Spring, and Warner Hot Springs, and is therefore probably derived from granitic rocks buried at no great depth beneath the recent valley fill.

West of Borego Valley no observations were made to confirm the inference of a fault line except to note that the mountain front in that region is a very steep and straight escarpment from 2,000 to 4,000 feet in height.

The southernmost fault scarp of this series was observed in Canebrake Canyon and at Agua Caliente Springs. At both places the
mountain front for several hundred feet from the lowland border consists of rotten grayish granite, broken into minute joint blocks and kaolinized and altered, but farther west in the interior of the mountains the rock is dense and unweathered. There is much evidence of hydrothermal weathering, a very natural thing to expect, at Agua Caliente Springs (see p. 232), where a large number of springs, part of which yield warm water, issue from the granitic rocks.

Cutting across this older system of faults is a system that strikes approximately N. 45° W. and is represented by several prominent faults. The most northerly fault of this system is the San Jacinto fault, which passes west and south of the San Jacinto Mountains, extending through Hemet Valley, down Coyote Canyon, and for several miles along the northeast side of Borego Valley. The uplift along this fault was on the northeast. Coyote Mountain, northeast of Borego Valley, is part of a prominent spur elevated in this uplift and is bordered on the southwest by a well-defined scarp. It is probable that the San Jacinto fault extends at least as far as Borego Mountain, but it is much obscured in that direction by recent alluvial deposits. Movement occurred along this fault at the time of the San Jacinto earthquake of 1899.

Several faults that have been recognized in the vicinity of Warner Valley extend southeastward into the western part of this region. One of these that passes near Warner Springs traverses Grapevine Canyon, turns nearly east along a part of San Felipe Creek, and disappears near The Narrows. Its uplift was on the northeast, and the tongue of granitic rock south of Borego Valley in the vicinity of The Narrows is believed to have been brought up by this fault. A prominent fault extends from Warner Valley down the headwaters of San Felipe Creek, and its eroded scarp forms the northeast side of San Felipe Valley, where it is a conspicuous mountain wall extending for 12 or 15 miles. Another fault passes through Banner and Rodriguez canyons and extends along the north side of Mason and Vallecito valleys, the mountain walls of which represent considerably eroded fault scarps. The two faults last named unite in the vicinity of Agua Caliente Springs and are not known to continue farther, but they may extend along the north side of Carrizo Valley at the base of the Vallecito Mountains and Fish Mountain.

VALLEYS FORMED BY FAULTING.

Associated with the second system of faults are several peculiar valleys whose formation may be ascribed to the faults themselves. The largest of these valleys are Borego Valley, San Felipe Valley,
Mason Valley, and Vallecito Valley. Collins Valley, adjacent to Borego Valley, and a little valley less than a mile in extent at Banner were formed in the same way. Each of these valleys has for its northeast boundary a high, steep mountain wall that originated as a fault scarp along some one of the faults mentioned above. Thus Borego Valley and Collins Valley lie southwest of the San Jacinto fault. The general shape of each valley is triangular. The south and west sides are much more irregular than the northeast side, and the mountainous borders on these sides are also somewhat less abrupt than those on the northeast. Most of the valleys are high at the southwest and drain to the northeast, probably as a result of the tilting of the faulted strips, which have been dropped on the northeast and elevated on the southwest.

In most places the faults have forced the streams, after reaching the northeast sides of the valleys, to flow southeastward, particularly in the canyons such as Coyote Canyon, Grapevine Canyon, and Banner Canyon. But some streams, such as San Felipe Creek northeast of San Felipe Valley and Banner Creek at Banner, occupy deep gorges that cut directly across the fault scarps at the northeast borders of these valleys. It is probable that these streams existed prior to the faulting and that the faulting took place gradually, the streams cutting down as fast as the rocks were lifted across their beds. A further suggestion that the previous drainage lines may have had a northeasterly trend is afforded by the granite ridges that divide some of the valleys. San Felipe Valley, for instance, is cut nearly in two by a low spur of granitic rock projecting from the southwest, and except for a very narrow rock-cut canyon Mason Valley and Vallecito Valley are entirely separated by such a ridge. These ridges may represent drainage divides that existed prior to the faulting.

Definite fault lines in the region northeast of the Salton Basin are very hard to make out, because of the great amount of erosion and the extensive cover of unconsolidated Quaternary material. However, it is probable that most of the mountains in this region originated by block faulting of the typical Great Basin type. The steep south front of the Cottonwood and Eagle mountains suggests a fault, and the drainage from high and little-dissected regions north of them cuts across these ranges by deeply intrenched canyons, such as Cottonwood Canyon, strengthening the theory that these ranges are part of an elevated fault block.

The northwest side of the Eagle Mountains, the northeast side of Pleasant Valley, and a prominent scarp at the south side of the Maria Mountains exhibit strong topographic evidence of having
originated through faulting. Definite evidence of faulting exists at
the north end of the Palen Mountains.

In the several areas where Tertiary beds are exposed there has
been much faulting on a minor scale. Small slips with slickensided
surfaces and offsets of definite beds can be seen at many places,
particularly in the Mecca Hills.

**TYPE AND AGE OF FAULTING.**

Most of the faulting observed is of the normal type. The Indio
fault is associated with much folding and may be in part due to
thrust movements.

The age of the faults is very difficult to establish, as the age of the
rocks they displaced is so indefinitely known. The original settling
of the Salton Basin must have occurred before late Tertiary time,
because in the resulting depressions great thicknesses of late Tertiary
sediments were deposited. Considerable faulting has occurred since
the deposition of these beds, which are displaced, for example, along
the Indio fault and the San Jacinto fault. The fact that movement
has occurred along the recognized fault lines during recent notable
earthquakes in California indicates that adjustment along some of
those faults is not yet complete; and the excellent state of preserva­
tion of many of the scarps suggests that much of the displacement
has occurred in Quaternary time.

**FOLDING AND METAMORPHISM.**

**FOLDING AND METAMORPHISM IN PRE-TERTIARY ROCKS.**

Folding has probably occurred many times in the pre-Tertiary
rocks. The beds of quartzite, limestone (marble), and gypsum in
the Maria and Palen mountains dip steeply in various directions.
The limestone is now entirely crystalline, indicating a considerable
degree of metamorphism. The schists that occur in nearly all the
mountain ranges are in places extremely fissile and cleavable. At
many places granite has been altered to granite gneiss, and the
resulting layers of light and dark material are crumpled and contorted
in minute and intricate folds. This feature is well exhibited in Box
Canyon on the Julian-El Centro road and in the San Bernardino
Mountains along the pass leading from Whitewater to Morongo
Valley.

**FOLDING IN TERTIARY ROCKS.**

Almost without exception the Tertiary rocks, both sedimentary
and volcanic, have been sharply folded, but as a rule the original
constituents have not been metamorphosed. The strata are generally
tilted at angles of less than 30° but in places reach the vertical or
are slightly overturned.
Carrizo Creek and adjacent areas.—In the valley of Carrizo Creek the general structure is synclinal, and the axis of the syncline is parallel to the creek, trending nearly due east. As a result the strata visible in this valley on the Julian-El Centro road lie for the most part nearly flat. However, sharp dips in various directions are not uncommon there and are the rule near the mountains north or south of the creek. (See Pls. VII and VIII.)

In the areas bordering Salton Sea the Tertiary beds exposed by erosion in the arroyos dip in different directions, but the exposures are not sufficient to give a clear idea of the structure. In fact, at most places here and elsewhere the details of the folds are too complicated to understand without very careful and minute study.

Indio and Mecca hills.—The Indio and Mecca hills exhibit perhaps the greatest degree of uniformity in the attitude of beds. The strata there are folded into closely compressed anticlines and synclines, which strike southeast, parallel to the general trend of the hills. The attitude of the beds is particularly well exposed along Shaver Canyon,

![Figure 4](https://example.com/figure4.png)

**Figure 4.** Structure section through the Mecca Hills along Shaver Canyon.

on the Mecca-Blythe road (see Fig. 4), but some of the many turns in the canyon give a false impression of the strike and dip of beds. At the entrance to the canyon on the southwest Tertiary beds of sand and clay rise from the Quaternary valley fill with a dip of 15° to 20° SW. The dip increases in the first half mile, and the strata finally stand nearly vertical or are slightly overturned to the southwest. A confused zone follows in which the beds are much crushed and the stratification nearly destroyed. Beyond this zone the strata dip steeply northeast for some distance, completing an anticlinal fold, beyond which they rise in a second anticline whose southwest limb has a dip not exceeding 30° but whose northeast limb plunges abruptly downward with a dip of 80° to 90°. Plate XVII, A (p. 240), shows the northeast limb of this fold at a place where it forms the southwest wall of Shaver Canyon. The anticline is also well exposed in the canyon below Burnt Palms and Hidden Spring (see Fig. 17, p. 271, and Fig. 18, p. 274), where it is not so closely compressed. This fold has been traced continuously for more than 3 miles and is believed to extend throughout most of the length of the Mecca Hills.
Beyond this prominent anticline the strata lie nearly horizontal for about a mile and then assume a gradually increasing dip to the southwest, which becomes pronounced near Shaver Well, where the Tertiary rock consists of a thick, coarse conglomerate resting on an irregular surface of dark schist. It is possible that most of this dip, amounting to about 15°, is initial dip acquired when the conglomerate was laid down on a sloping mountain side, as the Tertiary beds that reappear for a short distance northeast of the exposure of crystalline rock dip slightly to the northeast at a similar angle. At the exit from the canyon on the northeast the Tertiary beds disappear beneath the recent Quaternary fill of an elevated valley near the point where the Indio fault is believed to cross this region.

The Indio Hills show practically the same structure as the Mecca Hills, except that they are narrower and have no belt of undisturbed strata on the northeast. They rise from the desert floor on the southwest with dips of 15° to 20°, which quickly become much steeper, the beds passing through one or two closely compressed folds. Along the axis of an anticline the hills are terminated by the Indio fault. This leaves the strata dipping at an angle of about 45° SW. where they are exposed along the fault scarp. This condition is practically the same as would occur if the very steep limb of the second anticline in the Mecca Hills were replaced by a fault.

Volcanic rocks of eastern Imperial County.—The volcanic basalt and tuff interbedded with the Tertiary sedimentary rocks partake of the same degree of folding. Such interbedded volcanic rocks occur around Superstition Mountain and Carrizo Mountain. In eastern Imperial County, from the Palo Verde Mountains southward and westward, there are numerous volcanic flows, chiefly basalt, whose surfaces have dips of 30° or less, probably due to folding.

**Folding in Quaternary beds.**

The Quaternary deposits seen in this region are mostly undisturbed. In the Mule and Chuckwalla mountains gravel beds that are probably of Quaternary age are inclined several degrees at some places. The uncertainty as to the exact age of different deposits makes definite statements impossible.

**Igneous structure.**

There was little opportunity to unravel the manifold complications of igneous structure in this region. Probably most of the common types occur at different places. The granitic rocks appear to have been formed as great batholithic intrusions from which most of the overlying material has now been removed. The younger volcanic rocks are chiefly eruptive flows, but volcanic plugs appear here and there. Dikes and veins are found in practically all the mountain ranges.
GEOLOGIC HISTORY.

PRE-QUATERNARY EVENTS.

Most of the decipherable history of southeastern California, except that of recent events, can be pieced together from the foregoing description of the rocks and their attitude. The information as to the long ages that elapsed before the Tertiary period is very indefinite and fragmentary. In pre-Cambrian time great land masses and oceans apparently alternated, as is indicated by the extensive beds of conglomerate, quartzite, dolomite, limestone, and gypsum. Sedimentation in the Paleozoic and Mesozoic eras seems to be indicated by the marble of Carrizo Mountain and the shale and schist of the Peninsular Mountains.

At some time not definitely known, possibly at the end of the Triassic or of the Cretaceous period, occurred great batholithic intrusions accompanied by elevation of the region now occupied by the Peninsular and San Bernardino mountains. Great erosion followed this uplift, first exposing the granite and other crystalline rocks of these deep-seated intrusions and finally wearing them down to a low, nearly level surface of which remnants are still preserved at the summits of the Peninsular Mountains. Then occurred a period of great deformation in which the rocks underlying the worn-down surface were broken and great blocks were lifted thousands of feet to form the Peninsular Mountains.

About this time the region now occupied by the Salton Basin sank below the sea and began to receive marine sediments. The dates of all the great events prior to the sedimentation in the Salton Basin are very uncertain, but the age of this sedimentation is pretty definitely fixed as late Tertiary by the fossil remains which were buried in the sediments. The land at that time was apparently 1,000 feet or more lower than at present, because beds containing marine fossils occur at altitudes at least 1,000 feet above sea level in Carrizo and Fish mountains. That the climate and topography at that date were somewhat similar to those of the present is indicated by the nature of the deposits. Strata of gypsum and celestite occurring in the beds of this series indicate conditions of aridity. Probably a high range of mountains on the west served to prevent the moisture carried by the westerly ocean winds from reaching this region, as such a range does to-day. The variation in texture of the sediments indicates great local variations in relief and numerous sources of sedimentary material. Where the sediments appear near a contact with the original bedrock, as in the Mecca Hills, they resemble greatly the material that is now being deposited in alluvial fans at the borders of the desert basins.
Coincident with the deposition of these sediments occurred great outbursts of volcanic material, which formed beds of tuff, pumice, and basalt within the sediments. The extensive accumulations of volcanic andesite and rhyolite of the southeast corner of the region are probably of somewhat similar age and were poured out on portions of the land where erosion was taking place.

Subsequent to the deposition of the late Tertiary sediments uplift accompanied by faulting and folding again occurred extensively over the region. All the Tertiary beds were broken and bent at many localities, particularly where they were soft and yielding. The coarse conglomerate of the mountain borders seems to have been more competent to resist deformation and suffered less at some places. This period of disturbance apparently in this region marks the division between Tertiary and Quaternary time.

The faulting and folding disturbed the drainage systems previously existing and caused canyon cutting in some places and created lakes or valleys in others. In some places the drainage was totally deflected and established along new lines, as in the valley east of the Indio Hills. The accompanying uplift also caused erosion of the uplifted Tertiary beds into their present badland topography, a process that has continued to the present time. Doubtless it also accelerated erosion on the surrounding mountains.

QUATERNARY EVENTS.

In general the Quaternary period has been one of erosion from the higher regions and deposition in the lowlands. Most of the deposition has taken place on land, but in the Salton Basin and other depressions a small amount occurred under water. Slight crustal movements are represented in some places by gentle tilting in the latest sediments. Some changes of level have occurred and are recorded in stream terraces and in the unequal altitude of the old beach of the ancient lake, which ranges from about 30 to 45 feet above sea level. In the main, however, conditions have been fairly uniform, with the exception of the checkered history of the Salton Sea and its progenitor—the ancient Lake Cahuilla.

In Tertiary time and probably in part of Quaternary time the Salton Basin was an extension of the Gulf of California and was occupied by ocean water. Its isolation was effected mainly by the building of the Colorado River delta across the gulf from Yuma southwestward to the Cocopa Mountains. The delta has slopes extending northwestward into the present Salton Basin and southwestward into the gulf. Innumerable sloughs, channels, and river courses, occupied and abandoned, extend down these slopes in all directions. Since 1900 the Colorado has flowed nearly on the crest of its delta, emptying into Volcano Lake, a shallow sheet of water just west of the Cocopa
Mountains and about 40 miles southwest of Yuma. From Volcano Lake the water normally goes south through Hardy River to the old channel of the Colorado near Babcock, whence it flows to the gulf, but before levees were built to protect Imperial Valley it also flowed northward at times of high water into the Salton Sea, and the anomalous condition existed of a lake on a hill with an outlet at each end in opposite directions. During summer floods many of the sloughs and abandoned water channels also received some overflow, and water has occupied the Salton Basin half a dozen or more times since 1850.

The lowest point of the divide between Salton Basin and the gulf at Volcano Lake is approximately 30 feet above sea level and only a little above the maximum reach of exceptional tides. The bottom of the Salton Basin before its last filling was supposed to be 273.5 feet below sea level. Just how the basin became separated from the gulf is not certainly known, although it is generally supposed that the delta was merely built above the water level, isolating a body of salt water in the basin. This is Blake's original and unmodified explanation.

By whatever process the basin was isolated it later became filled with fresh water, as is indicated by the fresh-water shells that are scattered in myriads along the old beach of the ancient Lake Cahuilla. The only possible source of sufficient fresh water to fill so large a lake is Colorado River. This stream may either have flowed into the basin after its isolation, displacing the salt water gradually by overflow from the inland lake to the sea, or the original sea water may have evaporated and a later filling by Colorado River covered its salt crusts with mud and established a lake of fresh water above it.

The date of filling of Lake Cahuilla has not been exactly determined, but all observers agree that it has been very recent, in a geologic sense. It is even a matter thought by some to be within the traditions of Indians who inhabit the desert. Some recent work by MacDougal indicates that perhaps the basin has been occupied by fluctuating lakes for a long period and may have undergone desiccation and refilling several times. This assumption is based on the facts that the travertine coating on solid rocks along the old shore line is deposited in successive layers and that Indian carvings on these coatings of travertine are found buried at varying depths. MacDougal is of the opinion that the date of the last filling, corresponding to the old beach line, is not more than 300 or 400 years ago.

The originally accepted figure of 287 feet appears to have been an error. See Clapp, W. B., U. S. Geol. Survey Water-Supply Paper 213, p. 30, 1907.


At any rate the basin has been comparatively dry for nearly all the period of American history since the Spanish discoveries, and the Salton Sea, created in 1904–1907, is merely a replica on a smaller scale of former water bodies that have occupied the basin and left various evidences of their existence. The history of Salton Sea and its connection with Imperial Valley is summarized on pages 9–12, and the relation of the old shore line to the terraces of Colorado River is discussed on pages 32–33.

Mineral Resources.

Production.

There are in this region metallic and nonmetallic mineral deposits of wide variety. Gold has been much sought in all parts of California since 1849, and the southeastern desert has long been prospected, particularly since the completion of the Southern Pacific Railroad in 1879. Information as to mines, minerals, and output of individual localities is best given in the reports of the California State Mining Bureau and the State mineralogist, from which the following data are largely taken:

Riverside County.—A strip about 40 miles wide along the north side of the region here mapped lies in Riverside County. This county extends a few miles farther north and also a considerable distance west, taking in parts of the western slopes of the San Jacinto and San Bernardino mountains. Some interesting statistics as to its mineral production are summarized in the following table, which includes the products that are found principally in the desert areas:

<table>
<thead>
<tr>
<th>Mineral</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gold</td>
<td>$1,640,700</td>
</tr>
<tr>
<td>Salt</td>
<td>122,476</td>
</tr>
<tr>
<td>Silver</td>
<td>37,580</td>
</tr>
<tr>
<td>Copper</td>
<td>16,128</td>
</tr>
<tr>
<td>Lead</td>
<td>1,719</td>
</tr>
<tr>
<td>Bismuth</td>
<td>$2,400</td>
</tr>
<tr>
<td>Gypsum</td>
<td>30,219</td>
</tr>
<tr>
<td>Gems</td>
<td>7,350</td>
</tr>
<tr>
<td>Asbestos</td>
<td>7,000</td>
</tr>
</tbody>
</table>

Probably half the gold thus recorded came from the western part of Riverside County, outside the desert area, but one mine in the desert, the Lost Horse, is credited with a production of $350,000 prior to 1900. The salt was produced entirely from the deposits in the Salton Basin before the filling of Salton Sea. Practically all the copper and gypsum came from the desert mountain ranges. Gems and asbestos came from the San Jacinto and Santa Rosa mountains, near the western border of the region shown on the map. Since 1915 a few thousand tons of manganese ore has been produced in the mountains of eastern Riverside County. The western part of the county has resources of brick and cement materials and stone whose output considerably exceeds the value of the metallic products.
Imperial County.—Imperial County was formed from a part of San Diego County in 1907, and before that time its mineral output was credited to San Diego County. The production for 1917 is given by the California State Mining Bureau as follows:

Value of mineral products of Imperial County, 1917.

<table>
<thead>
<tr>
<th>Product</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brick and tile</td>
<td>$19,260</td>
</tr>
<tr>
<td>Gold</td>
<td>919</td>
</tr>
<tr>
<td>Manganese</td>
<td>38,140</td>
</tr>
<tr>
<td>Silver</td>
<td>5</td>
</tr>
<tr>
<td>Stone and miscellaneous</td>
<td>$65,660</td>
</tr>
<tr>
<td>Other minerals (copper, potash, and pumice)</td>
<td>5,416</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>129,400</strong></td>
</tr>
</tbody>
</table>

The total for 1914 was $239,140; 1915, $77,433; 1916, $105,333. The production of gold in 1917 was unusually low. At times there have been important gold mines in this county, some of which have produced several million dollars. The production of manganese was unusually large in 1917, being stimulated by the war needs.

San Diego County.—The desert area of San Diego County included in this report has some mineral wealth, which, however, has been very little developed because of lack of water and transportation. The gold mines of Julian are the most valuable mines near the desert and are estimated to have produced a total of $2,500,000. They were almost entirely idle in 1918.

Undeveloped Resources.

Gold.—Gold is widely scattered over the desert and has probably been mined in every mountain range. It occurs as placer gold and in veins in granitic rocks and mineralized zones in schist. The placers have usually been either of too low grade or too far from water to work profitably, although rich finds are occasionally made. None of the districts where veins occur have supported large mines for a long time. Julian and the Hedges or Tumco camp have each produced some millions of dollars' worth of gold. Important mines have existed at different times near Picacho, in the Chuckwalla Mountains, in the Eagle Mountains, and near Pinyon Well.

Copper.—Copper occurs mainly in mineralized zones in schist and crystalline rocks, notable in the McCoy, Palen, and Maria mountains. It is also known in the Chuckwalla and Chocolate ranges and probably exists at other places. The copper carbonates are in many places associated with iron, gold, and other minerals. None of the deposits have been extensively developed.

Silver and lead.—Veins of argentiferous galena occur in the Chocolate and Maria mountains. The Paymaster mine, in Imperial County, is said to have produced a considerable amount of silver-lead ore.

Manganese.—Manganese is widely distributed over southeastern California but has only recently been carefully prospected. It occurs

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in veins in crystalline rocks, in lava, and in limestone and has been produced in the Chocolate, McCoy, and Maria mountains. It is also reported from the Palen Mountains.

Iron.—A very large body of iron ore occurs in the north end of the Eagle Mountains. It is owned mainly by the Southern Pacific Co. and has never been developed. The ore has been formed by the replacement of dolomite in a metamorphic quartzite-dolomite series of rocks. 65

Gems.—Tourmaline is found in great quantity in the granitic rocks of the Peninsular Mountains. Most of it is black and worthless, but many tourmalines of gem quality have been found in Riverside and San Diego counties. Associated with the tourmaline are beryl, kunzite, and garnet, in some places of gem quality.

Salt.—Salt has been produced commercially only from the dry bed of Salton Sea, where the New Liverpool Salt Co. once did a prosperous business plowing the saline crust from the old sea bed and, after removing slight impurities, loading it onto a spur railway that ran to Salton, on the Southern Pacific line. The filling of Salton Sea has destroyed this industry.

Gypsum.—Some very large gypsum deposits occur in this region. The Palen and Maria mountains contain thick beds of gypsum associated with metamorphic limestone and quartzite, probably of Paleozoic age. The deposits in the Maria Mountains have been developed considerably by the United States Gypsum Co., which in 1916 produced 4,220 tons, worth $8,340, but operations were suspended in 1917. The deposit is near the California Southern Railway and will doubtless again become an important producer. In Imperial County there is a great deposit of gypsum on the north side of Fish Mountain, and another on the south side of Carrizo Mountain. The gypsum of Fish Mountain is believed to be interbedded with Tertiary strata.

Strontium.—Near the Fish Mountain gypsum deposit, on the line between Imperial and San Diego counties, is a considerable body of celestite, or strontium sulphate, which is described by E. S. Larsen 66 as capping a low hill at the north side of Fish Mountain. It might become valuable if transportation facilities were provided. The celestite occurs in tilted sedimentary beds that are probably of Tertiary age.

Clay and stone.—The value of stone and clay products in both Riverside and Imperial counties usually exceeds that of metals. The Riverside County production, however, is nearly all confined to the west slope of the peninsular divide. Limestone of good quality for the manufacture of cement and marble suitable for building stone

66 Personal communication.
are fairly abundant. Carrizo Mountain, in Imperial County, is composed largely of marble that will doubtless become important whenever transportation is provided. Granite and other building stones are common and are produced in the western part of the region. Gravel is fairly plentiful at most places, and clay is found in the Mud Hills and around Salton Sea.

Pumice.—Pumice is found at several places, especially interbedded with Tertiary sediments around Carrizo Creek and Superstition Mountain and east of Salton Sea. It may become important if transportation and a market are provided.

Petroleum.—Numerous borings for petroleum have been made in the region, especially southwest of Salton Sea, where the Tertiary beds with their numerous large fossil shells crop out. Traces of oil and rumored gas explosions are apparently the only results thus far obtained. The Miocene or Pliocene rocks that occur beneath the Salton Basin and crop out on Carrizo Creek are not generally regarded by geologists as favorable for oil, but no positive evidence to this effect is offered.

Other minerals.—Deposits of other minerals have been noted at several places, but their economic possibilities are not known. Sulphur occurs around the mud volcanoes near Salton Sea. Borax is reported at many places. Graphite occurs in Carrizo Mountain and was seen by the writer at the east face of the San Jacinto Mountains. Tungsten minerals are associated with the gold and copper ores at places, and a valuable saving of vanadium, from the mineral vanadinite, was made at the Eldorado mine in 1918.

HYDROLOGY.

IMPORTANCE OF WATER SUPPLY.

The lack of adequate water supply for the needs of plants, animals, and man is the condition that makes most of southeastern California a desert and that has caused it to be feared and shunned for many centuries by human beings. Only where water is obtainable is any development of agricultural or mineral resources possible, and in whatever proportion the water supply is inadequate development is hindered. In this section only the main features of the water supply are presented, some of the local details being reserved for the route descriptions or the descriptions of individual watering places (pp. 131–279).

SOURCES OF WATER.

PRECIPITATION.

The first source of water supply to be considered in any region is its rainfall. As brought out by the records given in the section on climate (pp. 12–16), the rainfall in the Salton Sea region varies widely
from place to place, showing differences approximately as great as the topographic differences and rather closely corresponding to the differences in relief. In general the moisture-bearing winds of the coast, sweeping inland, are chilled and forced to drop most of their water as rain or snow on the high summits of the Peninsular Mountains, more on the western than on the eastern slopes. Any moisture left over may fall in sporadic and uncertain rainstorms on the desert to the east. The controlling factor, however, is relief, and few points east of the divide are sufficiently high to affect greatly the general amount of precipitation in the desert.

The greatest precipitation in the region falls on the Peninsular Mountains. The part of these mountains described in this paper and shown on the maps (Pls. II and III) comprises perhaps 1,800 square miles, or one-sixth of the total area. But of this high mountain district at least a third drains westward to the Pacific. On the other hand, considerable water enters the northwest corner of the Salton Sea region from territory in San Gorgonio Pass and the high San Bernardino Mountains, which lie outside of the region as here defined. Records for Beaumont, Warner, Julian, and Campo indicate a yearly precipitation in excess of 20 inches for portions of this territory that are 3,000 feet or more in altitude. The precipitation gradually diminishes down the slopes toward the east. Thus, Cabezon (altitude 1,779 feet) has an average annual precipitation of only a little over 11 inches, and Palm Springs (584 feet) has less than 5 inches. The change as indicated by vegetation is gradual. Probably less than 1,000 square miles of land in this region or in adjacent tributary drainage basins receives more than 20 inches of precipitation a year, although a very small percentage of this area receives much more, perhaps as much as 50 inches in some years.

The remaining territory, about five-sixths of the total comprising the desert ranges and basins and the Salton Basin, has a very meager rainfall. The records indicate an annual average of less than 5 inches, in most places less than 3 inches. However, all the observations available were made at points of very low altitude. Undoubtedly more rain falls on the mountain ranges, particularly the Little San Bernardino, Cottonwood, and Eagle mountains, as is well proved by the vegetation there. The rainfall on these areas, however, probably would not raise the average to more than 5 inches.

The total average annual precipitation on the whole region is estimated to be 3,000,000 to 4,000,000 acre-feet.

COLORADO RIVER.

Colorado and Gila rivers combined, at Yuma, had an average annual discharge from 1902 to 1916 of 16,730,000 acre-feet, as shown by records of the United States Reclamation Service. The Gila
contributes a very uncertain amount, not more than 1,000,000 or 2,000,000 acre-feet. The Colorado carries several times as much water as the entire amount that falls as rain or snow on the Salton Sea region.

Colorado River, bordering the region on the east, is therefore its most important single source of water supply, either directly or indirectly. Its water is diverted for the irrigation of Palo Verde Valley, Yuma Valley, and Imperial Valley and is pumped locally for various uses along the river. The river supplies seepage to broad areas along its course, maintaining bodies of ground water that are extensively pumped, particularly in Palo Verde and Yuma valleys, where this ground water is the chief source of domestic water supply and a contributor to the supply of irrigation water. The flowing wells of the Holtville area of artesian flow, in Imperial Valley, are doubtless directly dependent on the influent river water for their supply. To the Colorado is also due the maintenance of the Salton Sea.

OCEAN WATER.

Before the geography of this region was well understood the occasional inflow of water into the Salton Basin was thought by certain observers to have some mysterious surface or subterranean connection with the ocean, particularly because the water dissolved great quantities of mineral matter from the salt beds of the basin and was very brackish. This idea has been disproved by a better knowledge of the country. Indeed, it does not seem probable that ocean water is being contributed even in slight degree to the ground water of the basin, although seepage from the ocean is a possibility suggested by the fact that much of the Salton Basin is below sea level and the Gulf of California is only 100 miles from the present Salton Sea. The analyses of ground water from wells in the Salton Basin, particularly the Holtville area, show no close resemblance to sea water.

OCCURRENCE AND QUALITY OF WATER.

SURFACE WATER.

STREAMS.

Permanent surface streams other than Colorado River are found in this region only in the Peninsular Mountains, on the west, where they are fed by the more abundant precipitation and the inflow is equalized by a forest covering on the mountain slopes. Most of the permanent streams flowing into the desert originate on the high slopes of the San Jacinto or San Gorgonio mountains. They include White-
water River, Snow Creek, the creeks of Tahquitz and Andreas canyons (see Pl. XIII), and a few others. Several, such as San Gorgonio River and Mission and Morongo creeks, originate outside the region mapped but contribute water to it. The southwest corner of the region shown on the map (Pl. II) does not drain into the Salton Basin. It contains several permanent streams, such as Potrero Creek, Cottonwood Creek, Pine Valley Creek, and Sweetwater River, which flow westward and discharge into the Pacific Ocean.

Numerous streams emerging from the mountains are intermittent. They flow for a considerable time after rains or during the rainy season but are dry for portions of the year. Such are many of the streams that occupy canyons in the Santa Rosa and other mountain ranges.

Many streams of the region are interrupted—that is, they flow perennially in certain portions of their courses and have only a subsurface flow in gravel or sand in other portions. Some of the mountain streams are interrupted from their headwater portions to the points where they discharge into the Salton Sea, notably San Felipe Creek, with its principal tributary, Carrizo Creek. Nearly every permanent or intermittent stream becomes interrupted in its lower portion as it nears the desert, because of gradual changes in the character of its bed and the increasing amount of porous gravel along its course. Without exception all the streams either sink completely into the desert soil or flow only in certain stretches before reaching their ultimate destination in the Salton Basin or other desert basins. Practically all of them disappear completely somewhere near their exit from the mountains.

In addition to the recognized streams there are innumerable dry washes and canyons in the desert surface and throughout the desert ranges. They are the results of stream erosion at times of flood and serve to spread out the water of the infrequent rains until it evaporates or sinks away.

The flow of the permanent streams is subject to great variations, which are directly dependent on variations in daily rainfall. Probably most of the run-off is contributed as flood water, which pours out of the mountains, carrying the great quantities of gravel and boulders that are seen about the mouths of canyons. Such floods have resulted in considerable damage or even ruin to good land or crops in cultivated areas, particularly in Coachella Valley. Extensive plans for combating this menace have been developed in recent years. They include the dispersion of flood waters over wide areas at the canyon mouths by means of rude jetties and earthworks and the building of protective levees. This serves the double purpose of

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protecting from floods and of causing the water to sink into the earth to be added to the ground-water supplies available for irrigation. None of the mountain streams are very large at normal times. Unfortunately few records of stream flow in this region are available, and there are no gaging stations in the region. United States Geological Survey measurements made in February, 1898, gave stream flows at various places in Whitewater River ranging up to about 18 second-feet. In the same month the flow of Snow Creek was 4½ second-feet. It is, however, not known what stages of the streams these records represent. San Felipe Creek has a flow of a few second-feet in the lower part of the San Felipe ranch, and Carrizo Creek at certain places has probably as much.

In general the best waters of the region are those of the mountain streams, which are satisfactory for irrigation, for domestic use, for use in locomotives, and for other purposes. No analyses of surface water from this region are available. Analyses of some surface stream waters from the Pacific slope not far away are given by Van Winkle and Eaton. These include careful studies of Santa Ana and San Luis Rey rivers and of Santa Ysabel and Cottonwood creeks, streams that closely resemble those of the eastern slope of the Peninsular Mountains. The total solids dissolved in these surface waters range from 200 to 400 parts per million, and the water corresponds closely in character to that observed in springs from granitic rocks of the desert, notably Jacumba Springs, Cottonwood Spring, and Corn Springs.

Colorado River water is widely used for irrigation and domestic purposes with satisfaction. For domestic use some purification, especially the removal of suspended matter, is necessary. The Southern Pacific Co. also uses this water in boilers but regards it as only fair. The results of a lengthy investigation of the character of river water at Yuma are given by Stabler. Continuous studies throughout the year 1905 are embodied in a table of monthly mean analyses. In Figure 5 this table has been combined with the record of stream flow for that year to show the relation between the mineral content and the volume of water carried by the Colorado. The graph illustrates strikingly how the mineral content decreases as the volume increases. The water ranges between about 1,000 and 350 parts per million of dissolved mineral matter. The monthly means give a yearly average mineral content of 707 parts. However, the true average is somewhat less if the varying volume in different months is taken into account.

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Computations from Stabler's figures based on both monthly content and discharge give about 585 parts for the average mineral content of the water. There is also a periodic variation of the percentage constituents of the mineral matter, the chlorine decreasing in ratio as the volume of water increases and the calcium and magnesium increasing. The Colorado at all times, but especially in flood seasons, carries an enormous amount of mechanical sediment. It is dirty and chocolate-colored throughout that part of its course bordering California.

Near the summit of the high western mountains there are a few small lakes, such as Hidden Lake, in the San Jacinto Mountains, and The Laguna, in the Laguna Mountains. (See Pl. II.) They are all outside the range of desert observations, and none of them were visited.

As sketched in the section on geologic history (pp. 57-60) the Salton Basin has in past times contained a much greater body of water than at present. The present Salton Sea was created by overflow water of the Colorado in 1904-1907 (pp. 11-12). Since the inflow has been largely stopped the lake is gradually shrinking by evaporation, which goes on at the rate of 5 or 6 feet a year. Inasmuch, however, as some water from the Imperial irrigation system is allowed to waste into this sea, there will probably come a time when the evaporation will no longer exceed inflow, and the sea will maintain an approximately
OCCURRENCE AND QUALITY OF WATER.

constant size if not interfered with. At its maximum, after the catastrophe of 1904-1907, it had an area of about 475 square miles. Its area in 1919 had shrunk to less than 300 square miles, and its greatest depth was about 30 feet. MacDougal estimates that it will maintain a permanent area of more than 200 square miles under present conditions of inflow and evaporation. The same author states that in 1907, when the sea was at its maximum size, the mineral content was about one-fourth to one-third of 1 per cent, or 2,500 to 3,500 parts per million, and the water was barely potable, although some persons used it without ill effect. The water has since undergone great concentration and is now entirely unfit for human use. Analyses given by MacDougal show a mineral content of over 16,000 parts per million in 1916. The Salton Sea is of practically no importance as a source of water supply. (See analysis No. 44, p. 283.)

The low interior parts of inclosed basins receive water during rains. This muddy storm water spreads out in very thin sheets, which generally do not last more than a few days. The water quickly evaporates, leaving alkali-coated and mud-cracked flats, known as playas, or "dry lakes." These ephemeral lakes are of no value as sources of water.

GROUND WATER.

GENERAL CONDITIONS.

Bodies of ground water of economic importance are found most commonly in the valleys or basins between the mountain ranges, such as the Salton Basin, Chuckwalla Valley, and Borego Valley. The processes of accumulation and dissipation of ground water in all such basins are very much alike, and an understanding of them is essential in forming an estimate of the value of a ground-water supply and in planning its utilization to best advantage.

A typical inclosed desert basin consists of three topographic zones arranged more or less concentrically. The outer zone is the rim of the basin. It consists chiefly of mountain ranges. As a rule, however, the mountains are not continuous but are interrupted by tracts of rock waste washed out from the mountains but standing high enough to form divides that separate the basin from adjoining basins. Under these alluvial divides the bedrock is usually, but not necessarily, buried to a less depth than in the low interior of the basin. The intermediate zone is that formed by the alluvial slopes. It borders the mountains, has a more or less even surface that slopes

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*Private companies kept records of the depth of water in Salton Sea for several years after it first began to fill, and since 1914 the U.S. Geological Survey has made readings on a staff gage 1 mile west of Durmid, at the mouth of Salt Creek. The depth of water in the sea in September, 1915, was 38.3 feet. (See U.S. Geol. Survey Water-Supply Paper 410, p. 122, 1915. See also MacDougal, D. T., A decade of the Salton Sea: Geog. Rev., vol. 3, p. 473, June, 1917.) According to the chief engineer's office, Imperial Irrigation District, the surface of the sea in 1922 fluctuated between -248 and -250 feet.*
away from the mountain base, and consists of coarse sand, gravel, and conglomerate, or ill-assorted mixtures of gravel, sand, and clay—the débris deposited at the foot of the mountains by floods. The inner zone occupies the lowest part of the basin. It is generally a nearly level plain with surface slightly concave upward, and in many basins the depression at the center is occupied by a playa, or "dry lake." The transition between the alluvial slopes and the playa is gradual, and in large basins the alluvial slopes usually include a belt several miles wide of excellent land suitable for irrigation.

The water that falls on such a desert basin passes through a definite cycle of events. The sectional diagram (Fig. 6), drawn through an ideal desert basin, will aid in an explanation of this process. On either side of the valley are rocky mountain slopes, at their bases steep alluvial slopes of porous gravel, and in the center a valley underlain chiefly by fine sand or silt. Beneath the valley, at varying depths, is bedrock generally like that of the surrounding mountains, and on this is built the valley fill of alternating beds and stringers of conglomerate, sand, and clay. As a rule this fill becomes finer in texture toward the surface, and from the mountain borders toward the interior. Some of the water that falls in the drainage basin is absorbed and percolates down to the water table, below which the porous deposits are saturated with ground water. Relatively little water is absorbed in the mountains, as the rocks are dense and impervious and their steep surfaces encourage a speedy run-off. Most of
the storm water is therefore poured out of the mountains over the alluvial slopes, where it is largely absorbed by the coarse-textured, porous material that underlies these slopes. Very little of the water that reaches the lower parts of the valley penetrates far enough into the underlying fine sand, silt, and clay to reach the water table. It either evaporates or is taken up by plants, which often spring up abundantly after heavy rains. Any water that is not previously absorbed or evaporated collects in the playa and ultimately evaporates, leaving behind the clay and silt which it held in suspension and the salts which it held in solution. Its rapid evaporation leaves the surface of the playa parched and sun cracked and produces the characteristic appearance of these "mud flats" or "dry lakes."

The mountains are therefore the chief areas contributing to the supply of ground water (Fig. 6), and the alluvial slopes form the main intake areas. The rocks that underlie the valley fill are in general nearly impervious and do not allow the water to escape readily. Hence there is likely to be an area of discharge at the surface somewhere in the basin. This is usually found at the lowest part of the valley and generally corresponds somewhat closely in outline with the playa and a fringe of lowland bordering the playa. The water table, or surface of the ground-water body, generally slopes very gently toward the low interior parts of a basin but is generally nearest the land surface in these low parts, where the water may be given off either by transpiration through plants, which often grow luxuriantly in such places, or by evaporation directly into the air. The size of this area of ground-water discharge depends largely on the supply of water that is added to the underground reservoir. If there is no loss of water by leakage below the surface into adjacent areas the amount of ground water returned to the surface in the low parts of the basin must equal the amount of intake from rainfall within the basin, and this quantity constitutes the maximum supply available for pumping. In many of the desert basins all the ground water is disposed of by leakage into adjacent areas. In a basin of this type there is no shallow-water area from which ground water is discharged by evaporation or transpiration.

In a basin that receives a large supply of water there is usually a large area of discharge, and very commonly in this area the surface layers of the valley fill are relatively impervious beds of clay, which confine the ground water under considerable pressure (Fig. 6). Wells that are sunk a short distance into these clay beds may contain little or no water because the material is so impervious (f, Fig. 6), but wells sunk deeply enough to penetrate a layer of porous sand may overflow freely at the surface (c, Fig. 6). The southeast end of Coachella Valley is the best example in this region of an area of flowing wells.
Farther back from the area of discharge toward the mountain borders the depth to water increases, and flowing wells are not obtainable. The depth to water depends both on the slope of the water table and on the slope of the land surface. Both the water table and the land generally rise toward the borders of the basin, but the land rises much more steeply, for in pervious material the water settles down to a nearly level surface like that of a lake or pond. Consequently the depth to water increases steadily from the playa toward the base of the mountains. Thus at point $d$, Figure 6, a good pump well may be obtained at moderate depth, say 50 feet, but at $c$ it may be several hundred feet to water. Finally a point is reached where the bedrock surface is higher than the water table. This is usually somewhere up on the alluvial fans near the mountains, where wells may penetrate bedrock without reaching water at all ($b$). However, at the very edge of the mountains, where the alluvium is only a few feet thick, it is in many basins possible to obtain water by digging down to bedrock in some canyon bottom. Wells at such locations ($a$) receive a small supply of the underflow percolating over the bedrock surface toward the main body of ground water in the basin.

The quality of the water in desert basins is influenced greatly by the nature and amount of soluble material in the rocks penetrated by the water and by the quantity of water circulating. The water falling on the mountains always absorbs at least a small amount of mineral matter from the rocks. If the rocks include limestone, gypsum, or beds of salt the amount of mineral matter dissolved may be large. Such conditions exist in the Palen Mountains, Maria Mountains, and elsewhere in this region. More commonly, however, soluble compounds are derived from the porous material that fills the basins, particularly the Tertiary beds, which in many places contain thick layers of gypsum and other salts as well as much finely distributed saline material. Much of the Quaternary valley fill corresponding to the material shown in Figure 6 contains beds of salt left by evaporating water in the playa at the center of the basin. In general the water at the sides of the basin is purest, and that at the center the least pure, because it has circulated farthest. Usually also there is a coating of alkali left at the surface in areas of ground-water discharge, and this impregnates strongly the water obtained from wells that get their supply near the surface in that part of the basin. The more water is fed into the basin the more rapidly it circulates and the less opportunity it has to become mineralized. A good comparison can be drawn between Coachella Valley and Chuckwalla Valley, which are of approximately the same size. Coachella Valley receives a large supply of water from the high mountains and yields well water of extraordinary purity. Chuckwalla Valley has a very meager supply, and its water is highly saline.

97In many of the basins the deeper beds are very likely Tertiary.
SALTON BASIN.

The Salton Basin is the largest single reservoir of ground water in this region. Including its several arms known as Coachella Valley, San Felipe Valley, Carrizo Valley, and Imperial Valley, it receives the drainage from more than 50 per cent of the total area here described (see table, p. 41), as well as some drainage from outside areas and some seepage from Colorado River. Water is obtainable from wells in most parts of the Salton Basin, but dry holes are reported in a few places. The quality of the water is so poor at many places that it is unfit for use.

Coachella Valley.

Coachella Valley is that part of the Salton Basin which extends from San Gorgonio Pass southeastward approximately to the present north end of Salton Sea. The name is usually restricted to the area northwest of Fish Spring or Salton station.

The valley receives the drainage from the eastern part of the San Jacinto Mountains and the southeastern slope of San Gorgonio Mountain, as well as that from smaller areas in the Santa Rosa and Little San Bernardino mountains. The largest perennial streams in the region are those of San Gorgonio and San Jacinto mountains, particularly Whitewater River, Snow Creek, Tahquitz Creek, and the streams in Andreas Canyon (see Pl. XIII) and Palm Canyon. The water discharged by these streams sinks into the gravel of the alluvial fans at the base of the mountains and percolates southeastward toward Salton Sea. The soil of the valley as far southeast as Indio is chiefly porous sand or gravel, and this part of the valley constitutes the intake area. The area of discharge begins near Indio and extends in a constantly widening belt to Salton Sea. The water in this area is confined under artesian pressure by the fine-grained silt and clay beds that underlie this part of the valley. The evidence of discharge is found in the rank growth of salt bush, mesquite, salt grass, and other plants that feed upon ground water. At many places in the southern part of this belt the artesian pressure causes springs that discharge water on the nearly level valley floor. Figtree John Spring and Fish Springs are the best examples. In this southern part of the valley the high pressure causes considerable water to escape by percolation through the confining clay beds, and its evaporation leaves heavy incrustations of alkali at the surface.

Persons who consider the matter hastily are likely to suggest some distant or mysterious source for the water that is found in Coachella Valley, because the supply within its own drainage basin seems to them inadequate to account for the large amount used. Colorado River is the source usually suggested. As pointed out by Mendenhall,\(^\text{14}\) how-

ever, such a source is contrary to all probability and to the observed facts. Colorado River is 100 miles away, and the intervening region contains large masses of impervious rocks through which it is unlikely that the river water could penetrate. Moreover, the ground water of Coachella Valley contains very little dissolved mineral matter (see analyses, p. 282), some of it having less than 200 parts per million of total solids, whereas Colorado River water contains 500 to 1,000 parts per million. (See Fig. 5.) Furthermore, a zone of warm and very highly mineralized water is found all about Salton Sea, between Coachella Valley and Colorado River. Mendenhall also noted that in the winter of 1904–5, a season of unusually heavy rainfall in Coachella Valley, the water table rose notably and flowing wells increased in yield, indicating the direct dependence of the ground water on rainfall.

The development and utilization of ground water in Coachella Valley are described more adequately by Mendenhall than it is possible to do in this paper, and the following paragraphs are quoted from him:

After the completion of the successful deep well at Walters [now called Mecca] in 1894, proving finally the presence of abundant artesian waters beneath this part of the desert, interest in the possibility of its reclamation was greatly stimulated, but the great cost of drilling wells by the ordinary method prevented further extensive development until 1900. In April of that year the first successful hydraulic well was put down at Indio. It reached a depth of 500 feet in 17 hours, and the cost was comparatively nominal. From the date of its completion until the present development has been continuous, and now [1909] from 350 to 400 deep wells are scattered about over those parts of the desert which are accessible from the stations between Indio and Salton Sea. Of this number from 250 to 300 are artesian. About 90 pumping plants have been installed, two or three wells frequently being coupled together and pumped from one station.

It is estimated that more than $100,000 is invested in the artesian wells that have been bored in the valley, and that the pumping plants with the wells on which they are installed represent an additional expenditure of $75,000. If the cost of reservoirs and of such pipe lines as have been put in are added, it will easily bring the total investment in works for the development and distribution of water to $200,000.

By the use of the waters which have been developed in this way 4,000 or 5,000 acres of land have been reclaimed and are successfully irrigated. The area in which flowing waters may be procured—it has been roughly outlined by the developments to date—covers approximately 140 square miles. This area extends from a point a short distance above Indio to a point below the present border of the Salton Sea. The greater part of it lies on the south side of the Southern Pacific Railway, but there is a strip from 1 to 2 miles wide on the north side of the line.

Much the stronger artesian flows are obtained at the lower elevations near the southern end of the belt. Wells at the upper or northwestern extremity of the valley give inferior yields, so that it has been found necessary to pump from many of them in order to obtain sufficient water for successful irrigation. This condition is due in part to the originally inferior yield of these higher wells and in part to a decrease in their flow which has followed the increased development. All of the flowing wells lie below the sea-level contour. A few of the northernmost are very near sea level, but the most of them are from 20 to 150 feet below.

The amount of land irrigated has increased since 1905, although the Department of Agriculture estimated its area in 1913 as about 4,000 acres. The area in which flowing wells are obtained is probably shrinking somewhat, though good flows are still obtained from Coachella southward. The present tendency in drilling is to make larger and deeper wells, which as a rule yield greater flows than smaller wells. Several flowing wells yielding from 25 to 100 miner's inches (0.5 to 2.5 second-feet) are reported to have been drilled in the territory south and west of Mecca. A 6-inch well 1,430 feet deep belonging to Charles Brown, 1½ miles southwest of Mecca, had a measured flow in October, 1917, of 23 miner's inches (more than 0.5 second-foot). A well recently drilled by the Southern Pacific Co. at Mecca, which is 14 inches in diameter at the surface and is 1,500 feet deep, has a larger flow than the Brown well and delivers water directly into tank cars that supply many railroad stations to the southeast where good water is not obtainable. Some wells yielding 100 miner's inches (2.5 second-feet) were reported to exist at ranches about 5 miles southwest of Mecca, but these reports were not verified.

Southeast of Mecca, in the vicinity of Mortmar, a considerable number of flowing wells have been drilled recently, but in that area the water is poor in quality, and a little farther southeast it is entirely unfit for irrigation.

West and northwest of Indio, in the upper part of the valley, where flowing wells are not obtainable, the irrigated area is being extended by pumping. At Indian Wells the water table stands about 50 feet above sea level and 40 or 50 feet below the surface. Farther west and north the depth to water increases gradually, but there is a considerable area where water is obtainable at depths less than 100 feet. The development in this area is still largely in the experimental stage.

Some of the most promising undeveloped land in Coachella Valley lies in the northern tip of the valley, north and east of Palm Springs Station. This part of the valley is separated from the rest by the Indio Hills, which run nearly east from Palm Springs Station for several miles and then bend southeast along the northeast side of Coachella Valley. These hills were presumably elevated along the Indio fault (see p. 50), thus isolating this portion of the valley and creating a barrier to the southward flow of ground water. As a result the water rises and there is ground-water discharge over an area of several square miles. At Seven Palms, in sec. 18, T. 3 S., R. 5 E., is a spring where water rises from artesian pressure, and several other artesian springs are reported in the region farther southeast. At Willow Holes a perennial stream flows for some distance in a wash that leads southward through the hills. Over all the area of ground-
water discharge there is a heavy growth of mesquite, salt grass, and other plants indicative of ground water at shallow depth. Only one flowing well was found in this part of the valley. It is owned by a cattleman named Talmadge, whose stock ranges the surrounding country. The well is in sec. 17, about half a mile northeast of Seven Palms. It is 12 inches in diameter and is reported to be 320 feet deep. In December, 1917, it yielded a flow of about 15 gallons a minute. The water is rather high in mineral content (see analysis No. 48, p. 283) but is probably of satisfactory quality for irrigation and was being used successfully on a little plot of alfalfa. A few ranches farther west, near Palm Springs Station, have wells that are reported to reach water at depths of 40 to 80 feet. However, there has been practically no attempt to develop water for irrigation in the localities where it is nearest the surface. The soil is a sandy silt in the southern part of the area and is rough and stony farther north. As the water is probably of good quality for irrigation and as the railroad facilities are good, it is likely that this small body of land will be developed before long.

The accompanying table gives the records of several wells in various parts of Coachella Valley.

### Detailed logs of wells in Coachella Valley.

#### R. W. Blair, Indian Wells.

<table>
<thead>
<tr>
<th>Thickness</th>
<th>Depth</th>
<th>Thickness</th>
<th>Depth</th>
</tr>
</thead>
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<td>Sand</td>
<td>64</td>
<td>Feet</td>
<td>72</td>
</tr>
<tr>
<td>Gravel</td>
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</table>

#### J. C. O'Neal, Indian Wells.

<table>
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<tr>
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<th>Thickness</th>
<th>Depth</th>
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</thead>
<tbody>
<tr>
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<td>68</td>
<td>Clay</td>
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<td>100</td>
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<td>Clay</td>
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#### Southern Pacific Railroad, Mortmar.

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<th>Depth</th>
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<tr>
<td>Soil</td>
<td>2</td>
<td>2</td>
<td>Red clay</td>
<td>92</td>
<td>412</td>
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<tr>
<td>Clay</td>
<td>26</td>
<td>35</td>
<td>Sand; water</td>
<td>27</td>
<td>430</td>
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<td>35</td>
<td>Red clay</td>
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<td>460</td>
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<tr>
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<td>Sand; water</td>
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<td>681</td>
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<td>35</td>
<td>Fine gravel</td>
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<td>684</td>
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<tr>
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<td>35</td>
<td>Fine sand; water</td>
<td>9</td>
<td>693</td>
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<tr>
<td>Fine sand</td>
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<td>35</td>
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<td>708</td>
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<tr>
<td>Pale-blue clay</td>
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#### Southern Pacific Railroad, Indio.

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<td>60</td>
<td>Water-bearing gravel</td>
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<td>120</td>
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<td>750</td>
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<td>Cement clay</td>
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OCCURRENCE AND QUALITY OF WATER.

**Detailed logs of wells in Coachella Valley—Continued.**

### Southern Pacific Railroad, Indio.

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<td>Clay and sand</td>
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<td>57</td>
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<td>Clay</td>
<td>147</td>
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<td>Sand</td>
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<tr>
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<td>Clay</td>
<td>24</td>
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<tr>
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### Southern Pacific Railroad, Mecca.

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<td>16</td>
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<td>Quicksand</td>
<td>7</td>
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<td>Quicksand</td>
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<td>122</td>
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<tr>
<td>Clay</td>
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<td>124</td>
<td>Fine sand and gravel</td>
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<td>Clay</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sand</td>
<td>12</td>
<td>136</td>
<td>thin seams of clay</td>
<td></td>
<td></td>
<td>8</td>
<td>Clay</td>
<td>156</td>
<td></td>
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### Data on wells in Coachella Valley.

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<thead>
<tr>
<th>Nearest post office</th>
<th>Location</th>
<th>Depth to water level in well</th>
<th>Diameter</th>
<th>Owner</th>
<th>Depth</th>
<th>Diam.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gray (Palm Springs Station)</td>
<td>Sec. 8</td>
<td>T.S. 3</td>
<td>R.E. 5</td>
<td>W. S. Talmadge</td>
<td>320</td>
<td>Inches</td>
</tr>
<tr>
<td>Palm Springs</td>
<td>NW. 18</td>
<td>5</td>
<td>6</td>
<td>Peter Rantrree</td>
<td>316</td>
<td>12</td>
</tr>
<tr>
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<td>SW. 18</td>
<td>5</td>
<td>6</td>
<td>W. S. Frey</td>
<td>204</td>
<td>12</td>
</tr>
<tr>
<td>do</td>
<td>SW. 18</td>
<td>5</td>
<td>6</td>
<td>G. E. Cook</td>
<td>114</td>
<td>7</td>
</tr>
<tr>
<td>do</td>
<td>SE. 24</td>
<td>5</td>
<td>6</td>
<td>A. Chapin</td>
<td>220</td>
<td>12</td>
</tr>
<tr>
<td>do</td>
<td>SE. 24</td>
<td>5</td>
<td>6</td>
<td>J. C. O'Neal</td>
<td>68</td>
<td>8</td>
</tr>
<tr>
<td>do</td>
<td>SE. 24</td>
<td>5</td>
<td>6</td>
<td>Southern Pacific R.</td>
<td>1,140</td>
<td>14</td>
</tr>
<tr>
<td>do</td>
<td>SE. 24</td>
<td>5</td>
<td>6</td>
<td>Charles E. Brown</td>
<td>663</td>
<td>Flows.</td>
</tr>
<tr>
<td>do</td>
<td>SE. 24</td>
<td>5</td>
<td>6</td>
<td>Southern Pacific R.</td>
<td>460</td>
<td>Flows.</td>
</tr>
<tr>
<td>do</td>
<td>SE. 24</td>
<td>5</td>
<td>6</td>
<td>Charles E. Brown</td>
<td>1,300</td>
<td>8,14</td>
</tr>
<tr>
<td>do</td>
<td>SE. 24</td>
<td>5</td>
<td>6</td>
<td>Southern Pacific R.</td>
<td>525</td>
<td>Flows.</td>
</tr>
<tr>
<td>do</td>
<td>SE. 24</td>
<td>5</td>
<td>6</td>
<td>Charles E. Brown</td>
<td>1,450</td>
<td>Flows.</td>
</tr>
</tbody>
</table>
As has been suggested in preceding pages the ground water in Coachella Valley is generally good. In fact, it is by far the best found in a large area in the Salton Sea region. Analyses of water at Mecca, Indio, Palm Springs, Whitewater, Talmadge Well, Figtree John Spring, and Fish Springs are given on pages 282-283. The analysis of water at Whitewater represents surface water from Snow Creek. It is evident that the ground water is practically as pure as the surface water at many places, the only notable exception north of the southern limit of the valley being the Talmadge well. In general, ground water is used with satisfaction for domestic purposes, irrigation, and raising steam, being especially desirable for railroad locomotives because of the generally poorer quality of other available water. For railroad uses water is hauled from Mecca nearly as far as Yuma by the Southern Pacific Co.

In the south end of Coachella Valley, near Fish Springs and Mortmar, the water rapidly becomes poor in quality. (See analyses for Fish Springs and Dos Palmas.)

**IMPERIAL VALLEY.**

Little effort has been made to develop ground water in the Imperial Valley because of the convenience of the supply of ditch water, which is settled in large open pools and used for domestic purposes on the ranches and is treated by various purifying processes for use in the cities. Moreover, several deep holes drilled at Brawley, El Centro, and elsewhere have been dry or the water obtained has been

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Gray (Palm Springs station)</td>
<td>Gallons per minute.</td>
<td>Irrigation, stock.</td>
<td>Probably sand or gravel.</td>
<td>1916-17</td>
<td>See analysis, No. 48, p. 283.</td>
</tr>
<tr>
<td>Palm Springs</td>
<td>Flow 15.</td>
<td>None</td>
<td>do</td>
<td>1917</td>
<td></td>
</tr>
<tr>
<td>Indian Wells</td>
<td>Pump 225</td>
<td>Domestic, irrigation.</td>
<td>do</td>
<td>1909</td>
<td></td>
</tr>
<tr>
<td>do</td>
<td>Pump 50-60</td>
<td>Domestic, stock.</td>
<td>do</td>
<td>1913</td>
<td></td>
</tr>
<tr>
<td>do</td>
<td>Pump 500</td>
<td>Domestic, irrigation.</td>
<td>do</td>
<td>1910</td>
<td></td>
</tr>
<tr>
<td>do</td>
<td>Pump 430</td>
<td>Locomotive boilers</td>
<td>do</td>
<td>1909</td>
<td></td>
</tr>
<tr>
<td>Indio</td>
<td></td>
<td>Coarse sand</td>
<td>do</td>
<td>1911</td>
<td></td>
</tr>
<tr>
<td>Mecca</td>
<td>(Flow 100.</td>
<td>do</td>
<td>Sand</td>
<td>1912</td>
<td></td>
</tr>
<tr>
<td>do</td>
<td>135.</td>
<td>do</td>
<td>do</td>
<td>1900</td>
<td>See analysis, No. 29, p. 282.</td>
</tr>
<tr>
<td>do</td>
<td>200.</td>
<td>Domestic, irrigation.</td>
<td>Gravel</td>
<td>1917</td>
<td></td>
</tr>
</tbody>
</table>

*When pumping at the rate of 500 gallons a minute the water level in the well was lowered to 21 feet below the surface.*
unfit for use, so that attempts to get well water there have been abandoned.

There is, however, an area covering several townships near Holtville in which flowing wells are easily obtained. The water from these wells is much clearer than the ditch water and requires no settling, and for that reason wherever its chemical quality is good enough it is highly prized for domestic use. In only a few places is the mineral content too high for this purpose.

The area in which flowing wells exist in considerable number is shown in Figure 7, which gives the location of all wells of which
records were obtained. Practically all of this area lies east of Alamo River, west of the old beach, and north of Holtville. It extends 12 or 15 miles to the north of Holtville, but in that direction the full extent of the area in which flowing wells can be obtained has probably not been determined by drilling. Attempts to obtain flowing wells west of Alamo River have usually failed, although the reason is not very clear. The pressure head is insufficient to produce flows anywhere east of the old beach and at most points south of Holtville; so that except at the north the extent of the flowing-well area may be considered fairly definitely fixed.

The table on pages 83-84 gives the records of 68 wells in the Holtville area. Most of the data were furnished by Mr. D. E. McNeil, of Holtville, who has done the greater part of the drilling in the region. About half of these records have been previously published, but they are included for the sake of completeness. The records given probably cover 90 per cent of the flowing wells that were in use in this area in 1918. Exclusive of wells Nos. 5, 6, 29, 42, 44, 63, and 64, which have little or no flow or for which records of flow are not available, there are 61 wells with a total yield of 1,222 gallons a minute, an average yield per well of about 20 gallons a minute (about 2 miner's inches). The different wells vary widely in yield, but none have flows equal to those of the large flowing wells in Coachella Valley.

The wells in the Holtville area are all of small diameter, most of them only 2 inches, though some are 4-inch wells. They are constructed with a view to supplying only domestic needs. There is not much need of well water for irrigation, and as a rule its quality is not good enough for that purpose, though the overflow from wells is generally mixed with ditch water without harmful effects. It is probable that the yield could be increased considerably, if desired, by drilling larger wells and using more care in construction. The material penetrated is all soft, and drilling is done by the hydraulic rotary method. Larger wells could easily be drilled but might require larger drill rigs than are used at present.

Detailed logs are not available for the wells in this area, but the strata penetrated consist almost everywhere of tight clay that yields no water and of fine sand that may or may not yield water. The clay is usually predominant, and the strata of sand are thin. The records show that the water-bearing strata are encountered at very different depths in different wells, even in wells that are close to each other. The depth to which it is necessary to drill to get flowing water is not predictable but varies greatly within short distances. However, failures are very few within the proved area of flowing wells if drilling is continued to depths of 500 to 1,000 feet.

Colorado River appears, without much doubt, to be the chief source of the water obtained in the Holtville area. The water can hardly come from Coachella Valley, for the same reason that Colorado River water can not reach Coachella Valley—that is, because water from all sides of the Salton Basin is seeping toward the lowest part of the basin (Salton Sea) and there discharging by evaporation and transpiration. Moreover, between Holtville and Coachella Valley there intervene 50 or 60 miles of nearly impervious sedimentary beds in which ground water circulates slowly if at all. Where water is found in them, as at Fish Spring and Kane Spring, it is much more highly mineralized than the average well water near Holtville.

The best evidence that the water of the Holtville area comes from the south and east is the fact that the height above sea level to which water will rise in wells increases rapidly in that direction, indicating certainly that the flow of ground water is toward Salton Sea. The subjoined table gives the height to which the water will rise at several points beginning at Alamorio, in the north end of the Holtville area, and extending southeast to Alamo School, thence east to Colorado River at the international boundary west of Yuma. The data as to head of water at the flowing wells in the Holtville area are derived from measurements made by Hutchins. Ordinarily the pressures are not sufficient to raise a column of water more than about 30 feet above the surface of the ground. Those wells have been chosen in which the pressure head is highest at any given locality, and any additional data used would simply indicate a still deeper hydraulic gradient.

Water levels in Imperial Valley.

<table>
<thead>
<tr>
<th>Well No. on Fig. 7</th>
<th>Owner</th>
<th>Water pressure at surface</th>
<th>Height to which water will rise above surface</th>
<th>Depth to water below surface</th>
<th>Elevation of well with respect to sea level</th>
<th>Elevation of water table with respect to sea level</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>D. C. Huddleston</td>
<td>15</td>
<td>34.5</td>
<td>-130</td>
<td>-95.5</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>D. R. Raymond</td>
<td>16</td>
<td>80</td>
<td>+125</td>
<td>+45</td>
<td></td>
</tr>
<tr>
<td>34</td>
<td>F. M. Ferguson</td>
<td>73</td>
<td>110</td>
<td>+200</td>
<td>+90</td>
<td></td>
</tr>
<tr>
<td>55</td>
<td>Holtville Nataatorium</td>
<td>80</td>
<td>110</td>
<td>+200</td>
<td>+90</td>
<td></td>
</tr>
<tr>
<td>62</td>
<td>Alamo School</td>
<td>28</td>
<td>110</td>
<td>+200</td>
<td>+90</td>
<td></td>
</tr>
</tbody>
</table>

Inasmuch as the water is under greater pressure to the southeast, as shown by the fact that it rises higher in wells in that part of the area, it is absolutely impossible for the artesian water of the Holtville area to have its source in Coachella Valley. The only other sources to be considered are (1) the rainfall on the desert east of Holtville, south-

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west of the Chocolate Mountains, and (2) Colorado River. Probably contributions to the ground-water supply are received from both these sources, although the rainfall on the drainage basin between the Sand Hills and the Chocolate Mountains, from which the supply for the artesian area would apparently have to come, is so slight that it hardly seems adequate to contribute materially to so large an area of discharge. Moreover, the water table at Holtville rises markedly to the south as well as to the east, pointing directly to Colorado River instead of the Chocolate Mountains, which are to the northeast.

Such chemical analyses as are available (see p. 283) substantiate the view that the well water near Holtville is derived from the southeast. There is a notable though erratic increase in mineral content from southeast to northwest, grading from 525 parts per million in the county well near the Sand Hills to more than 4,000 parts in the Huddleston well, at Alamorito. (See table, p. 283.)

If the well water at Holtville is derived from Colorado River, it comes as seepage from a long distance. River water probably begins to percolate westward at Yuma and Pilot Knob, saturating the porous Quaternary gravel south of the Chocolate Mountains. The supply is doubtless augmented by seepage into the ground for some distance south of the international boundary as well as by water from the ditches and canals in that part of Imperial Valley southeast of the region of flowing wells. The amount of seepage from canals that reaches the water table north of the international boundary is probably very small, however, as the soil is generally tight and impervious. Moreover, water entering the ground so near the area of flowing wells could not produce the pressure head that causes the flows at Holtville.

It seems that the best part of the Holtville artesian area has been developed. The head of the water at several places indicates that flowing wells can not be expected in territory more than 20 or 30 feet above sea level. The well at Alamo School (altitude 15 feet) is in fact the only flowing well situated above sea level. Therefore flows can not be expected anywhere east of the old beach or very far south of Alamo. It is probable that they could be obtained for some distance north of the area now developed, in the direction of Calipatria and Niland, but the water would be of very poor quality. The topographic features are favorable for obtaining flowing water over a large area west of Alamo River, but all efforts in that area have failed, chiefly because water-bearing sand was not encountered. It is possible that the strata in that direction become entirely impervious, or it may be that a buried fault zone cuts off the flow of ground water in that direction. Mr. McNeil states that in well No. 64, near El Centro, a thin stratum of water-bearing sand was encountered at a depth between 800 and 900 feet. The water was under great pressure, and sand clogged the well until no water could be obtained.
The quality of the ground water in Imperial Valley varies considerably within short distances, but all of it is rather high in mineral matter and for many uses properly classed as poor. The seven analyses given on page 283 show a mineral content ranging from about 900 to more than 4,000 parts per million, the predominant salts being either sodium chloride (common salt) or sodium carbonate, either of which is very undesirable in water for irrigation or boilers. There appears to be a rather definite though variable increase of salinity in the ground water from south to north, as might be expected, in view of the derivation of the water by seepage from Colorado River toward Salton Sea and its accumulation of dissolved salts as it progresses farther and farther from its source.

Records of wells near Holtville, Imperial Valley, Calif.

<table>
<thead>
<tr>
<th>No.</th>
<th>Owner</th>
<th>Depth (feet)</th>
<th>Diameter (inches)</th>
<th>Principal water-bearing stratum. Depth (feet)</th>
<th>Other water-bearing strata</th>
<th>Artesian flow (gallons per minute)</th>
<th>Date completed</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>A. Taecker</td>
<td>517</td>
<td>4</td>
<td>504-517... Fine sand.</td>
<td>None</td>
<td>20.</td>
<td>1915</td>
</tr>
<tr>
<td>2</td>
<td>J. L. Taecker</td>
<td>529</td>
<td>4</td>
<td>633-643... Fine sand.</td>
<td>None</td>
<td>25.</td>
<td>1915</td>
</tr>
<tr>
<td>3</td>
<td>Charles Phegley</td>
<td>630</td>
<td>2</td>
<td>Near 500... Sand...</td>
<td>None</td>
<td>20.</td>
<td>1915</td>
</tr>
<tr>
<td>4</td>
<td>J. D. Adams</td>
<td>500</td>
<td>2</td>
<td>280-315... Sand...</td>
<td>None</td>
<td>0.5</td>
<td>1910</td>
</tr>
<tr>
<td>5</td>
<td>Charles Phegley</td>
<td>315</td>
<td>2</td>
<td>340-347... Quick sand.</td>
<td>None</td>
<td>30.</td>
<td>1910</td>
</tr>
<tr>
<td>6</td>
<td>Magnolia School</td>
<td>347</td>
<td>2</td>
<td>517-555... Sand...</td>
<td>None</td>
<td>60.</td>
<td>1910</td>
</tr>
<tr>
<td>7a</td>
<td>Mrs. D. C. Hud­dieston</td>
<td>535</td>
<td>4</td>
<td>291-305... do...</td>
<td>None</td>
<td>15.</td>
<td>1911</td>
</tr>
<tr>
<td>8</td>
<td>T. B. Shank</td>
<td>320</td>
<td>2</td>
<td>291-305... do...</td>
<td>None</td>
<td>10.</td>
<td>1916</td>
</tr>
<tr>
<td>9</td>
<td>J. Sullivan</td>
<td>704</td>
<td>2</td>
<td>291-305... do...</td>
<td>None</td>
<td>5.</td>
<td>1916</td>
</tr>
<tr>
<td>10</td>
<td>J. E. Peck</td>
<td>633</td>
<td>4</td>
<td>291-305... do...</td>
<td>None</td>
<td>10.</td>
<td>1916</td>
</tr>
<tr>
<td>11</td>
<td>T. B. Shank</td>
<td>640</td>
<td>4</td>
<td>291-305... do...</td>
<td>None</td>
<td>9.</td>
<td>1916</td>
</tr>
<tr>
<td>12</td>
<td>D. R. Raymond</td>
<td>229</td>
<td>2</td>
<td>291-305... do...</td>
<td>None</td>
<td>7.5</td>
<td>1916</td>
</tr>
<tr>
<td>13</td>
<td>O. N. Shaw</td>
<td>272</td>
<td>2</td>
<td>291-305... do...</td>
<td>None</td>
<td>15.</td>
<td>1916</td>
</tr>
<tr>
<td>14</td>
<td>Lucy Painter</td>
<td>247</td>
<td>2</td>
<td>163-170... do...</td>
<td>None</td>
<td>10.</td>
<td>1916</td>
</tr>
<tr>
<td>15</td>
<td>L. H. Rogers</td>
<td>310</td>
<td>2</td>
<td>224-225... Sand...</td>
<td>None</td>
<td>7.5</td>
<td>1916</td>
</tr>
<tr>
<td>16</td>
<td>J. Chalupnik</td>
<td>340</td>
<td>2</td>
<td>224-225... Sand...</td>
<td>None</td>
<td>7.5</td>
<td>1916</td>
</tr>
<tr>
<td>17</td>
<td>S. C. Scott</td>
<td>320</td>
<td>2</td>
<td>224-225... Sand...</td>
<td>None</td>
<td>20.</td>
<td>1916</td>
</tr>
<tr>
<td>18</td>
<td>C. L. Penery</td>
<td>315</td>
<td>2</td>
<td>224-225... Sand...</td>
<td>None</td>
<td>5.</td>
<td>1916</td>
</tr>
<tr>
<td>19</td>
<td>Sunset Spring School</td>
<td>100</td>
<td>2</td>
<td>224-225... Sand...</td>
<td>None</td>
<td>5.</td>
<td>1916</td>
</tr>
<tr>
<td>20</td>
<td>O. N. Shaw</td>
<td>200</td>
<td>2</td>
<td>224-225... do...</td>
<td>None</td>
<td>5.</td>
<td>1915</td>
</tr>
<tr>
<td>21</td>
<td>John Pool</td>
<td>200</td>
<td>2</td>
<td>224-225... do...</td>
<td>None</td>
<td>5.</td>
<td>1916</td>
</tr>
<tr>
<td>22</td>
<td>C. E. Walters</td>
<td>140</td>
<td>2</td>
<td>Near 140... do...</td>
<td>None</td>
<td>50.</td>
<td>1915</td>
</tr>
<tr>
<td>23</td>
<td>Stevenson Bros</td>
<td>153</td>
<td>4</td>
<td>224-225... do...</td>
<td>None</td>
<td>50.</td>
<td>1916</td>
</tr>
<tr>
<td>24</td>
<td>A. H. Griswold</td>
<td>200</td>
<td>2</td>
<td>224-225... do...</td>
<td>None</td>
<td>15.</td>
<td>1916</td>
</tr>
<tr>
<td>25</td>
<td>Frank Haag</td>
<td>210</td>
<td>2</td>
<td>224-225... do...</td>
<td>None</td>
<td>7.5</td>
<td>1916</td>
</tr>
<tr>
<td>26</td>
<td>J. H. Cox</td>
<td>300</td>
<td>2</td>
<td>224-225... Sand...</td>
<td>None</td>
<td>15.</td>
<td>1916</td>
</tr>
<tr>
<td>27</td>
<td>Robo Bros</td>
<td>684</td>
<td>2</td>
<td>633-650... Coarse sand...</td>
<td>None</td>
<td>50.</td>
<td>1917</td>
</tr>
<tr>
<td>28</td>
<td>E. R. Worley</td>
<td>620</td>
<td>2</td>
<td>224-225... Sand...</td>
<td>None</td>
<td>60.</td>
<td>1917</td>
</tr>
<tr>
<td>29</td>
<td>Rose School</td>
<td>905</td>
<td>2</td>
<td>224-225... Sand...</td>
<td>None</td>
<td>8.</td>
<td>1917</td>
</tr>
<tr>
<td>30</td>
<td>M. Zunstein</td>
<td>490</td>
<td>2</td>
<td>224-225... Sand...</td>
<td>None</td>
<td>10.</td>
<td>1912</td>
</tr>
<tr>
<td>31</td>
<td>Fuller Bros</td>
<td>927</td>
<td>2</td>
<td>224-225... Sand...</td>
<td>None</td>
<td>50.</td>
<td>1913</td>
</tr>
<tr>
<td>32</td>
<td>H. I. Roberts</td>
<td>580</td>
<td>2</td>
<td>224-225... do...</td>
<td>None</td>
<td>15.</td>
<td>1913</td>
</tr>
<tr>
<td>33</td>
<td>Eastside School</td>
<td>281</td>
<td>2</td>
<td>224-225... do...</td>
<td>None</td>
<td>7.5</td>
<td>1916</td>
</tr>
<tr>
<td>34</td>
<td>F. M. Ferguson</td>
<td>909</td>
<td>2</td>
<td>224-225... do...</td>
<td>None</td>
<td>60.</td>
<td>1917</td>
</tr>
<tr>
<td>35</td>
<td>Rob Alexander</td>
<td>927</td>
<td>2</td>
<td>224-225... do...</td>
<td>None</td>
<td>8.</td>
<td>1912</td>
</tr>
<tr>
<td>36</td>
<td>J. L. McMinn</td>
<td>852</td>
<td>2</td>
<td>224-225... do...</td>
<td>None</td>
<td>15.</td>
<td>1914</td>
</tr>
<tr>
<td>37</td>
<td>W. A. Thompson</td>
<td>517</td>
<td>2</td>
<td>224-225... do...</td>
<td>None</td>
<td>11.5</td>
<td>1912</td>
</tr>
<tr>
<td>38</td>
<td>J. W. Brameschen</td>
<td>478</td>
<td>2</td>
<td>224-225... do...</td>
<td>None</td>
<td>7.5</td>
<td>1912</td>
</tr>
<tr>
<td>39</td>
<td>Hooker &amp; Bell</td>
<td>695</td>
<td>2</td>
<td>224-225... do...</td>
<td>None</td>
<td>66.</td>
<td>1913</td>
</tr>
<tr>
<td>40</td>
<td>W. L. Hedges</td>
<td>418</td>
<td>2</td>
<td>224-225... do...</td>
<td>None</td>
<td>50.</td>
<td>1916</td>
</tr>
<tr>
<td>41</td>
<td>A. L. Storey</td>
<td>900</td>
<td>2</td>
<td>224-225... do...</td>
<td>None</td>
<td>15.</td>
<td>1914</td>
</tr>
<tr>
<td>42</td>
<td>Ed Gorman</td>
<td>846</td>
<td>2</td>
<td>224-225... do...</td>
<td>None</td>
<td>20.</td>
<td>1914</td>
</tr>
<tr>
<td>43</td>
<td>E. J. Merrowen</td>
<td>827</td>
<td>2</td>
<td>224-225... do...</td>
<td>None</td>
<td>5.</td>
<td>1914</td>
</tr>
<tr>
<td>44</td>
<td>Central School</td>
<td>827</td>
<td>2</td>
<td>224-225... do...</td>
<td>None</td>
<td>5.</td>
<td>1914</td>
</tr>
</tbody>
</table>

* For analysis, see No. 54, p. 283.

* Stepped flowing about 1 year after completion.

* For analysis, see No. 58, p. 283.
Records of wells near Holtville, Imperial Valley, Calif.—Continued.

<table>
<thead>
<tr>
<th>No. on Fig.</th>
<th>Owner</th>
<th>Depth (feet)</th>
<th>Diameter (inches)</th>
<th>Principal water-bearing stratum.</th>
<th>Other water-bearing stratum.</th>
<th>Artesian flow (gallons per minute)</th>
<th>Date completed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Depth (feet).</td>
<td>Character.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>45</td>
<td>Skilling &amp; Gorman.</td>
<td>950</td>
<td>2</td>
<td>848-883...</td>
<td></td>
<td>20.5...</td>
<td>1912</td>
</tr>
<tr>
<td>46</td>
<td>A. L. Hickey</td>
<td>655</td>
<td>2</td>
<td>690-658...</td>
<td>Sand</td>
<td>34.5...</td>
<td>1913</td>
</tr>
<tr>
<td>47</td>
<td>Theo. Prim</td>
<td>898</td>
<td>2</td>
<td>899-993...</td>
<td>Near 900</td>
<td>None</td>
<td>1912</td>
</tr>
<tr>
<td>49</td>
<td>L. W. Boyd</td>
<td>600</td>
<td>2</td>
<td>Near 900</td>
<td>do</td>
<td>None</td>
<td>1917</td>
</tr>
<tr>
<td>50</td>
<td>Lear Bros</td>
<td>640</td>
<td>2</td>
<td>Near 818</td>
<td>Sand</td>
<td>214-145; No flow...</td>
<td>1914</td>
</tr>
<tr>
<td>51</td>
<td>Dan Oakley</td>
<td>812</td>
<td>2</td>
<td>598-557...</td>
<td>do</td>
<td>493-483; 508-522.</td>
<td>1915</td>
</tr>
<tr>
<td>52</td>
<td>C. D. Manning</td>
<td>994</td>
<td>2</td>
<td>Near 812</td>
<td>Sand</td>
<td>48...</td>
<td>1914</td>
</tr>
<tr>
<td>53</td>
<td>Timken ranch</td>
<td>620</td>
<td>4</td>
<td>do</td>
<td>do</td>
<td>7...</td>
<td>1910</td>
</tr>
<tr>
<td>54</td>
<td>Ed Boyd</td>
<td>873</td>
<td>4</td>
<td>Between 400 and 500</td>
<td>do</td>
<td>5...</td>
<td>1910</td>
</tr>
<tr>
<td>55</td>
<td>Harard &amp; Strang</td>
<td>873</td>
<td>4</td>
<td>600-700...</td>
<td>do</td>
<td>84...</td>
<td>1910</td>
</tr>
<tr>
<td>56</td>
<td>Holtville Natatorium</td>
<td>852</td>
<td>4</td>
<td>848-862...</td>
<td>do</td>
<td>11...</td>
<td>1912</td>
</tr>
<tr>
<td>57</td>
<td>City of Holtville</td>
<td>1,008</td>
<td>4</td>
<td>851.5-852; 1,094-1,098; Near 460</td>
<td>do</td>
<td>2.5...</td>
<td>1911</td>
</tr>
<tr>
<td>58</td>
<td>do</td>
<td>852</td>
<td>2</td>
<td>828-832...</td>
<td>do</td>
<td>7.5...</td>
<td>1909</td>
</tr>
<tr>
<td>59</td>
<td>do</td>
<td>1,410</td>
<td>4</td>
<td>836-846; 1,100-1,120; Near 460</td>
<td>do</td>
<td>48...</td>
<td>1929</td>
</tr>
<tr>
<td>60</td>
<td>W. A. Thompson</td>
<td>813</td>
<td>2</td>
<td>793-803...</td>
<td>do</td>
<td>3...</td>
<td>1913</td>
</tr>
<tr>
<td>61</td>
<td>F. S. Est</td>
<td>809</td>
<td>2</td>
<td>772-809...</td>
<td>do</td>
<td>18.5...</td>
<td>1913</td>
</tr>
<tr>
<td>62</td>
<td>W. B. Hill</td>
<td>861</td>
<td>2</td>
<td>794-817...</td>
<td>do</td>
<td>15...</td>
<td>1910</td>
</tr>
<tr>
<td>63</td>
<td>Alamo School</td>
<td>877</td>
<td>2</td>
<td>864-877...</td>
<td>do</td>
<td>5...</td>
<td>1912</td>
</tr>
<tr>
<td>64</td>
<td>Verde School</td>
<td>670</td>
<td>2</td>
<td>832-643...</td>
<td>Very fine sand.</td>
<td>No flow; pumped</td>
<td>1914</td>
</tr>
<tr>
<td>65</td>
<td>C. E. Kam</td>
<td>813</td>
<td>2</td>
<td>793-803...</td>
<td>do</td>
<td>3...</td>
<td>1918</td>
</tr>
<tr>
<td>66</td>
<td>Highline School</td>
<td>403</td>
<td>2</td>
<td>384-405...</td>
<td>Fine sand</td>
<td>30...</td>
<td>1917</td>
</tr>
<tr>
<td>67</td>
<td>Kunz</td>
<td>346</td>
<td>2</td>
<td>do</td>
<td>Sand</td>
<td>30...</td>
<td>1917</td>
</tr>
<tr>
<td>68</td>
<td>Frank McCowan</td>
<td>610</td>
<td>2</td>
<td>414-420...</td>
<td>Very fine sand.</td>
<td>None</td>
<td>2...</td>
</tr>
</tbody>
</table>

For analysis, see No. 50, p. 283.  
For analysis, see No. 56, p. 283.  
For analysis, see No. 57, p. 283.  
For analysis, see No. 55, p. 283.

SAND HILLS AREA.

As indicated in the description of ground water in the Holtville area, it is believed that a continuous body of ground water permeates the porous Quaternary material east of the old beach and southwest of the Chocolate Mountains, probably all the way to Colorado River. This territory consists of a nearly level sand plain as far east as the Sand Hills and of a gravel plain from the Sand Hills northeast to the mountains.

Wells in this area are few, the two county wells on the Yuma road being practically the only ones in use. Several wells have been drilled southwest of the Sand Hills, and all are reported to have reached water, but so far as could be learned they are all abandoned. One well was in sec. 4, T. 17 S., R. 17 E., and another near the border of the Sand Hills, probably in T. 15 S., R. 18 E. The two county wells are drilled wells. The western well, known as the new county well, is reported by Mr. McNeil, the driller, to be 140 feet deep. Water was reached at that depth and rose to a level 80 feet below the surface. A boring 880 feet deep was made 20 feet east of
the present well in an attempt to get flowing water, but the water in that also stood at 80 feet below the surface. The strata penetrated were entirely sand and gravel. The old county well is reported to be 120 feet deep and to contain 10 feet of water. An effort was made to measure it, but the casing is very crooked and in bad condition, and the plumb would sink only about 60 feet.

The only other place in this area at which a well has been drilled is at Amos, on the Southern Pacific Railroad, where the railroad company drilled a test well in 1917. The following log is furnished. An analysis of the water from the strata at 454 to 475 feet made by the railroad chemists is given on page 282. The water was considered unsatisfactory for boilers and has not been used by the railroad company.

Record of well drilled at Amos, Calif., by Southern Pacific Railroad.

<table>
<thead>
<tr>
<th>Well completed May, 1917.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gravel and cemented gravel</td>
</tr>
<tr>
<td>Clay</td>
</tr>
<tr>
<td>Fine sand</td>
</tr>
<tr>
<td>Soft clay</td>
</tr>
<tr>
<td>Sandstone</td>
</tr>
<tr>
<td>Clay</td>
</tr>
<tr>
<td>Water sand (bad water)</td>
</tr>
<tr>
<td>Gravel and boulders</td>
</tr>
<tr>
<td>Cement gravel</td>
</tr>
<tr>
<td>Water sand (bad water)</td>
</tr>
<tr>
<td>Cement gravel</td>
</tr>
<tr>
<td>Quick sand</td>
</tr>
<tr>
<td>Water sand (bad water)</td>
</tr>
<tr>
<td>Clay</td>
</tr>
<tr>
<td>White sand</td>
</tr>
<tr>
<td>Clay</td>
</tr>
<tr>
<td>Water gravel (poor water; see analysis)</td>
</tr>
<tr>
<td>Fino sand</td>
</tr>
<tr>
<td>Clay</td>
</tr>
<tr>
<td>Sand</td>
</tr>
<tr>
<td>Clay</td>
</tr>
<tr>
<td>Black sand</td>
</tr>
</tbody>
</table>

The elevation at Amos is 259 feet above sea level, and according to the record furnished water was first reached at a depth of 268 feet. It is not known whether the water rose in the well. If not, the water table would be 9 feet below sea level. In general it is probable that water can be obtained anywhere in the Sand Hills area, and that the position of the water table ranges from sea level on the northwest to about 100 feet above sea level on the southeast.

Area Northeast of Salton Sea.

On the northeast side of Salton Sea, between Niland and Mortmar, there are some indications of ground water, but practically none is utilized. Much of the land between Salton Sea and the old beach in this area is a barren clay plain dissected by innumerable small arroyos. Northeast of the old beach the topography is more rugged and at places verges closely on the badland type.

From Flowing Well to Frink Spring there is a strip of land lying between the power line and the old beach in which there is abundant evidence of ground-water discharge. Several small springs bubble up, and their water flows for a short distance. Frink Spring is an especially large one of this type. The springs are surrounded by patches of tules and rushes, and the water forms a mineral incrus-
tation on the soil and plants. Sometimes this incrustation is white but more often grayish, and when the water evaporates the soil puffs up and becomes mealy. Small tracts are covered with mesquite and salt grass, but at many places the water appears to be too alkaline for plant growth and only damp salt-incrusted soil testifies to the escape of ground water. At Frink Spring there is an area of several acres of arrow weed, mesquite, and smaller plants that feed on ground water. A trench has been constructed in which there is a flow of 3 or 4 miner's inches (35 to 45 gallons a minute).

Along the line of springs that closely follows the road for several miles southeast of Frink Spring there is a low, barely noticeable bench on which numerous exposures of a hard conglomerate containing large pebbles of granite, porphyry, and metamorphic igneous rocks were seen. At Frink Spring this conglomerate is overlain on the west by fine-grained sandstone. In places it is noticeably folded and broken. On the east it is covered by recent detritus from the old beach. Water escaping upward through this rock has a tendency to deposit streaks and fillings of mineral matter in cracks and crevices, and much of the conglomerate surface is lined by these incrustations.

At Dos Palmas a spring of the artesian type, such as Fish Springs and others at the south end of Coachella Valley, supports several acres of rank vegetation. In the area south and east of it are a number of similar small oases. The only attempts to develop water for irrigation northeast of Salton Sea have been made in this vicinity, where there are strong indications of a small area of artesian flow. The area is extremely inaccessible on account of bad roads, and very little time was devoted to it. It is known, however, that flowing wells are obtainable for 4 or 5 miles south of Dos Palmas. Mr. George DeHart, who lived near Dos Palmas in 1918, stated that at least 20 flowing wells existed in the neighborhood. The deepest one was 215 feet deep. One well had a reported flow of 25 miner's inches (225 gallons a minute). The water was being used for irrigation with unsatisfactory results, its quality being very poor. This observation was confirmed at one tract noted by the writer, where the water had evidently ruined a crop.

The Southern Pacific Co. drilled a test well at Durmid in 1902, but no water was obtained. The following log is given:

*Log of Southern Pacific Co.'s well at Durmid.*

<table>
<thead>
<tr>
<th>Thickness</th>
<th>Depth</th>
<th>Thickness</th>
<th>Depth</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feet</td>
<td>Feet</td>
<td>Feet</td>
<td>Feet</td>
</tr>
<tr>
<td>Sediment</td>
<td>2</td>
<td>2</td>
<td>25</td>
</tr>
<tr>
<td>Yellow clay</td>
<td>10</td>
<td>12</td>
<td>104</td>
</tr>
<tr>
<td>Red sand</td>
<td>15</td>
<td>27</td>
<td>6</td>
</tr>
<tr>
<td>Yellow clay</td>
<td>10</td>
<td>37</td>
<td>10</td>
</tr>
<tr>
<td>Fine red sand</td>
<td>10</td>
<td>47</td>
<td>streaks of shell rock 1 inch to 966</td>
</tr>
<tr>
<td>Soft sticky clay</td>
<td>125</td>
<td>170</td>
<td>12 inches thick</td>
</tr>
</tbody>
</table>
The ground water northeast of Salton Sea probably comes from several sources. On the northwest, near Dos Palmas and Mortmar, water is contributed by Coachella Valley, whose large supply seeping southeastward discharges about the upper end of Salton Sea. On the southeast, near Niland, some water is doubtless supplied from the Holtville area, from which water appears to be seeping northwestward. Undoubtedly part of the water escaping in springs in this area is due to rainfall on the mountain slopes to the northeast, particularly in the vicinity of Dos Palmas, to which Salt Creek brings the drainage of a considerable territory. The water thus supplied from various sources becomes impounded under the impervious clay present at places in the area. There are also probably considerable parts of the area in which ground water is not present, owing to the impervious nature of the underlying Tertiary clay beds, as at Durmid, where the dry hole was drilled. The water contributed from the various sources escapes along a zone of discharge near the old beach at places where the erosive action of the waves of Lake Cahuilla uncovered pervious rocks such as sand or conglomerate through which the water can escape.

The water in this region is of very poor quality (see analyses of Dos Palmas and Frink springs, p. 282), and most of it is unfit for irrigation and nearly every other use. It is possible that some of the water in the artesian area at Dos Palmas may be used for irrigation of special crops, but the chances for developing water of good quality are very slight.

San Felipe Area.

The San Felipe area lies southwest of Salton Sea, northeast of the Vallecito and Fish mountains, along the lower valley of San Felipe Creek. It receives the drainage, chiefly underflow, of San Felipe and Carrizo creeks as well as that from numerous small mountain canyons, all of which are dry except when it rains. At a few places in the vicinity of Harper Well and farther east there is a small surface flow in the channel of San Felipe Creek, which is a good example of an interrupted stream.

The land lying west of the old beach in this area is composed of clay hills of Tertiary material and is devoid of water or vegetation except at a few places like Barrel Spring and in the deep arroyos south of the Santa Rosa Mountains, where local structural conditions give rise to little springs that generally contain very bad water. In the dry wash of San Felipe Creek water appears to come near the surface at places east of Barrel Spring but does not flow above ground. In the bed of the wash east of Borego Mountain a few mesquite trees grow at places, and these may indicate an approach of the ground water to the surface.
In the flat plain east of the old beach a number of wells, most of them 200 to 500 feet deep, have been drilled. Harper Well, in sec. 26, T. 12 S., R. 10 E., at 100 feet below sea level, yields a flow of about 2 gallons a minute and is said originally to have yielded more. Between Harper Well and San Felipe town site are three wells, at intervals of 1 mile apart, beside the road. Their open casings protrude from the ground. They are said to have been drilled by the county authorities to encourage settlement in this vicinity. Water stands at 15, 16, and 20 feet, respectively, in the wells from east to west. The well by the abandoned garage in the San Felipe town site, in sec. 6, T. 13 S., R. 10 E., contained water at 27.5 feet below the surface. About 2 miles west of this well, on the south side of the road, probably in sec. 1, T. 13 S., R. 9 E., is a well near a large concrete reservoir in which the depth to water was 22.5 feet. On the claim of H. J. Sternberg, about 3 miles south by west of Harper Well, in sec. 10, T. 13 S., R. 10 E., is a well in which the depth to water is reported as 45 feet. The general fact indicated by these wells is that water is deeper to the south and west as the land gradually rises, a condition naturally to be inferred where there is a permanent free body of ground water.

Tait\(^7\) gives some data on several wells in this plain and states that 25 or 30 have been put down and that most of them reached water at depths of 30 to 40 feet or less. Logs of some of the wells show strata of clay, sandstone, and gravel. The Sternberg well ended in boulders at 510 feet. Two dry holes 500 feet deep are reported.

It is evident that there is a permanent body of ground water in the area, the surface of which is about 100 feet below sea level. Therefore, water should be found at depths less than 150 feet anywhere east of the old beach where permeable strata are present. The plain is underlain at no great depth by Tertiary beds similar to those exposed about its borders, and these beds are presumably folded complexly, as elsewhere, and covered by a thin deposit of silt. At certain places the strata penetrated by a drill are impervious, thus accounting for the dry holes, but generally the rocks are saturated up to a certain level.

All the drilling in this area has been done in the hope of obtaining strong flowing wells. Under the conditions outlined this is not believed to be possible. The sectional diagram drawn through San Felipe and Harper Well (Fig. 8) illustrates the conditions as they appear to be. Ground water saturates all the permeable rocks below about 100 feet above sea level and flows out as intermittent surface drainage in areas whose altitude is less than that. The first few feet of surface soil back to the beach line is fine silt and sand of the old

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lake bed. Below the soil folded Tertiary strata are found. The essential features of an artesian area are an intake at a considerably higher elevation and the trapping of the water beneath an impervious covering as it sinks down into the porous rocks. The only supply of water of any importance in this plain is that brought in by Carrizo and San Felipe creeks as underflow in their stream gravel, and the layer of silt east of the old beach is not thick enough, impervious enough, or continuous enough to trap the waters beneath it effectively. It is cut through and broken at many places by arroyos, which expose the older folded rocks beneath. In places it probably acts as a covering sufficient to produce a small artesian head and give weak flows, as at Harper Well, but it does not seem to offer any prospect of strong flows.

The poor quality of the water, too, is a serious drawback to irrigation in this area. Tait states that the water in most of the wells is salty and unfit for irrigation or domestic use. The water of the Harper, San Felipe, and Sternberg wells is used for domestic purposes and stock, but all of it tastes rather bad, that of Harper Well being considered perhaps the best. It is doubtful if good water for irrigation can be had at any depth in this area, as all the supply has percolated for many miles through rocks containing large amounts of soluble salts. The analyses of water from Harper Well, Kane Spring, San Felipe Creek, and McCain Spring (see p. 283) show the general character of

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the water, though better water probably occurs west of Harper Well than that represented by the samples analyzed.

Part of the land in this area lies low enough to make irrigation from the Imperial canal system possible, and there is a chance of irrigation from that source if sufficient water is available from the Colorado.

**COYOTE WELLS AREA.**

In a small body of land around Coyote Wells, on the San Diego-El Centro highway west of Imperial Valley, ground water is found near the surface, and there is some possibility of its development for irrigation. The drainage from the south side of Carrizo Mountain and the north side of a spur of the Peninsular Mountains supplies this tract with a small quantity of water which sinks into porous gravel west of Coyote Wells and travels eastward. East of Coyote Wells its flow beneath the surface is checked by a ridge of Tertiary clay which extends almost continuously from Carrizo Mountain across to Yuha Well. The ground water rises to pass over this barrier, and there are small areas of discharge indicated by mesquite and other vegetation. At a watering place known as Coyote Holes, 2 miles east of the present settlement of Coyote Wells, water was formerly obtained by digging in stream gravel.

The accompanying table gives records of several wells near Coyote Wells, but there are a number of others for which records were not obtained. These wells penetrated sand and gravel, and their records indicate that the water table near and east of Coyote Wells is not more than 20 feet below the surface in the low ground where the wells are situated. Farther west, where the land rises, the depth to water increases rapidly. However, in an area of a few square miles water is within easy pumping lifts of the surface.

**Data on wells near Coyote Wells.**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>R. R. Co.</td>
<td>2 miles northeast of Coyote Wells store.</td>
<td>Dug</td>
<td>4 by 4</td>
<td>22</td>
<td>16</td>
<td>None.</td>
</tr>
<tr>
<td>Mrs. Sinsibaugh</td>
<td>Coyote Wells store.</td>
<td>Dug</td>
<td>4 by 4</td>
<td>8</td>
<td></td>
<td>Domestic.</td>
</tr>
<tr>
<td>Do</td>
<td>Coyote Wells station.</td>
<td>Dug</td>
<td>4 by 4</td>
<td>8</td>
<td></td>
<td>Domestic.</td>
</tr>
<tr>
<td>Mrs. Sinsibaugh</td>
<td>414 miles west of Coyote Wells store.</td>
<td>Drilled</td>
<td></td>
<td>115</td>
<td>50</td>
<td>Domestic and irrigation.</td>
</tr>
<tr>
<td>Do</td>
<td>1\frac{1}{2} mile west and 4\frac{1}{2} mile north of Coyote Wells store.</td>
<td>Dug</td>
<td></td>
<td>65</td>
<td>61</td>
<td>Do.</td>
</tr>
<tr>
<td>Henry E. Walker</td>
<td>4 mile east of Coyote Wells store.</td>
<td>Dug</td>
<td></td>
<td>30</td>
<td>12</td>
<td>Do.</td>
</tr>
</tbody>
</table>

For analysis, see No. 14, p. 282.

For analysis, see No. 15, p. 282.

For analysis, see No. 16, p. 282. This water gave poor results.

The water as indicated by the three analyses is not of good quality and probably cannot be successfully used for irrigation at most
localities. The experiments made with it to date are rather discour­aging. Still, there are probably a few localities in this area where
the water and soil are adapted to irrigation. The supply fed in
from the mountains on the west is too small to support any exten­sive area of irrigated land.

WESTERN MOUNTAIN VALLEYS.

Within and near the base of the Peninsular Mountains are a num­ber of small valleys that receive a considerable supply of water from
relatively large mountain areas and have independent bodies of
ground water. The surplus water from these valleys discharges either
as surface or subsurface drainage into the Salton Basin. The largest
of these valleys are San Felipe Valley, Mason Valley, Vallecito Valley,
Carrizo Valley, Borego Valley, and Clark Valley.

SAN FELIPE VALLEY.

San Felipe Valley comprises 15 to 20 square miles of valley land
inclosed by moderately high mountains in the eastern part of T. 12 S.,
R. 4 E., the southwestern part of T. 12 S., R. 5 E., and the north­eastern part of T. 13 S., R. 5 E. Through Banner Creek on the south,
Arkansas and other canyons on the west, and the headwaters of San
Felipe Creek on the northwest, reaching back to the divide at the
Warner ranch, it receives the drainage from an area approximately
twice its size on the east slope of the Peninsular Mountains. In
addition, there is a small amount of drainage, chiefly intermittent,
from the slopes on the east and south.

Nearly all the streams that enter the valley from the west are
perennial in the mountain region, though at places the streamways
are dry at the surface and all the water percolates through the stream
gravel. Banner Creek is the largest contributor. A large part of its
flow is forced to the surface by a natural rock dam in the gorge half
a mile below Banner. A current-meter gaging here on February 13,
1918, showed a flow of about 1 second-foot. The flow in the upper
part of San Felipe Creek is probably nearly as great, and that from
the western canyons much more. In addition, there is the subsurface
flow and the run-off from occasional floods.

San Felipe Valley is divided topographically into three parts, in
which ground-water conditions are in general similar. The upper 2
miles of the valley, extending about 1 mile down into the San Felipe
ranch, forms one division. Here a small valley, little more than half
a mile wide, is separated by low spurs of the inclosing mountains
from the larger valley below. The waters of upper San Felipe Creek
sink into the higher portions of this division and leave a dry, steeply
sloping floor covered with a moderate growth of grass. In the lower
half mile, in an area of probably 160 acres in the upper part of the
ranch, a rank grove of willows and large cottonwoods with luxuriant growth of grass indicates that ground water is being forced very near the surface, and just below this area a stream nearly equal to Banner Creek bursts up from numerous springs and flows for a distance over the low natural dam.

This water, together with that from Banner Creek and the western canyons, unites to form a body of ground water under the second division. Here also the outer edges of the valley grade from rocky fans into grassy slopes and give way finally to a marsh in the territory a mile or so east of the San Felipe ranch house. Shallow wells of good water are easily obtained from the ranch house eastward. One well near the house yields a small flow, and four others in the vicinity or a little east are fitted with windmills and furnish water for stock and for the irrigation of small plots of ground.

A low granite ridge, jutting out from the south, constrains the eastward passage of the ground water and marks off a third division of the valley, in T. 11 S., R. 5 E. The flow rising at a point about 2 miles east of the ranch house appears to be continuous through the lower valley, and here ground water is shallow over most of the central portion. A heavy growth of mesquite covers the ground, and grass is plentiful, making excellent pasturage. Springs rise here at places, indicating a slight pressure on the water beneath. San Felipe Creek, where visited near the center of this valley, had a flow estimated as at least 3 second-feet. At the lower extremity of the ranch this water spreads out over an alkali flat probably half a mile in diameter and passes northeastward through a narrow gorge from which it sinks into the desert farther east.

The creek at many places in San Felipe Valley flows between cut banks 10 to 20 feet deep, which show very evenly stratified fine sand containing great amounts of mica and considerable clay. The possibility that this part of the valley is occupied by lake beds is very strongly suggested, though no direct evidence was obtained.

Southeast of the ranch is a considerable extension of the valley, part of which, separated from the rest by a low divide, is an undrained basin in the center of which is a small playa. This area is covered by grass and in places by creosote bush and cacti, indicating that water is rather deep. Three dug wells furnish information about water in this end of the valley. These wells indicate the existence of a ground-water body that is probably continuous under the southeast end of the valley. As the Bushore Well is not far from the divide that isolates little basins to the southeast, it appears that a considerable area in this end of the valley may have water at depths of 50 to 100 feet.
Little use has been made of the water up to date, the owners of the San Felipe ranch preferring to engage in grazing and using the water only for stock. A little of the flow that rises over the first natural dam is led over some alfalfa ground in the upper part of the second division, and a few other plots are irrigated by water from wells. There is several square miles of excellent soil in the valley, most of which could probably be irrigated by proper conservation of the water available. The gorge at the lower end of the valley is said to afford a possible dam site and from a distance appeared to be worth investigating.

All the water with the possible exception of that in the vicinity of the alkali flat is of good quality. A sample taken from a stock well near the northwest corner of sec. 34, T. 11 S., R. 5 E., near the lower ranch gate, probably represents the most saline water in the valley. It has a slightly noticeable salty taste.

It is also suggested that the water available in this valley would make an excellent municipal supply should any developments in the desert to the east necessitate the consideration of such a possibility.

**MASON VALLEY.**

Mason Valley receives the drainage of Rodriguez Canyon, which is probably large during occasional floods, and that from several large canyons on the south originating in the Laguna Mountains, on which there is a fairly heavy precipitation. These canyons feed perennial springs at the valley borders, near some of which ranches have been established. All the run-off sinks into the gravel at the foot of the mountains and passes underground toward the lower end of the valley, where it rises over a rock dam in the canyon leading into Vallecito Valley. A stream estimated at 20 to 30 miner's inches (more than 0.5 second-foot) was flowing here in November, 1917. Part of this flow is utilized during the summer in irrigation on the Campbell ranch, and it is said that a 4-inch pipe will carry the total flow at certain seasons of the year. However, the granite ridge between Mason and Vallecito valleys is sheared and shattered, and the location...
of certain springs on the Campbell ranch at the foot of the east base of this ridge suggests that ground water escapes from Mason Valley through channels other than the outlet in the canyon.

Near the canyon at the lower end of the valley there is a considerable tract where ground water is shallow and mesquite trees thrive. Grass also grows well on parts of this land. Wells in the lower part of the valley are reported by settlers to have been made at various times and to have reached water at depths of 30 to 65 feet. There are two wells at ranches in the upper end of the valley that are equipped with windmills, but the owners could not be found and the wells were not accessible for measurement. One of the wells is about a quarter of a mile south of the United States Geological Survey sign at the road fork in the west end of the valley, probably in sec. 34, T. 13 S., R. 5 E. It is reported by a Mr. Ebersol, who lived in the valley in 1918, to be 184 feet deep and to contain 5 or 6 feet of water. The windmill is said to pump it dry in about three hours. The other well is near the main wash through the valley, about half a mile south of the first, probably in sec. 3, T. 14 S., R. 5 E. It is reported that the depth to water in this well is 126 feet but that the well is dry during parts of the year. Much trouble is said to be incurred in well drilling in this area because of quicksand, which impedes the drill and sometimes shuts off the supply of water after the well is completed.

It appears that there is a permanent ground-water body under Mason Valley which may be tapped at depths ranging from 20 to 200 feet on the desirable agricultural land, probably more than 50 feet under most of it. The quality of the water should be excellent, as that in the wells is reported good and the creek water escaping from the valley is unusually good and very satisfactory for irrigation.

The canyon at the east end of the valley is in places less than 200 feet wide and affords an ideal dam site for storing the surplus water that now escapes from the valley. This water could easily be used on land below, in Vallecito Valley. However, this water is understood to be at present filed upon and partly in use by Mr. Campbell and others interested in land in Vallecito Valley. The total water supply, including the flood waters, if conserved would probably not be sufficient to irrigate more than a few sections of land. Some land may be reclaimed by pumping in Mason Valley, but the considerable depth to water and the poor transportation facilities from the valley are adverse conditions.

Vallecito Valley.

Nearly all the writer's conclusions as to the ground-water supply in Vallecito Valley are based on surface indications, there being no wells in the valley and no settlers except at Campbell's ranch, at the extreme west end of the valley. Probably all the surplus ground water of Mason Valley is fed into Vallecito Valley. There are also
large canyons entering from the south and containing streams reported as perennial that discharge considerable water from the Laguna Moun-
tains. On the north the canyons are short and the mountains arid, so that the contribution from that side is very small.

As in Mason Valley and San Felipe Valley, a barrier across the lower end of Vallecito Valley causes water to rise throughout a large area, forming a swamp that covers an area of a quarter section or more. Springs rise in all parts of this swamp, and it is covered with an almost impenetrable growth of mesquite, arrow weed, tule, grass, cottonwood, and other plants. A stream carrying probably 1 second-foot runs at places south of the stage station but disappears farther east in the gravel of its stream bed. The springs at which travelers obtain water rise in a mass of tule on the north side of the valley, away from the side whence comes the obvious contribution of water, and this suggests a possible connection with the fault lines to which the formation of this valley is believed to be attributable. (See p. 52.) The quality of this water is indicated by analysis No. 49 (p. 283). In general the surface water appears to be good.

The Campbell ranch, at the west end of the valley, utilizes some water from the canyon below Mason Valley and some from small hillside springs developed west of the house for domestic purposes and irrigation. Otherwise no attempt at development has been made. Grass grows abundantly in the borders of the swamp and makes good pasture, for which it is used almost continuously. It is probable that considerable water could be impounded by a dam below the springs but perhaps not enough to justify the expense, for the structure would have to be long enough to extend up the gentle northern slope of the valley. Moreover, the only land on which the impounded water could be used is in Carrizo Valley, 8 or 10 miles away. Water could doubtless be obtained in relatively shallow wells in a small area of good land bordering the swamp, and the evident pressure on the waters that rise here indicates a fair possibility of obtaining flowing wells in the low parts of the valley. The water table is undoubtedly deep on the sides of the valley.

CARRIZO VALLEY.

Carrizo Valley lies between Carrizo Mountain and Fish Mountain, east of the Laguna Mountains. Most of its area is occupied by badlands developed in soft Tertiary strata. The badlands are not suitable for agriculture and probably do not contain much ground water. Some ground water occurs along the immediate channel of Carrizo Creek, which is dry except for a stretch of about 1 mile near Carrizo Station, where it flows perennially. Considerable water is supplied to this valley by Carrizo and Vallecito creeks and small mountain streams, and this water could probably be developed at favorable places.
Indications of water are common along the channel cut by Carrizo Creek through the badlands. This channel usually supports a growth of mesquite bush and at some places considerable grass, so that the water is probably shallow over most of its area. Its depth may range from practically nothing to 50 feet. Strabley’s well, at Carrizo, is a 12-inch drilled well, 360 feet deep, which is said to have reached bedrock and which once yielded a small flow at the surface. At present the water in the well stands higher than the surface of the adjoining stream.

The conclusion seems warranted that a considerable body of water exists along the course of Carrizo Creek as underflow in the stream gravel. Whether a permanent body of ground water extends under the badlands is problematical, but there is no apparent reason why they should not contain water, wherever the rocks are pervious enough to permit its infiltration, at approximately the level of Carrizo Creek.

Artesian water is not likely to be obtained in any valuable quantity in this valley, because there is no extensive covering to entrap it and no intake area high enough to provide artesian head. The supply is practically all from the underflow of Carrizo Creek, which in places approaches very near or even reaches the surface.

The quality of the water is a matter for serious consideration; that of Strabley’s well (see analysis No. 9, p. 283), though considered usable locally, is highly mineralized and probably hardly fit for irrigation, and the creek water at the same place tastes bitter and deposits much alkali in the stream bed. The fact that these waters are percolating through soft rocks that contain much mineral matter such as gypsum and other salts suggests that they have probably assimilated too much alkali to be of use for irrigation. It is possible that in the west end of the valley, above the junction of Carrizo and Vallecito creeks, better water might be obtained in wells, as that area is nearer the source, and the water supplied from the mountains is originally very pure.

Very little agricultural land is available anywhere in the valley. Although the ground water in this valley has some value, it appears that efforts at conservation should be directed more toward saving the water as it emerges from mountain canyons than toward development of the ground-water supplies.

**Borego Valley.**

Borego Valley slopes from an altitude of 1,000 feet at its north end, where Coyote Creek spreads out its broad alluvial fan, to about 500 feet just west of Borego Spring. This slope is fronted by a ridge composed chiefly of coarse detrital sand that slopes northward from The Narrows. Where the opposing slopes meet the ground is practi-
OCCURRENCE AND QUALITY OF WATER.

Caly level, and in places extensive sun-cracked mud flats indicate that water sometimes stands on the surface. There is, however, an outlet to the east through the arroyo in which Borego Spring is situated. A United States Geological Survey bench mark gives the elevation as 452 feet near the cabin at the spring. The arroyo at Borego Spring is a rather wide channel cut to a depth of 50 or 100 feet below the level of the bordering clay hills, which are composed of folded, loosely consolidated Tertiary sediments. North of Borego these clay hills bound the valley on the east in a line running directly toward Coyote Mountain. East of this line the clay hills rise to elevations of 1,000 feet and are dissected into typical badlands. South of Borego they continue an unknown distance. On the west high mountains rise precipitously above the valley to heights of 5,000 feet, and at their bases considerable alluvial slopes spread out and merge with the even valley floor. On the northeast an escarpment 500 feet or even more in height extends from Coyote Mountain up Coyote Creek and separates Borego Valley from Clark Valley.

A number of small mountain streams west and north of Borego Valley have a perennial flow, and their water sinks into the gravel at the valley border. The largest stream is Coyote Creek, the flow of which is estimated by local residents at 100 to 300 miner's inches (1,100 to 3,300 gallons a minute). There is a considerable rainfall on the ranges to the west, which are above 5,000 feet in height, and all the run-off of the eastern slope adds to the ground water of Borego Valley.

Only a few wells have been put down in the valley, and of some of these nothing could be learned. T. O. Fewell has a dug well in sec. 10, about 30 feet deep, in which the water level is at 21 feet below the surface. About a mile to the southeast are two wells owned by Jack French, of Brawley, one of which yields an artesian flow of 10 gallons a minute from an unperforated casing 2 1/2 inches in diameter. Another similar well near by flows a little less. The wells are reported as being 78 and 68 feet deep. Still farther south, probably in sec. 14, is an artesian well by the roadside, which yields a flow of probably more than 10 gallons a minute from a 4-inch casing reduced to a 1-inch outlet. The depth of the well is not definitely known but is not great, as it is said that no wells much more than 100 feet deep have been drilled in the valley.

In the vicinity of Borego Spring there is every indication of the escape of a considerable amount of water held under slight artesian pressure. This is indicated by a marsh several acres in extent containing numerous seeps of water and a rank growth of moisture-loving plants. Moreover, in much of the lowest part of the valley west of this outlet ground water is constantly being discharged at
the surface, as is indicated by a luxuriant growth of salt grass and a slight alkali incrustation on the soil.

Conditions appear ideal in this valley for the development of a good-sized artesian basin. A considerable continuous supply of fresh water from the mountains sinks into the valley and becomes confined beneath the impervious layers of fine silt and clay deposited lower in the valley. The artesian head is probably sufficient to give considerable flow in the lower part of the valley if wells were drilled deep enough and large enough to get its full benefit. Such wells should be not less than 300 feet in depth.

The quality of the water is not very well known. Water from one of French’s flowing wells and from Borego Spring has been analyzed. (See Nos. 7 and 6, p. 282.) That of Borego Spring should indicate probably the highest concentration of the valley waters, as it escapes through the Tertiary clay beds at the outlet of the valley. It is high in sulphate and probably not wholly satisfactory for irrigation but is considered a fair water for stock and is used for drinking. Well water of desirable purity should be obtainable in the valley farther west and north.

Lack of railroads or even passable wagon roads has retarded any attempts to develop the valley agriculturally. It has considerable areas of good grazing land and has been used largely for cattle range. In the winter of 1917–18 several homesteaders had taken claims in the valley and were attempting in a small way to try out the land and water for farming. Undoubtedly part of the valley contains good farm land, which will some day be developed.

**CLARK VALLEY.**

Clark Valley, which centers around Clark Dry Lake, in Tps. 9 and 10 S., R. 7 E., is an inclosed basin of considerable size at the south side of the Santa Rosa Mountains. It is very inaccessible and was not visited during this investigation, but ground water must occur near the surface around Clark Dry Lake, as Clark Well is reported to be a shallow dug well. The topographic features of the valley suggest that it contains a considerable body of ground water.

**PLEASANT VALLEY.**

Pleasant Valley lies mainly in the western part of T. 3 S., R. 9 E., north of the Cottonwood Mountains and south of the Hexie Mountains. It receives the drainage from parts of the northeast slope of the Cottonwood Mountains and a long strip of the upland to the north. Water for cattle has been much desired in this valley because it has a fairly good growth of bunch grass, but the only supply available is at Pinyon Well, in the mountains on the southwest, and that is generally taken by mining companies. In the playa south of
the abandoned mining camp on the hillside a hole about 60 feet deep was dug, but no water was found. It penetrated bedrock at the bottom. Other holes even deeper are said to have been made in the valley but with no success. In the eastward-draining wash about 3 miles from the playa there is an old well at the site of an abandoned mill. It apparently once had a pump attached and must have yielded some water.

A considerable flow of ground water must escape from this basin into the desert on the east, and this water could probably be obtained by drilling where the bedrock underlying the valley is lowest. The sinking of a hole a little farther south away from the playa might be suggested in the hope that the lowest part of the bedrock depression will be found there, as it appears not to be beneath the playa. Undoubtedly water could be had at some places in the canyon to the east that drains the basin, although not enough was seen of it to warrant recommending any particular site. The most favorable place would be where the canyon is narrow, with solid rock on either side.

PINTO BASIN.

South of the Pinto Mountains and north of the Eagle and Cottonwood mountains is a large basin centering in T. 3 S., R. 12 E. It contains no settlements or watering places, so far as known, and only a road along the west side of the basin was traveled in making the present investigation. The lowest part of the basin is 1,300 feet above sea level, but the low interior is nearly surrounded by mountains that rise to an altitude of 4,000 feet. A considerable area in the mountains is tributary to this basin, but the precipitation on this area is small. Pinto Basin probably receives ground water from Pleasant Valley, and it may discharge underground into other basins on the north and east. Little is known of the mountain barriers there except that they are broken by high alluvial divides. A dry hole 140 feet deep is reported to have been dug in the center of this basin.

Undoubtedly a large amount of ground water sinks into this basin and should be found by drilling perhaps not more than 200 feet deep, at its center. The quality of the water would probably be rather poor.

BLYTHE JUNCTION BASIN.

Blythe Junction Basin is an inclosed desert basin lying north of the Maria Mountains, west of the Riverside Mountains, south of the Turtle Mountains, and east of Arica Mountain. The lowest part of the basin is somewhere near the center of T. 2 S., R. 21 E. On the east, between the Maria and Riverside mountains, an alluvial divide of unknown height separates it from the valley of Colorado River.

81 Merrill, F. J. H., Mines and mineral resources of Los Angeles, Orange, and Riverside counties, Calif., p. 77, California State Min. Bur., 1914.
82 Idem.
and a similar divide between the Riverside and Turtle mountains separates it from the same valley farther north. Only a low alluvial divide north of Arica Mountain forms the boundary between Blythe Junction Basin and the basin of Danby Dry Lake. Southwest of the basin a high and rather narrow alluvial fill between the Maria and Palen mountains separates it from Chuckwalla Valley. Approximately the south half of the basin is shown on the map (Pl. III).

Wells are known at five places in the basin, two of which (Gyp and Brown wells) are within the area mapped and three are farther north. The Gyp Well is 585 feet deep and is reported to have reached poor water at 125 feet. This was cased out, and good water for domestic use obtained at greater depth. There seems to be some reason to doubt the statement that water was reached at 125 feet, as explained below. The Brown Well was 304 feet deep and the water level was 297 feet below the surface in October, 1917. About 2 miles north of the Brown Well, at a higher elevation, is the Priest Well, 587 feet deep, in which the water level is 507 feet below the surface. Near the center of the basin, 2½ miles northeast of Brown Well, is the Gray Well (abandoned), at which water was reported to have been 137 feet below the surface. At Rice (formerly called Blythe Junction), about 6 miles east of north from the Brown Well, water was reached at a depth of 355 feet in a railroad well, now abandoned.

The only information available as to altitudes in the basin is that afforded by the profile of the California Southern Railroad, which goes south from Rice, crossing near the center of the basin and leaving it through the pass between the Little Maria and Maria mountains on the south side. The figures of altitude given on this profile, by comparison with profiles of the Parker branch and main line of the Atchison, Topeka & Santa Fe Railway, appear to be about 40 feet too high, and the proper correction has been made in the figures given here. The altitude of this pass is 1,040 feet above sea level. The lowest point on the profile, near the Gray Well and only a little west of the center of the basin, is 705 feet above sea level; Rice is 935 feet above sea level. From the depth to water at Rice, 315 feet, the water table there appears to lie 580 feet above sea level. Assuming that the Gray Well is approximately 710 feet above sea level, and using the depth to water given as 137 feet, we find that the water table there would be 573 feet above sea level, which corresponds rather closely with that at Rice. The Brown and Priest wells start at successively higher altitudes and go correspondingly deeper to water, which indicates that the level of the water table is nearly constant beneath the valley. As the Gyp Well is very near the outer edge of the valley, at probably 860 feet above sea level, it seems doubtful whether water could be expected there at the reported depth of 125 feet.
Blythe Junction Basin does not appear to have an area of groundwater discharge at its center. Though the writer has not visited the lowest part of the basin and has no definite information as to its nature, it appeared from a distance to be covered with sand dunes and to be devoid of the rank dark mass of vegetation that usually denotes an area of shallow water. The depth to water at the Gray Well, not far from what appears to be the lowest part of the basin, would indicate that there water is considerably below the surface. It appears likely that discharge of ground water is effected by subterranean drainage eastward to the Colorado River valley, which in this vicinity lies 350 feet above sea level. This allows an ample gradient for subterranean drainage. It is possible, too, that the waters of Danby Basin to the northwest may be connected with those of this basin through the wide alluvial fill between the two and may add some water to the supply of Blythe Junction Basin.

The water in this basin is of rather poor quality. The railroad well was abandoned because the water was unsuitable for use, and the water at the Gray Well was too salty to drink, being used only in gold milling. The Priest Well yields water unsuitable for domestic use (see analysis No. 42, p. 283). The Brown Well yields drinkable water (see analysis No. 8, p. 282), and the water at the Gyp Well is reported as good.

In general, it appears that a large body of ground water exists at a rather uniform elevation beneath this basin and may be obtained by drilling to this level in the valley fill. Its quality, however, is variable. There does not seem to be any probability of obtaining flowing wells in the valley. Both the poor quality of most of the water and its depth are unfavorable for irrigation from wells within the limits of the basin.

CHUCKWALLA VALLEY.

Chuckwalla Valley, including the two basins centering around Ford Dry Lake and Palen Dry Lake, is nearly surrounded by mountains that rise 2,000 to 4,000 feet above sea level. Between the mountain ranges on the north and west are alluvial divides that rise to 1,500 feet or more. The lowest part of the valley is in Ford Dry Lake, which, according to surveys made by irrigation companies, is bounded approximately by the 360-foot contour. Between Ford Dry Lake and the Palo Verde Mesa, east of it, is a low alluvial divide which reaches across the valley from the McCoy Mountains to the Mule Mountains and the lowest part of which is about 460 feet above sea level. A similar divide, about 440 feet above sea level at its lowest point, runs from the south end of the Palen Mountains toward

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the Chuckwalla Mountains, separating Ford Dry Lake from Palen Dry Lake. The bottom of Palen Dry Lake is apparently between 400 and 420 feet above sea level, but the survey was not complete in this part of the valley.

Chuckwalla Valley contains over 200,000 acres of land suitable for agriculture if water could be provided for it. In addition there is more than 100,000 acres just east of it, at about the same elevation, on a plain lying above the Colorado River terrace that forms the western boundary of the Palo Verde Valley. This plain is generally known as the Palo Verde Mesa. A number of projects for the irrigation of these lands have been broached in recent years,\(^4\) of which that of the Chuckwalla Development Co. about 1910 was probably the most serious. It was intended to irrigate the land with water from Colorado River, and power would have had to be generated to lift the water to canals at the elevation of the mesa. On account of excessive cost and engineering difficulties the project was abandoned after surveys and investigation. Irrigation by pumping from wells has also been considered, as ground water is found at varying depths under all the arable land. As usual, hopeful persons have expected to obtain artesian water, and the fact that water has risen near the surface in some deep wells has helped to increase this expectation. Probably a score or more of deep borings have been made, but unfortunately no records were kept of most of them, and even the location of many of the wells is now unknown. Attempts at irrigation from wells so far have not been successful, although failure may not be due entirely to the quality or quantity of water.

Ford Dry Lake is a barren flat exhibiting the smooth, mud-cracked surface of a typical playa, but it shows no signs of being an area of ground-water discharge. The scant vegetation on its surface and around its border is chiefly creosote bush. Several wells drilled on its edges show the water table to be 70 feet or more beneath its surface.

Palen Dry Lake, from all information available, is a place of ground-water discharge. The writer has not visited this playa but is informed on good authority that at places it supports a rank growth of mesquite and salt bush, which are indicators of water at a slight depth. A number of wells have been dug at its edges and have reached brackish water at 14 feet or less. Water is said to be 10 or 12 feet below the surface under most of the playa. It seems, therefore, that some ground water is dissipated through plants, and it is quite possible that in parts of the playa there is direct evaporation of ground water.

The ground water of Chuckwalla Valley doubtless originates within its drainage basin. The divide on the west, between the Eagle and

\(^4\) California Conservation Comm. Rept., 1912, pp. 317-318
Chuckwalla mountains, is certainly effective as a barrier to ground water. It is rather narrow and at several places has outcropping ridges of bedrock, which indicate that the rocks are not buried deeply. Moreover, the water table near the west end of Chuckwalla Valley slopes eastward, as shown below, and not westward, toward Salton Sea. A high and rather narrow divide on the northwest, between the Eagle and Coxcomb mountains, separates this basin from the basins around Dale and is probably also an effective barrier. Between the Coxcomb and Palen mountains, directly north of Palen Dry Lake, a high but wide alluvial divide separates the valley from the basin of Cadiz Dry Lake, nearly 40 miles away. Little is known of that playa except that it is about 600 feet above sea level, and even if there is connection between the ground-water reservoir of Chuckwalla Valley and that of the Cadiz Basin there is probably no loss of water from Chuckwalla Valley into that basin. The divide lying between the Little Maria and Palen mountains and separating Chuckwalla Valley from Danby and Blythe Junction basins is narrow and has the appearance of being underlain at shallow depths by bedrock such as is exposed in the adjacent mountains. A large area south of Chuckwalla Valley is in part mountainous and in part appears to be underlain at shallow depths by volcanic rock. The fact that the water table, as shown by the Wiley Well, rises rapidly to the south also indicates that little or no water escapes in that direction to the Salton Basin.

On the east, however, the conditions are different. The water table apparently extends as a continuous surface between the McCoy and Mule mountains from Chuckwalla Valley to the Colorado River valley, which lies at the lower level and consequently receives water from Chuckwalla Valley.

The following table of wells gives information as to the altitude of the water table in Chuckwalla Valley and the adjacent part of the Colorado River valley, known as Palo Verde Valley. It affords a basis for conclusions as to the relation of the ground-water bodies in the two valleys. Altitudes of the surface at the wells are estimated from contour lines on the irrigation maps and may be somewhat in error.
Water levels in wells of Chuckwalla Valley and Palo Verde Valley.

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<th>Depth to water</th>
<th>Altitude of water table above sea level</th>
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</tr>
<tr>
<td>11</td>
<td>Palen Playa</td>
<td>31</td>
<td>16</td>
<td>20</td>
<td>410</td>
<td>16</td>
</tr>
<tr>
<td>12</td>
<td>Palo Verde Valley, 3 miles west of Blythe</td>
<td>260</td>
<td>0</td>
<td>250</td>
<td>260</td>
<td>0</td>
</tr>
<tr>
<td>13</td>
<td>Colorado River east of Blythe</td>
<td>260</td>
<td>0</td>
<td>250</td>
<td>260</td>
<td>0</td>
</tr>
<tr>
<td>14</td>
<td>Willey Well</td>
<td>9</td>
<td>8</td>
<td>20</td>
<td>700</td>
<td>10</td>
</tr>
</tbody>
</table>

*This is probably a perched water table. See description of well, p. 250.*

From the information tabulated above a profile of the water table (Fig. 9) has been drawn through points 1, 2, 11, 3, 6, 7, 8, 9, 12, and 13, following approximately the axis of Chuckwalla Valley and extending east to Colorado River. It shows that the water table slopes gradually from the west end of Chuckwalla Valley toward Colorado River valley but rises slightly under the Palo Verde Valley, which is practically a flood plain over which the river flows between natural levees at an elevation higher than that of the outer parts of the plain. This reversal of slope is undoubtedly due to the fact that the Colorado

![Figure 9: Profile of water table through Chuckwalla Valley to Colorado River.](image-url)

is an influent stream in this desert region, and percolation from the river maintains a supply of ground water beneath the adjacent land. The fact that the gradient of the water table is steeper in the western part of Chuckwalla Valley indicates that the contribution to the ground water beneath the valley is greatest from that direction, as might be expected, because the Eagle and Chuckwalla mountains are higher and more extensive than most of the other ranges.

As the water table slopes away from Colorado River at Blythe, a question arises as to what becomes of the ground water that per-

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*An influent stream is one whose surface is higher than the local water table and which is not separated from the water table by any impervious bed.*
colates eastward from Chuckwalla Valley. In fact, much of this ground water ultimately reaches Colorado River. On the west side of Palo Verde Valley at the foot of the main terrace is a strip of marshy land or sloughs where water stands at or near the surface. Farther south, at Palo Verde, where the elevation is somewhat less, these sloughs unite into a well-defined stream called the Laguna, which runs perennially and discharges a large amount of water into Colorado River a few miles below Palo Verde. Its mouth is about 25 feet lower than the marsh west of Blythe and still more below the level of the Colorado east of Blythe. It appears that the flow of ground water through the valley gravel is constricted by the Palo Verde Mountains, which approach very near the river, and a large amount of the water that originally percolated from the Colorado, together with any contributed by the Chuckwalla Valley, reaches the river at this point. The opinion that ground water from Chuckwalla Valley mingles with that of the Colorado River valley seems further justified by the fact that the ground water of the Palo Verde Valley is highly variable in quality, some of it being too salty to drink or use for irrigation. This mineral content can not have been originally contained in the river water that percolates into the soil. (See analyses, pp. 282–283.)

The only place at which the gradient of the water table beneath Chuckwalla Valley approaches the land surface is about Palen Dry Lake. As the water table rises rather rapidly west of this place it is possible that weak flows of good water might be obtained from deep wells on the west and possibly on the north sides of the playa. The shallow ground water is all brackish and probably unfit for use, but better water might be had at greater depths and would be likely to rise as high as the water near the surface, if not higher. Unfortunately, however, the soil in the vicinity of the playa is alkaline and may be unsuitable for agriculture. However, it is possible that water might be obtained on good land in the territory mentioned, either from flowing wells or by pumping from a reasonable depth.

The water table rises from the playas toward the mountains but much more gradually than the land surface, and as the mountains are approached the water consequently becomes deeper and deeper. Its availability for irrigation depends on the depth from which pumping is economically feasible.

Not enough water can ever be obtained to develop more than a small part of the land that is otherwise adapted to farming, but this should not prevent the utilization of the water available. The annual rainfall in this area is probably less than 3 inches, and of this only a very small part is added to the underground supply.

Unfortunately, the water from wells so far drilled in Chuckwalla Valley does not show any very encouraging analyses. (See table on
However, Mr. Hopkins reported excellent water from deep strata in the Hopkins well, and the chances are that fair water would be found at some level in a deep well almost anywhere in the valley. The height to which water will rise seems relatively independent of the stratum from which it comes, and undesirable water might be cased out.

**Palo Verde Mesa.**

Ground-water conditions under Palo Verde Mesa are suggested in the description of the Chuckwalla Valley, where it is shown that there is connection between the two and between the waters of the mesa and those of Colorado River valley on the east. Information as to the mesa is based on four wells and may be tabulated from north to south as follows:

<table>
<thead>
<tr>
<th>Wells on Palo Verde Mesa.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Well</td>
</tr>
<tr>
<td>------</td>
</tr>
<tr>
<td>Sec.</td>
</tr>
<tr>
<td>---</td>
</tr>
<tr>
<td>25</td>
</tr>
<tr>
<td>20</td>
</tr>
<tr>
<td>31</td>
</tr>
<tr>
<td>26</td>
</tr>
</tbody>
</table>

The altitudes at the surface are estimated from the irrigation surveys and are accurate within a few feet. The inference seems safe that beneath the mesa there is a permanent body of ground water whose upper surface is 240 feet or more above sea level, which makes it at least 100 feet below the land surface on the lowest parts of the mesa and probably much deeper toward the borders.

The quality of this water is indicated by only one analysis, that of the Patterson Well, on the road in sec. 31, T. 6 S., R. 22 E. The water of this well is locally considered excellent and seemed satisfactory where tried in a small way for irrigation. The analysis (see No. 41, p. 283) shows a rather high mineral content but not too high for an irrigating water, especially where the soils are so porous and well drained as those of this bench. It is questionable, however, whether water can be economically lifted 100 to 150 feet for use in irrigation. Mr. Patterson used a 2-horsepower gasoline engine for pumping water and reported the capacity as 1,500 gallons an hour and the cost for operation as 4 cents an hour, which would amount to $8.68 an acre-foot, probably an excessive cost for irrigating water under most conditions.

**Arroyo Seco Valley and Adjacent Areas.**

The largest drainage basin tributary to Colorado River within this region is that of the Arroyo Seco, in northeastern Imperial County.
It lies south of the Chuckwalla and Palo Verde mountains and north of the Chocolate Range. Similar to this in surface features and in ground-water conditions is a contiguous territory between the Little Chuckwalla, Mule, and Palo Verde mountains, which, although it drains northward to Chuckwalla Valley, deserves rather to be described here. The surface slope of the Arroyo Seco valley is fairly steep, the Arroyo Seco descending in its 40 miles of length from an altitude of about 2,500 feet at the divide in T. 8 S., R. 16 E., to 200 feet at Colorado River. The valley is made up of rather even surfaced plains broken here and there by low ranges of projecting hills and isolated peaks which bear witness to the thinly covered rock surface that is veneered over by alluvial deposits. Most of the rock exposed in the region is a porphyritic rhyolite, probably of Tertiary age, which seems to underlie a great part of the plain at no great depth. The Palo Verde Mountains and the hills around Smith Well are composed entirely of this rock. The Black Hills are largely the same, although at places in that range the lava flows rest on granite. Volcanic rock is also found at places in the Chuckwalla Mountains, but that range is chiefly composed of granite and plutonic rocks older than the lavas. The Chocolate Range is a complex of Tertiary volcanic and older crystalline rocks. Some of the lava hills that dot the plains are evidently tilted buttes, composed of lava sheets that dip beneath the recent sediments on one side and are exposed in scarpns on the opposite side. There is no drier or more poorly watered area in the southwestern desert than the Arroyo Seco valley. The Arroyo Seco and other washes that drain this plain are dry except for brief periods during the infrequent rains. The only well within the plain which derives water from it is the Smith Well on the Blythe-Glamis road. The Wiley and Chuckwalla wells are on the northern edge of the valley, and Salvation Spring and the Peg Leg Well are near its southern boundary. Mr. J. M. Shiner, superintendent of mill construction at the Smith Well, reported that in a wash 5 miles northeast of that place a hole was dug 290 feet deep. It penetrated what he called a "tufa" formation but did not reach water, though the bottom of the hole was below the Colorado River level. Several holes have been dug southwest of the Smith Well, but no water was found even where mesquite brush was taken as an indication. The Paymaster mine, 3 miles southwest of the Smith Well, has a dry shaft 400 feet deep.

Apparently all the ground water in the Arroyo Seco valley percolates freely to Colorado River, but that of the wash that runs from Chuckwalla Well to Wiley Well finds its way into the ground-water reservoir of Chuckwalla Valley, farther north. Nevertheless it is probable that small bodies of ground water exist in local subterranean reservoirs and might be tapped along drainage courses, as at
the Smith Well. The most favorable places to look for water are in the dry washes where bedrock crops out in the vicinity on either side and appears to be near the surface. In the wash above the Wiley Well water collects at places above clay beds and is held in stream gravel near the surface. At the old Mule Springs stage station, 6 miles from the Wiley Well, water was once obtained from such gravel in a shallow well, and doubtless similar conditions exist elsewhere both in that wash and in the Arroyo Seco. About halfway between the Wiley and Chuckwalla wells, where the road follows a wash through the hills connecting the Chuckwalla Mountains and Black Hills, water could probably be obtained at several places in the washes at depths of less than 100 feet. Several patches of mesquite were seen just north of two little lava buttes about 3 miles southeast of Chuckwalla Well and may possibly indicate a little water, although the bushes are not luxuriant. The chief trees in the washes are ironwood, palo verde, and black willow, none of them very good indicators of water. Water is needed in this area mainly for mining purposes, as the possibilities of irrigation are too small to be worthy of consideration.

COLORADO RIVER VALLEY.

Along Colorado River there is a strip of lowland of varying width that is more or less subject to overflow. It is separated from higher land away from the river by a conspicuous bluff 50 to 100 feet in height at the front of a terrace that represents a former level of the valley fill deposited by the Colorado. The lowland between the river and the bluff has a soil composed of very fine silt and sand. It is excellent agricultural land, and large bodies of it have been reclaimed by irrigation in Palo Verde and Yuma valleys, where the lowland strip is several miles wide. Under all the lowland ground water occurs at or very near the surface, its presence being shown by heavy growths of mesquite and willows and other plants indicative of water. Wherever there is need for water, wells are sunk in the soft soil and an abundant supply is obtained.

PALO VERDE VALLEY.

Palo Verde Valley centers around Blythe and Palo Verde and is being rapidly developed by irrigation, for which water is diverted from Colorado River. (See pp. 243–244.)

The highest altitude of the lowland around Blythe and to the north is about 275 feet above sea level. Farther south, around Palo Verde, it is not more than 230 feet. The western part of the lowland near the foot of the bluff averages slightly lower than corresponding parts farther east. In this low area on the west water stands the year around in numerous lagoons and marshes. Driven wells are easily put down and reach water at depths of not more than 10 or 20 feet.
in all parts of the valley. In the town of Blythe the water level is 6 to 12 feet below the surface, and as there is no municipal supply, all domestic water is obtained from wells.

Wells of any size are put down by the method of sand pumping. All the wells reported were less than 150 feet deep. The material penetrated is fine sand or gravel, with a few boulders below 100 feet.

The quality of the water is generally good. Three samples collected in the town of Blythe show almost identical analyses. (See Nos. 3, 4, and 5, p. 282.) The shallow water is said to taste slightly of the humus in the soil, and for that reason driven wells are usually sunk to depths of 20 feet or more. Most of the wells are not more than 100 feet deep. Much of the water in the south and west end of the valley is said to be distinctly salty, and some of it has been found unsatisfactory for irrigation. There is a noticeable variation both in different levels of the same boring and at different places in the same vicinity. The analyses of water from Rannells and Palo Verde (Nos. 43 and 39, p. 283) show a somewhat greater mineral content in the water of that area.

The source of most of the ground water in the Palo Verde Valley is undoubtedly the seepage from Colorado River. The differences in mineral content between the well waters and the river water must be accounted for either by the taking up of mineral matter by the water from the deposits underlying the valley, through which it percolates, or by admixture with ground water and surface water from adjacent areas. It appears reasonable that Chuckwalla Valley, which contributes ground water from the south and west, should affect the waters of Palo Verde Valley considerably and account in part for the diversity of composition, particularly in the south end of the valley.

Ground water is being used to some extent in the valley for irrigation. Some of it is not as pure as river water but apparently is safely within the limits of irrigation water under conditions that are at all favorable. The lift is not great, and the yield of properly constructed wells is generally large. Mr. E. A. McDonald, of Blythe, an experienced well driller in the valley, reports a number of wells that deliver 100 to 200 miner's inches (about 1,100 to 2,200 gallons a minute). Two wells on the ranch of James Wilkinson, 2½ miles west of Blythe, fitted with a centrifugal pump and a 32-horsepower engine, are said to yield 150 miner's inches (about 1,650 gallons a minute) under continuous pumping. The water level before pumping is 9 feet, and the drawdown is reported to be 15 to 18 feet. It seems probable, however, that the river water will prove cheaper and more desirable in quality for irrigation than well waters.
Yuma Valley lies north of Yuma on the California side of Colorado River and comprises a large body of lowland which, like Palo Verde Valley, is being developed by irrigation from Colorado River. Most of the valley belongs to the Yuma Indians and is cultivated by them under Government supervision. Although ground water is present very near the surface under all the valley, it is used only for domestic supply. Wells for this purpose are driven and are usually less than 20 feet deep. A 2-inch pipe is generally used, and a hand pump is attached. The ground water in this area is supplied by seepage from Colorado River, and the water table is said to fluctuate noticeably with the stage of the river, which without levee protection would inundate a large part of the valley in summer flood seasons. The quality of the ground water in the valley is somewhat variable, some of it being reported as poor for drinking. No samples were collected, and practically no time was spent in studying the ground water of this valley.

KINDS OF DESERT WATERING PLACES.

Water occurs in numerous and widely differing ways over the desert in scattered watering places of several kinds. The principal types are springs, streams, wells, natural tanks, and cisterns or other artificial reservoirs.

SPRINGS AND STREAMS.

In the aggregate there are a large number of springs in the region, but many of them are widely separated. They were originally the main source of supply for desert travelers but are now greatly supplemented by numerous wells. In the mountain areas of moderate rainfall springs of the hillside type are common in granitic rocks. Hillside springs are supplied by water seeping from fractures in the rocks. At the point of discharge there is usually a mass of soil weathered from the rock and remaining in position as a residual cover, which protects the water from direct evaporation and causes slow seepage. Such springs are often indicated by water plants and slight seeps, and more water can be developed by tunneling into the soil and rocks, but never a large supply. Mountain Springs is a good example of this type. Another kind of spring frequently seen is that caused by a rock dam or other obstruction across a canyon or stream course. Such are Grapevine Springs and Hidden Spring. A third type is the artesian spring, in which ground water under pressure rises to the surface at some pervious point in the strata above and forms a pool on the nearly level surface of the desert basin.

Cory, H. T., Imperial Valley and Salton Sink, p. 1245.
Fish Spring, Figtree John Spring, and others in the southern Coachella Valley are the most noted springs of this type. These three types include most of the springs in the Salton Sea region.

Streams are also used as watering places, especially Colorado River and the streams of the Peninsular Mountains. Many springs supply streams that flow for a short distance and are of some importance as watering places.

**Wells.**

Wells of various sizes and depths have been dug or drilled in this region. They tap the supply of ground water either in large basins or along dry stream channels or near running streams. They are sunk when water is needed and abandoned when this necessity disappears. Consequently no catalogue of desert wells is a permanent record of watering places. However, certain wells tap the only supply of water that is easily attainable in large areas, so that their existence as permanent landmarks is almost as assured as that of springs.

**Natural Tanks.**

Natural tanks are found only in watercourses over hard rock, chiefly in mountain ranges. They are merely depressions in the stream bed, of such shape that they hold water after a rain. Most of them are little hollows at the foot of waterfalls that exist while water runs in the canyons after a rain. They are usually full or partly full of gravel and boulders, and the water fills the interstices. It is often necessary to dig out the gravel in order to get water. Some tanks that are large and well shaded hold water the year around. Others hold water only a few days or months after a rain. Fractures in the inclosing rocks may allow them to drain slowly. The gravel filling is a protection against animals and evaporation.

**Artificial Reservoirs.**

Artificial reservoirs in this region are few. They may either catch the supply of a spring or well or may be made by damming canyons to impound a stream or catch rain water. In the Imperial Valley much of the water for domestic use at ranches is ditch water that has been run into small ponds or reservoirs and allowed to settle and clarify. Cisterns to catch rain water from roofs are seldom found in this region. At many stations along the Southern Pacific Railroad large cisterns have been sunk in the ground and are filled with water hauled by rail from Mecca, Yuma, or other places, to supply domestic and other needs of railroad employees and travelers.
A knowledge of certain principles that govern the accumulation of water on the surface or underground is useful in looking either for immediate supplies or for places to develop permanent supplies of water. Because of the fundamental principle that water runs downhill, it seeks the lowest place, either on the surface or underground, to which the nature of the topography or the rocks will allow it to penetrate. Thus all surface streams flow along valleys and occupy the beds of stream channels. In the desert the nature of the underlying rock has much to do with the flow of water, for small streams are completely absorbed where they pass over porous material. Therefore, although a streamway may be dry in most of its course it may contain running water at some point where it passes over impervious rock such as granite or beds of clay. Streams may flow in the mountain canyons but disappear in the desert. They flow most commonly where the canyons are very narrow and where bedrock forms the stream channel. These are features to search for in looking for water.

Along the Colorado River lowlands surface water is often found in old lakes formed by abandoned stream channels, in places several miles from the river. On the Colorado delta the stream has numerous abandoned channels that receive flood water in the summer and may hold it in pools along their channels the year round.

The best prospect of finding ground water is along stream courses and in the bottoms of valleys, including the lowest parts of the desert basins. The water comes to the surface at some places as springs, most commonly either in mountain canyons which are narrow or in which hard rocks form the stream beds, or on nearly level ground in the lowest parts of desert basins. Springs may also occur where beds of clay or other impervious layers extend across arroyos and act as dams to impound the underflow. At some points in sandy districts an artesian spring becomes covered by a fixed sand dune and the spring rises through a little hill. Such springs occur west of the Salton Sea. Along the Colorado River lowlands ground water is very shallow at many places and may even come to the surface and stand in pools.

**Vegetation.**

Certain kinds of plants are more or less reliable indicators of water either at the surface or near it. The premier of all these in the Salton Sea region is the wild palm (*Neowashingtonia filamentosa*). It is an unfailing sign of a spring, or else water within a foot or two of the surface. Moreover, the tree stands up so conspicuously, with its
green head high in the air, perhaps 50 or 60 feet, that it is visible for long distances and makes an excellent natural signpost. It is found in most of the canyons or arroyos, particularly around the borders of the Salton Basin, in which water rises near the surface. It is also found at nearly all the artesian springs of Coachella Valley. Unfortunately, it does not always indicate good water; sometimes, indeed, it is found at springs of very bad water. But usually a healthy clump of palms means a spring of drinkable water. The palm does not extend to high altitudes. In the Peninsular Mountains it is seldom found more than 1,000 feet above sea level. In the eastern desert ranges it may extend as high as 2,000 feet. So far as known, however, it is absent from all the ranges near Colorado River in this region, probably because the water supply is too scant.

Salt grass (Distichlis spicata, Pl. VI, A) is a little forked-leaved grass common in lowlands where moisture escapes at the surface by evaporation or in moist areas about springs. It is usually found where palms grow but occurs also in many places where they are absent, and it is an almost equally good indication of water, which will be found not more than a few feet below the surface. The water, however, may be very brackish. Often better water is obtained by draining the seep or using it for a while, or by digging deeper.

The tule (Scirpus olneyi) and rush (Juncus) are certain indicators of shallow water and grow usually on the borders of springs or streams. They are said to indicate water of good quality. All of them are easily recognized by their long, smooth green stems. They grow to heights of 4 or 5 feet at places.

Mendenhall gives the following information:

Lowland purslane (Susevium portulacastrum) is a plant that grows on moist soils. It indicates water, but usually water of poor quality.

Wild heliotrope (Heliotropicum curassavicum), sometimes called "Chinese pusley," is one of the rarer plants. It grows only in moist soil, but since it has strong alkali-resisting powers the water near it may be brackish.

Arrow weed (Pluchea sericea) is a reliable indicator of ground water, but the depth is apt to be several feet, possibly 25. Usually, however, a heavy growth signifies water within 5 or 10 feet of the surface. Arrow weed is common along dry arroyos where there is a shallow subsurface flow and in basins where ground water is near the surface. It also grows freely beside pools or running streams. Wild cane is a reliable indicator of shallow water. It was observed in Coachella Valley, in Canebreaké Canyon, and in a few other places. It often grows to a height of 10 or 12 feet as a tall jointed stalk with green leaves at the joints.

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A certain type of salt bush (*Atriplex*) is a common occupant of areas where the permanent water level is near the surface. It occupies much of the Salton Basin and the Colorado River valley. In some places where it grows the water stands several feet below the surface but probably rises near to the surface by capillarity.

Trees of various kinds are good indicators of ground water. Willows in the jungles along the Colorado probably testify to the abundant supply of shallow ground water, though they also depend perhaps on overflow. The black willow (*Chilopsis linearis*) of the dry washes in mountain canyons appears to be no reliable indicator of permanent ground water, although it is evidence of at least an unusual supply of flood water. Cottonwoods and sycamores are reliable signs of a permanent water supply. They grow throughout a considerable range of altitude, being found up to at least 3,000 feet above sea level.

Mesquite in certain situations is regarded by desert dwellers as a reliable indication of the presence of ground water at places where no other sign of it can be expected. It grows luxuriantly at many localities in this and other parts of southern California. As a rule it is found in the lowland valleys, but it grows well at Grapevine Spring (altitude 3,400 feet) and is found extensively in upper San Felipe Valley, at the San Felipe ranch, in T. 12 S., R. 5 E. (altitude 2,500 feet). It occurs at the Anshutz Well, in the Eagle Mountains, at an altitude probably near 2,000 feet, and at the Packard Well, said to be 1,800 feet in altitude, in the Palen Range. It is most common in desert valleys and in mountain canyons wherever water rises near the surface.

There are different species of mesquite common in the desert, but the small variety known to desert dwellers as "running mesquite" (*Prosopis juliflora*) is the one considered the most infallible indicator of water. A closely related species known as the screw bean (*Prosopis odorata*) is somewhat less common. Both are leguminous plants, and *Prosopis juliflora* bears abundant pods of small beans, which have been used by the Indians in making bread.

A detailed study of the flora of the Salton Basin has been made by the Carnegie Institution of Washington, and it is stated by S. B. Parish that the mesquite prefers an open soil fairly free from alkali but is tolerant of widely varying conditions. He says further: "*Prosopis pubescens* [odorata] and more rarely *Prosopis glandulosa* [juliflora] are sometimes seen as solitary specimens on dry detrital soils, but they probably never grow where permanent moisture is beyond the reach of their deeply penetrating roots."

Data gathered by the writer on this subject are summarized in the following table giving places at which the mesquite has been seen.
and including a few significant wells near which it occurs but at which the depth to water appears to be greater than its roots can penetrate.

Data showing relation of mesquite trees to water level.

<table>
<thead>
<tr>
<th>Well</th>
<th>Location</th>
<th>Depth to water (feet)</th>
<th>Character of mesquite growth</th>
<th>Nature of soil</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adams</td>
<td>Palen Mountains</td>
<td>20</td>
<td>One lone mesquite bush beside well; some others not far away in bed of dry wash.</td>
<td>Stream gravel.</td>
</tr>
<tr>
<td>Anshutz</td>
<td>Eagle Mountains</td>
<td>8</td>
<td>Trench cut in side of canyon shows roots of mesquite penetrating crevices of rock to water; small clumps of mesquite in vicinity.</td>
<td>Granite, somewhat jointed and sheared.</td>
</tr>
<tr>
<td>Blair, R. W.</td>
<td>S.E. 24</td>
<td>34</td>
<td>Abundant mesquite 10 to 12 feet high near by.</td>
<td>Very porous sand, forms dunes in neighborhood.</td>
</tr>
<tr>
<td>Chuckwalla</td>
<td>33</td>
<td>7</td>
<td>Mesquite abundant locally in bed of dry arroyo.</td>
<td>Stream gravel and clay.</td>
</tr>
<tr>
<td>Clemens</td>
<td>317</td>
<td>13</td>
<td>Stunted mesquite bushes locally in dry arroyo.</td>
<td>Gravel and clay.</td>
</tr>
<tr>
<td>Cook, C. E.</td>
<td>N. 22</td>
<td>6</td>
<td>None..................................................................</td>
<td>Porous sand.</td>
</tr>
<tr>
<td>Imperial, new county well</td>
<td>1</td>
<td>18</td>
<td>None..................................................................</td>
<td>Porous sand and silt.</td>
</tr>
<tr>
<td>Frey, W. S.</td>
<td>SW. 18</td>
<td>6</td>
<td>Thick forest of trees 10 to 20 feet high in neighborhood.</td>
<td>Porous sand; forms large dunes in vicinity.</td>
</tr>
<tr>
<td>Harper</td>
<td>26</td>
<td>12</td>
<td>Abundant forests of mesquite 10 to 15 feet high in neighborhood.</td>
<td>Gravel and rock; well ends in limestone.</td>
</tr>
<tr>
<td>Indian Wells post-office</td>
<td>24</td>
<td>5</td>
<td>Large patch of mesquite locally in bed of dry arroyo.</td>
<td>Sandy silt.</td>
</tr>
<tr>
<td>Packard</td>
<td>Palen Mountains</td>
<td>18</td>
<td>Scattering growth 5 to 6 feet high near by.</td>
<td>Stream gravel.</td>
</tr>
<tr>
<td>San Felipe town site</td>
<td>5</td>
<td>13</td>
<td>Scattering growth 5 to 6 feet high near by.</td>
<td>Sandy silt.</td>
</tr>
<tr>
<td>Shaver</td>
<td>277</td>
<td>6</td>
<td>Plentiful clumps 10 feet high in vicinity.</td>
<td>Do.</td>
</tr>
<tr>
<td>Sternberg</td>
<td>SW. 10</td>
<td>13</td>
<td>Scattering growth 2 to 3 feet high all around.</td>
<td>Do.</td>
</tr>
<tr>
<td></td>
<td>347</td>
<td>12</td>
<td>Heavy timber of mesquite 10 to 12 feet high.</td>
<td>Do.</td>
</tr>
<tr>
<td></td>
<td>337</td>
<td>12</td>
<td>Somewhat lighter than two above.</td>
<td>Do.</td>
</tr>
<tr>
<td></td>
<td>47</td>
<td>13</td>
<td>Heavy timber over large areas.</td>
<td>Porous sandy silt.</td>
</tr>
<tr>
<td></td>
<td>Palo Verde Valley</td>
<td>0-12</td>
<td>Scattering but persistent growth over largest strip east of old beach.</td>
<td>Do.</td>
</tr>
<tr>
<td></td>
<td>Yuma Valley</td>
<td>8-15</td>
<td></td>
<td>Sand and silt.</td>
</tr>
<tr>
<td></td>
<td>Desert east of Imperial Valley</td>
<td>20-30</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Flowing well; water stands in arroyo 8 feet below well.

In every extensive tract that is covered with mesquite there is a gradual dwarfing of individual trees farther away from some central district in which water is shallow, suggesting that the size of the tree is a direct function of the depth to water. This relation, however, is probably modified somewhat by the character of the soil.

Figure 10 shows the relation of the tree's growth to the depth to the water table in typical districts where sufficient information is available to plot the surface relief and ground-water levels with considerable accuracy. Sections B and C are in the Harper Well and San Felipe district. They appear to indicate that the maximum depth at which a mesquite can reach water in this district is 40 to
50 feet. The soil is generally porous sandy silt but in places is rather compact clay.

Section A shows conditions in the Indian Wells region of Coachella Valley. The mesquite grows as a dense forest 15 to 20 feet high in low places and of somewhat less size on high sand dunes about Indian Wells, where the least depth to the water table is 32 feet and the maximum probably 50 feet on top of the dunes. The soil is an
exceedingly loose sand. It indicates a maximum depth to the water table where the plant grows freely of perhaps 50 to 60 feet.

Section D is a section from Alamo School to the new county well, on the east side of Imperial Valley. There is a strong flowing well at Alamo School. Water does not stand anywhere at the surface but is under artesian pressure for some distance east of the schoolhouse. Mesquite grows abundantly to heights of 10 or 12 feet west of the old beach, and it covers thinly a strip 2 to 3 miles wide above the beach to the east but is rather stunted. The depth to water at the line of disappearance is probably 30 to 40 feet. The soil is mixed sand and clay.

From the isolated occurrences tabulated it appears that healthy mesquite clumps in canyons and arroyos generally indicate water at a depth of less than 25 feet, although stunted specimens in small numbers may not be reliable indicators of water. Where mesquite covers large districts water is certainly present at depths probably less than 50 feet in any soil and less than 30 feet in very compact soil. Where healthy mesquite appears in isolated localities there is almost certainly water within at least 30 or 40 feet, usually less than 20 feet, of the surface. In examining carefully these isolated clumps of mesquite some good reason is nearly always discoverable for the presence of water near the surface, and the mesquite is especially valuable in seeking water because it appears to have overlooked but few of the possible places where it might get a foothold.

A great number of desert plants, particularly those inhabiting dry detrital slopes, "mesas," and sandy mountain arroyos, have no connection whatever with ground water and really are indicators of its absence near the surface. Creosote bush (Larrea tridentata) usually indicates nothing as to water and covers many large areas where ground water may be entirely absent. It thrives better, however, where a supply of water is available—particularly, it appears, in the coarse sandy soils of the mountain valleys.

Howard, Dr. V., The mesquite: Am. Naturalist, vol. 18, pp. 450-459, May, 1884. This author gives the habitat of the mesquite as including parts of the United States south of the 37th parallel, particularly Texas and the Southwest, and South America to Brazil and Chile. He states that the roots are of great horizontal and vertical extent, probably penetrating 30 or 40 or perhaps 60 feet deep, and he thinks that they usually reach the water table.

Meinzer, O. E., Geology and water resources of Sulphur Spring Valley, Ariz.: U. S. Geol. Survey Water-Supply Paper 320, p. 383, pls. 1 and 2, 1913. Meinzer, O. E., and Hare, R. F., Geology and water resources of Tularosa Basin, N. Mex.: U. S. Geol. Survey Water-Supply Paper 343, pp. 197-199, pl. 2, 1915. The plates in each of these papers show the zone of mesquite to coincide closely with the zone in which the depth to the water table is 25 to 50 feet.

Cannon, W. A., Root habits of desert plants, pp. 80-81, Carnegie Inst. Washington, 1911. This author concludes that there is a very marked relation between the size of mesquite and the supply of ground water but thinks that it may grow without its roots reaching the water table where floods are numerous. He notes the marked diminution in height of the bushes as the distance increases from places where ground water is near the surface.
Ocatilla (*Fouquieria splendens*, Pl. VI, B) is not known in any association with permanent water supply. Ironwood (*Olneya tesota*) and palo verde (*Cercidium torreyanum*) usually indicate dry soils with perhaps a considerable supply of flood water. Cactus and yucca subsist in stony or sandy soils in the entire absence of ground water.

**MUD VOLCANOES.**

A description of this region would be incomplete without a mention of the mud volcanoes near the mouth of Alamo River, at the southeast end of Salton Sea, although they were not visited during this investigation and nothing can be added to the existing descriptions of them. They are a group of boiling mud springs which erupt steam and gases, accompanied by mud, which forms little craters around the springs. The surrounding ground is said to be very soft and treacherous in places. Crystals of aragonite are said to occur around the springs, and one writer states that boracic acid was found in samples of the water, which is highly mineralized.

A still larger group of mud volcanoes apparently similar to those near Salton Sea occurs about 75 miles to the south, near Volcano Lake, at the head of the Gulf of California, in Mexican territory. These are well described by Barrows, who suggests that they are due to the infiltration of water from the Colorado overflow down to beds of rock heated by pressure and mechanical readjustments resulting from the constantly increasing weight of the overlying sediment. Mud cones similar to the mud volcanoes are known in regions where water is present under pressure beneath soft soil; some good examples occur on Long Island. Inasmuch as water under strong artesian pressure exists in the pervious rocks both southeast and northwest of Salton Sea and appears to be moving toward the lowest part of the basin, it seems reasonable to think that the artesian pressure is at least partly responsible for the mud volcanoes. Moreover, such observations as are available indicate that the artesian water has a temperature notably above the normal in all the deep wells, particularly those nearest the Salton Sea.

It should be noted also that the mud volcanoes occur very near four small volcanic hills known as the Obsidian Buttes, which indicate volcanic activity within the Quaternary period in this vicinity.

For several years the mud volcanoes were covered by Salton Sea, but they have recently emerged as the sea receded. While covered

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they acted as boiling subaqueous springs, their activity apparently being unchecked by the overflow.93

SUGGESTIONS TO TRAVELERS.

GENERAL ADVICE.

To a traveler taking the proper precautions the desert is much less to be dreaded than the average stranger imagines. Only in midsummer heat is it really dangerous. Nevertheless, a few short trips without mishap should not lead to a careless contempt for its perils. No matter in what sort of vehicle or for what length of time it is planned to enter the desert, adequate provision for possible misfortunes should be made. Probably more fatalities and hardships result at present from the failure of automobilists to know the road or to take a little food or an extra supply of water than from any other cause. Of course, with a good automobile and good luck it is possible to travel across this region in a day; but an accident in the midst of a lonely waste may leave a party stranded without help for days, or until it is possible to walk to civilization.

It is necessary, first, to learn definitely about the road. The best maps available should be procured. The maps in this volume are believed to be the best general maps of the region yet published, but for numerous byways and burro trails they are not accurate in detail. Moreover, desert roads are frequently changed owing to the exigencies of travel, and what is a plain road one day may be obliterated by a sandstorm and abandoned the next. Still, the main routes are controlled by surface features and remain much the same. Numerous private maps of local districts are valuable, and the automobile clubs and touring bureaus supply good maps of the chief automobile roads, though they are not drawn accurately to scale.

Inquiries about the roads and watering places should be made of local garage men and hotel keepers. Garage men usually have the latest information as to the condition of automobile roads. Inquiry about watering places and their condition should be made at the time of the trip, as a broken pump may render a good well entirely useless for a water supply.

Some food should be taken even for an automobile trip of only a few hours. A surplus of water over probable needs of men and automobiles should be taken. Surplus oil and gasoline should also be taken, and it should be remembered that desert roads may require twice as much per mile as pavement. Supplies for horses should be ample for all possible contingencies.

The following excellent suggestions to desert travelers are given by Mendenhall and are especially pertinent for persons traveling with teams:

Where teams are used animals accustomed to the desert should be procured if possible, for horses or mules that are unused to desert conditions fret on the sandy roads and rapidly weaken from drinking the saline waters. They are also in danger of pneumonia from the cold of the winter nights and the wide extremes of temperature. During winter journeys blankets should be provided to protect the animals at night.

Travel in the desert far from the railroads and from food supplies is of course more expensive than in other regions. A party leaving a supply station to go 100 miles or more into an uninhabited part of the desert must take along everything needed, even to the most minute detail. This means that if the trip is to last for two weeks enough hay and grain for each animal and enough provisions to last each man that length of time must be taken. For four horses, drawing a wagon that carries four persons and their bedding, provisions, and tools, another team of four horses must also be taken to haul sufficient hay and grain to feed the eight horses for two weeks. There are but few places in the desert, away from the railroads, where grain or hay of any kind can be procured. As the teams are rarely able to travel faster than a walk, heavy horses that are good walkers should be selected. The tires should be as wide as can be procured. Desirable widths of tires for freight wagons are 6 to 9 inches; for light wagons 3 inches. * * * For packing trips experienced prospectors select burros on account of their endurance of heat and thirst, their foraging abilities, and the slight amount of care they require. They are slow and too light to carry heavy packs, so that on expeditions where speed is essential, or heavy freight is to be moved and feed is available, horses or mules are to be preferred.

SPECIAL SUGGESTIONS TO MOTORISTS.

More people travel the desert in automobiles than in any other way, although horses are used and even foot travelers are sometimes seen. Low-geared trucks with large tires have an advantage in freighting or traveling extraordinarily sandy roads. With an experienced desert driver the average car can travel almost any road that is passable for wagons. Without careful driving it may fail to get anywhere on even a comparatively good road. Automobile parties should always carry a supply of spare tires and tubes. A vulcanizing outfit for making patches is especially desirable. A tire gage is very useful, and an air pump and a jack are necessary.

Sand is the worst obstacle in this part of the desert. Fortunately it is less prevalent than popular fancy imagines. The average road consists of a pair of wheel ruts; and in sandy places it is essential to stay in these ruts. They should be left only to pass another vehicle, and then two wheels of the car should be kept in a rut if the sand is bad. Parties attempting to pass on a sandy road can usually do so by helping push each other's cars by hand if other means fail. Fresh wheel ruts are easily traversed even in deep sand, but old ruts or
wagon tracks make very difficult traveling for automobiles. If a car gets stuck in such ruts it is often possible to back up and by getting a fresh start in one's own tracks break the road ahead through bad sand. A shovel is sometimes useful in short stretches for cleaning out covered ruts.

It is common practice when trouble in sand is experienced to deflate the tires in part. This gives the tire a greater bearing surface by allowing it to flatten out and increases the effectiveness of the car's gearing by reducing the diameter of the wheel. As there is danger of rim cutting if the tires are too soft, no more air should be allowed to escape than is absolutely necessary. No fixed rule is known, but for Ford cars a pressure of 35 or even 30 pounds was found safe and always gave good results. Tires are not damaged by running "soft" in sand, but they should be immediately pumped up when hard ground is reached, or they will suffer rim cuts, stone bruises, or blow-outs. The tire gage is a necessity for judging the safe reduction of air pressure.

One great trouble in soft sand is that the wheels lose traction and spin, digging down deeper and deeper into the sand. This result is frequently brought about by attempting to start too suddenly or by going too slowly when moving. After a wheel has dug in it has to be dug out with a shovel, jacked up, and the hole surfaced with brush, canvas, or stones to provide a bearing. Very effective use can be made of two strips of heavy canvas, say 30 feet long and 18 inches wide, for such difficulties. The strips must be thrust under the rear wheel, then laid lengthwise ahead in the ruts, and it is necessary to lift the front wheels and set them on the canvas to hold it down while the rear wheels pull. Otherwise the canvas is chewed up and thrown out in the rear by the spinning wheels. Canvas solved the trouble of the worst sand for the Geological Survey party without much recourse to brush or shoveling. Progress is slow, but almost any bad place may be crossed in this manner. The use of canvas for occasional trips on well-traveled roads is seldom necessary. Most travelers, instead of using canvas, fill the ruts with broken twigs, brush, stones, or anything else available when they get stuck, but unfortunately the brush is usually thinnest where the sand is thickest. There are on the market various devices for pulling out automobiles that get stuck, and one of these may be a valuable part of the equipment. On some roads in this region there are steep hills and sandy grades which automobiles can not ascend but which they can descend with ease. Such roads can be used only in one direction. To reach or return from certain places it is necessary to choose circuitous routes in order to obtain feasible grades.

Canvas belting has since been recommended to the writer for this purpose and doubtless would be more durable than canvas, although more bulky.
PROVISIONS.

In the larger agricultural settlements in this region there are towns which have hotels and restaurants and at which food, clothing, and mechanical equipment can be purchased. Persons planning to take trips of a day's duration or longer should take plenty of food, which will necessarily be in condensed form, chiefly canned goods and staples such as flour, sugar, coffee, and bacon. For short trips it was found very easy to carry fresh bread in paper seals, especially using a tight can for a container. Crackers can be used for longer journeys, or bread can be made in camp. Butter in tight containers will keep for some time in winter. Cans with tightly fitting lids are desirable containers for such things as flour and coffee. As much of vegetables, fruit, and canned milk should be taken as space will permit, because these things add variety to the rather small number of staples. Above all, essential things that will be unobtainable in camp should not be forgotten.

CLOTHING AND BEDDING.

Persons camping in this region should remember that the nights are cool. Warm blankets and plenty of bedding are essential to comfort and to health. Bedding is usually made into a roll for the day, and a large sheet of canvas is convenient to protect it by day or night. There are no particular fashions or inherent necessities in clothing for the desert, except that something extra may be needed for warmth at night.

FUEL.

Fuel can be found at most places in this region, though it may be necessary sometimes to camp at a completely barren spot. Dead wood decays very slowly in this climate and is abundant at most places where small brush grows freely. Roots or branches burn readily with great heat. Most of the desert plants bear thorns, and heavy gloves are useful protection in gathering firewood. An ax or hatchet may be used but is rarely necessary. Fuel is stripped away in the vicinity of many water holes, so that it may be necessary to go several hundred feet away from these common camping grounds to get a good supply.

Some kind of camp light is necessary. Ordinary kerosene lanterns are most used, but carbide or electric lamps are sometimes satisfactory substitutes.

WATER.

The most serious problem in desert travel is to obtain enough good water for drinking and camp uses and for teams or automobiles. It is necessary to have canteens, kegs, or water bags of sufficient capacity for all needs. Even tourists who do not plan to stop at all should
carry a few canteens of water. Good canteens can be purchased at stores in all the towns. Water bags are excellent for keeping drinking water cool, but they waste water by evaporation. For cooking 5-gallon kegs or cans are satisfactory containers. A day's supply is usually sufficient to carry, as there are very few watering places farther apart than a day's journey, even on foot.

GETTING LOST.

The main roads are usually very plain and are adequately marked by signposts erected by public and private agencies, so that there is little danger of getting lost while traveling on them. However, new roads are often made and old ones are abandoned, causing uncertainty at some places. A branch road to an active mine may be plainer than the main road. Some of the little-used roads are so indistinct that they are extremely difficult to follow. To be able to get back upon the right road if he has gone astray the traveler should form the habit of careful observation, noting the prominent landmarks, such as mountains and peaks, and the branch roads, signposts, and minor details of the road. He should remember, however, that the aspect of mountains is very different from different points of view. Moreover, all objects in desert regions, as a rule, appear much nearer to unaccustomed observers than they really are. It is well to scale the distance on the map if possible before attempting to walk to any particular place. The traveler should be able to tell directions by the stars, and it is well to carry a compass. Persons using the compass should remember that it is affected by iron or steel objects and electric currents at close distances.

If it is necessary to walk a long distance a canteen of water and a pocket full of food should be taken. If the weather is warm it is better to walk by night than by day. A road should be followed if possible, as the greatest danger of perishing is in wandering about where there is no road. If it is necessary to travel where there is no road a straight course should be taken toward some star or distant landmark. Distances covered can be estimated by pacing, allowing about 2,000 paces to a mile.

If the traveler meets with an accident or gets lost far out in the desert, it is important not to get excited, nor to rush wildly about wasting energy and ruining self-control. Any bad situation should be thought over carefully, and a sensible solution should be arrived at by studying the available maps, estimating probable distances to the most certain points of relief, and then making plans to walk, wait, or signal. It should be remembered that there are usually several travelers passing every day on the main automobile roads, and on these roads help may be obtained easiest by waiting. On less frequented roads waiting is inadvisable.
In addition to the signs established by the United States Geological Survey, many other signposts are found in this region, particularly along the main traveled roads. Those of the Automobile Club of Southern California are probably the most numerous. They are made of enameled metal, like those of the Geological Survey, and are found along all the automobile roads. The Goodrich Touring Bureau has also established a large number of signs along some of the automobile roads, particularly in Imperial County. Riverside County at one time erected many signs in the eastern part of that county. These signs are of zinc sheets with names punched through and though hard to read are very durable.

There also many signs erected by private persons. They are usually painted on wood and are of all sizes. Some consist of only a shingle tacked to a stick with an inscription in lead pencil. Such signs are easily turned, and their directions are then misleading. They are common along the less frequented roads where miners have temporary camps, and if new and in good condition they are generally reliable. Some typical signs of this region are shown in Plate XIV.

Some very crude and primitive signs are used by prospectors to indicate trails and directions to water in out-of-the-way places. A common trail marker is made by placing several stones in a pile or by setting small stones on top of large boulders in conspicuous places. This mark is used especially along footpaths or burro trails in mountainous regions. Unfortunately, it does not give an idea of direction or distance to water, although it frequently designates the trail to a spring. A sign used to denote water is a tin can in an inverted position on the end of a stake. Where this is found at a road fork, the branch beside which the can is placed is the one that leads to the nearest water. Bottles are used frequently in the same way as cans and are also placed on mounds beside the road, with the mouth of the bottle pointing toward the nearest water. Bottles and cans, however, are common refuse around camps and along roads and should not be depended upon unless their position is clearly the result of design and not of accident.

An interesting feature of many trails and watering places in the mountains consists of the carvings and hieroglyphics left by the Indians. Many of these appear conspicuously on boulders along a trail or on smooth rock surfaces near a watering place. The canyon trail to Anshutz Well (p. 269) is marked by hundreds of these curious carvings. They are also numerous at McCoy Spring and Corn Spring. Although these carvings may suggest the presence of water or indicate trails leading to it, they are undecipherable to the average traveler, and it is probable that the Indians meant them to express many things.
besides direction and distance, even to so necessary an article as water in the desert. Descriptions and sketches of Indian carvings in the Chuckwalla Mountains near Corn Spring are given by C. R. Oreutt, who suggests that many of the figures indicate watering places or trails to water and states that a circle represents a spring or tank and a straight line attached to the circle indicates the direction of a trail leading to water. Such figures were common in the locality he visited.

**BIBLIOGRAPHY OF SOUTHEASTERN CALIFORNIA.**

The following is an incomplete list of the more important publications relating to southeastern California. References to the region are scattered through many scientific publications and numerous periodicals, some of which are referred to in footnotes throughout the text but not included in this list. This statement is particularly true of the publications of the California State Mining Bureau, whose many bulletins contain much information about this region, though complete citations are not attempted in the bibliography.

**HISTORY.**

Emory, W. H., Notes of a military reconnaissance from Fort Leavenworth in Missouri to San Diego in California: 30th Cong., 1st sess., S. Ex. Doc. 7, 1848. Gives a daily journal of Emory's trip from the present site of Yuma to San Diego, with observations on country traversed.


Ives, J. C., Report on the Colorado River of the West, explored in 1857-58: 36th Cong., 1st sess., 1861. Contains a graphic account of Ives's trip in a steamer up the Colorado to the head of navigation.

Bell, Horace, Reminiscences of a ranger, Los Angeles, Caxill Mathes, 1881. An interesting and intimate account of personages and events in the early days of settlement, with a chapter on legends and popular information about the desert.


Guinn, J. M., History of California, California Hist. Soc., 1907. A particularly full account of the early days in southern California, but relating more especially to the coast region.

*West American Scientist, October, 1888.*
Wright, H. B., The winning of Barbara Worth, Chicago, Book Supply Co., 1911. This book is a romance of the reclamation of Imperial Valley and has done much to shape its features in the popular fancy.

Kennan, George, The Salton Sea, Macmillan, 1917. A detailed account of the settlement and flooding of Imperial Valley.

**ENGINEERING AND AGRICULTURE.**


Problems of Imperial Valley and vicinity: 67th Cong., 2d sess., S. Doc. 142, 1922.

**GEOGRAPHY, GEOLOGY, AND NATURAL HISTORY.**


Blake, W. P., Geological report of California, New York, H. Balliere, 1858. A very accurate account of Blake’s observations with the Pacific Railway explorations and in many respects still the most complete account of the desert written. Enlarged from the material in vol. 5 of the U. S. Pacific R. R. Expl.


Loew, Oscar, U. S. Geog. Surveys W. 100th Mer. Rept. for 1876. Scattered data on the Colorado Desert. Doctor Loew was the geologist accompanying the Bergland survey.

Stearns, R. E. C., Remarks on fossil shells from the Colorado Desert: Am. Naturalist, vol. 13, pp. 141–154, 1879. Contains descriptions of fresh-water shells taken from a dug well at Walters (now Mecca) and similar shells found in the beach line deposits of Lake Cahuilla.

Orcutt, C. R., articles in West American Scientist, San Diego, Calif., 1855–1903, notably in the issues of September and October, 1888, May, 1899, October, 1890, and April, 1891, which describe Orcutt’s trips across the basin of the present Salton Sea through the Chuckwalla Mountains and to Coyote Wells and Laguna Maquata (Mexico). See also The Colorado Desert: California State Min. Bur. Tenth Ann. Rept., pp. 899–919, 1890.

Fairbanks, H. W., Geology of San Diego County, Calif.: California State Min. Bur. Eleventh Ann. Rept., pp. 76–120, 1892. Deals with the desert only in its western border around Carrizo Creek.


Barrows, D. P., Ethno-botany of the Coahuilla Indians, Chicago Univ. Press, 1900.

Bowers, Stephen, Reconnaissance of the Colorado Desert mining district, California State Mining Bureau, 1901. Deals particularly with oil claims and possibilities on west side of the desert in the Carrizo region.


Mendenhall, W. C., Notes on the geology of Carrizo Mountain and vicinity: Jour. Geology, vol. 18, pp. 336–355, 1910. Results of a few days’ reconnaissance, with good reconnaissance map of Carrizo and Fish mountains.

Surr, Gordon, Gypsum deposits of the Maria Mountains, Calif.: Min. World, Apr. 15, 1911.


Merrill, F. J. H., Mines and mineral resources of Imperial County and San Diego County, Calif., California State Min. Bur., 1914.

MacDougal, D. T., and others, The Salton Sea, a study of the geography, the geology, the floristics, and the ecology of a desert basin: Carnegie Inst. Washington Pub. 193, 1914. The geology is chiefly a summation of previous studies. The plant studies are detailed and very valuable.


Merrill, F. J. H., Mines and mineral resources of Los Angeles, Orange, and Riverside counties, Calif., California State Min. Bur., 1917.

Smith, J. P., Geologic formations of California: California State Min. Bur. Bull. 72, 1917. Contains a geologic map of the State and descriptions of formations. The part relating to the southeastern desert is chiefly a rough compilation.


Chase, J. S., California desert trails, Houghton Mifflin Co., 1919. Partly descriptive and partly historical. Contains descriptions of some watering places on which few data were obtained in this investigation.


**WATER SUPPLY.**


MAIN ROUTES OF TRAVEL.

There are several roads or combinations of roads that may be taken by the traveler going from the southern coast of California eastward to Phoenix, Ariz., or beyond. These routes start at Los Angeles or San Diego. They are called by various names in their different parts, and no one is so universally used or so uniformly good as to have earned for itself a definite name, though several are known as "ocean to ocean" highways and are so designated on signposts. In general, the traveler crossing this region from Los Angeles goes eastward through Banning and San Gorgonio Pass, then southeastward through Coachella Valley, at the south end of which he may turn east and go from Mecca across the uninhabited desert to Blythe, cross Colorado River at Ehrenberg Ferry, and continue eastward by various routes to Phoenix, or he may turn south, on the west side of the Salton Sea, into Imperial Valley, from which he has a choice of roads by way of Niland and along the Southern Pacific Railroad or by way of Holtville and across the Sand Hills to Yuma. Nearly all travelers from San Diego eastward follow one well-established route as far as Imperial Valley, from which they have the choice of routes to Arizona just mentioned.

The traveler from Los Angeles may go into Imperial Valley by way of San Diego, which he can reach by various coast and inland roads of much scenic attractiveness. There is also a much-traveled road by way of El Cajon Pass, in San Bernardino County, which crosses the Colorado at Parker, near Needles. This road is the longest route to Phoenix, but its quality renders it as attractive as any other. The distance from Los Angeles to Phoenix is 492 miles by way of Imperial Valley, 520 miles by way of San Diego, 425 miles by way of Blythe and Ehrenberg, and 530 miles by way of El Cajon Pass. A brief description of the road from Los Angeles to Banning is included here for the sake of completeness and as an aid to travelers entering the desert for the first time. The roads in Arizona are described by Ross and Bryan.

PLAN OF LOGS AND DESCRIPTIONS.

For convenience of description the main roads are divided into such units as will probably be used throughout their length in any combination of roads crossing the region. As far as possible these units are grouped in natural sequence as commonly used in crossing the desert from west to east.


45354—23—wsp 497——10
The road logs, which are given first, are intended to furnish accurate information about distances and guiding points on the road and are made brief enough to be convenient for the traveler whose time is short, yet explanatory enough, it is hoped, to enable him without other guide to reach his destination safely. Logs of important roads are given in each direction. Reference is made to the signs directing to watering places that have been erected by the United States Geological Survey, also the signs erected by the Automobile Club of Southern California (abbreviated to "Auto Club"), by the B. F. Goodrich Co., and by counties. (See Pl. XIV.) All the signs mentioned are believed to be reliable. Distances in the logs are given in miles and tenths as measured by actually traveling the road.

Names corresponding to the titles of the logs appear on the maps and afford a ready means of referring to the logs—for example, the main road southwest of Salton Sea is labeled "Coachella-Brawley road" on the map and the log is given under the heading "Coachella-Brawley."

The logs are followed by more detailed descriptions of many of the routes. Each description begins with a brief general characterization of the road, from which the reader may determine his course. In any case it will be wise to obtain before starting local information as to the condition of the road, which may very easily have changed since the material for this book was gathered. Secondary roads are described after the main roads and also from west to east as far as possible.
ROAD LOGS.

LOS ANGELES–BANNING.

All roads from Los Angeles to Banning lead nearly due east across the thickly settled portion of southern California. Paved streets connect almost all the towns, and the network of good roads is probably unequaled anywhere else in the United States. The distance from Los Angeles to Banning ranges between about 83 and 94 miles, according to the route that is selected.

BANNING–COACHELLA–MECCA.

BANNING TO MECCA (61 MILES).


<table>
<thead>
<tr>
<th>Mile</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0</td>
<td>Banning, two blocks north of railway station. Start east over paved road.</td>
</tr>
<tr>
<td>1.0</td>
<td>Southern Pacific Railroad. Go east along tracks.</td>
</tr>
<tr>
<td>5.8</td>
<td>Cabezon railway station and store. Water and gasoline.</td>
</tr>
<tr>
<td>12.9</td>
<td>Geological Survey and Auto Club signs. Branch road goes northeast to Morongo Valley, etc. (See p. 187.)</td>
</tr>
<tr>
<td>13.9</td>
<td>Whitewater station on south side of road. Good water at faucet west of building.</td>
</tr>
<tr>
<td>14.5</td>
<td>Cross railway and go south, away from track.</td>
</tr>
<tr>
<td>15.2</td>
<td>Bridge over wide wash draining east. Usually dry, but water from Whitewater River generally discharges into this wash about 300 feet east. Road hugs mountain side after crossing bridge.</td>
</tr>
<tr>
<td>15.6</td>
<td>Rock cut at Whitewater Point. Road turns southeast.</td>
</tr>
<tr>
<td>21.1</td>
<td>Turn due south.</td>
</tr>
<tr>
<td>22.3</td>
<td>Palm Springs post office. Water supplies and minor repairs; hotels.</td>
</tr>
<tr>
<td>22.6</td>
<td>End of pavement. Continue south on dirt road, which is usually in good condition.</td>
</tr>
<tr>
<td>24.2</td>
<td>Auto Club signs. Branch road goes south to Palm Canyon. (See p. 192.) Turn east.</td>
</tr>
<tr>
<td>25.9</td>
<td>Road turns southeast along base of mountains.</td>
</tr>
<tr>
<td>34.0</td>
<td>Wooden sign on east side of road says “Water.” Good water at Frey Well, one-fourth mile east of road. Little used because not near the road.</td>
</tr>
<tr>
<td>35.1</td>
<td>Road turns due east.</td>
</tr>
<tr>
<td>35.6</td>
<td>Road paved from this point nearly to Indio.</td>
</tr>
<tr>
<td>36.5</td>
<td>Ranch house on north side of road. Water.</td>
</tr>
</tbody>
</table>

1 Throughout these logs heavy type is used only to denote watering places.
37.5 Ranch house on north side of road. **Water.**

39.0 Road bears southeast over region of many sand dunes covered with dense mesquite growth.

40.6 **Indian Wells,** store and post office. **Water** at trough and faucet by roadside. **Gasoline.**

41.2 Cut in solid rock at point of Indio Mountain. Road continues southeast through sand dunes and mesquite.

42.5 Turn due east.

44.0 Turn north.

44.5 Turn east. Branch road goes west.

44.9 End of pavement. Continue east.

46.4 Auto Club signs. Good branch road on left goes north half a mile to **Indio.** **Water,** supplies, repairs, and hotels at town. To reach Mecca from Indio one must return to this point and continue east.

47.0 Railway. Turn southeast along track.

48.3 Railway crossing. Auto Club and Goodrich signs. Go due east away from track. Branch road, little traveled, continues along track.

48.9 Auto Club and Goodrich signs. Turn south (right).

49.5 Concrete pumphouse and weir of Government pumping plant for Cabezon Indian Reservation on east side of road.

49.6 Auto Club sign. Cross railway and turn southeast beside it. Branch road goes straight south. Branch also comes in from along railway, northwest.

49.8 Branch road from west crosses tracks and goes east to ranches. **Main road follows railway.**

50.2 **Coachella,** central business block, opposite railway station. **Water,** gasoline, repairs, supplies, hotels. Continue southeast out of town.

50.5 Turn due south away from railway.

51.0 Auto Club sign. Go 100 feet east and then continue south.

52.9 Auto Club sign. Branch road goes west. **Main road turns east (left).**

54.8 Auto Club and Goodrich signs. Branch road crosses railway and goes east. **Main road follows railway toward southeast.**

54.9 **Thermal** railway station. **Water,** gasoline, supplies, hotel.

55.7 Go south, away from railway, avoiding bad road along track.

55.9 Crossroads. Main road turns east to railway.

56.0 Railway. Turn to right and follow railway. Branch road goes east across track.

57.3 Auto Club sign. Branch roads go west and east. Follow railway.

57.6 Abandoned town of Arabia. Auto Club and Goodrich signs. Branch road turns south to Brawley. (See p. 134.) Continue along railway for shortest route to Mecca.

58.5 Branch road goes west. Follow railway.

59.7 Branch road goes west. Follow railway.

60.8 Auto Club and Goodrich signs. Cross Southern Pacific Railroad. Go east into Mecca. Road south goes to Brawley. Road west also connects with Coachella-Brawley route.

60.9 **Mecca post office.** **Water,** supplies, gasoline, minor repairs, hotel. **Turn south to depot.**

61.0 **Water fountain** just north of Mecca railway station.

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**MECCA TO BANNING (61 MILES).**

0.0 **Mecca water fountain,** near railway station. Go north 200 feet to post office and turn west.
0.2 Auto Club and Goodrich signs. Cross Southern Pacific tracks and turn to right following road along railway. Road south goes to Brawley. Road west connects with Coachella-Brawley route 2 miles west and may be used going either way, but route along railway is shorter to Coachella.

1.3 Goodrich sign. Branch road going west connects with Coachella-Brawley route. Follow along railway.

2.5 Branch road going west connects with Coachella-Brawley route. Follow railway.

3.4 Auto Club and Goodrich signs. Branch road entering from south is Coachella-Brawley road. (See p. 134.) Abandoned town of Arabia just north of road fork. Continue along railway.

3.7 Branch road goes east across railway, and 200 feet north another road goes west from railway. Goodrich sign here points west to Coachella and Banning, but one may as well continue along railway, which is shorter.

5.0 Branch road goes east across railway. Main road turns west 0.1 mile away from railway, avoiding bad road.

5.1 Crossroads. Turn north (right).

5.3 Reach railway and again go along track.

6.1 Thermal railway station. Water, gasoline, supplies, hotel.

6.2 Auto Club and Goodrich signs. Branch road goes east across railway. Main road turns west away from railway. Continue west.

8.1 Auto Club sign. Branch road continues west. Main road turns north (right).

9.0 Auto Club sign. Go 100 feet west and then continue north.

10.5 Railway. Follow road along railway, northwest into Coachella.

10.8 Coachella, central business block, opposite railway station. Water, gasoline, repairs, supplies, hotels. Continue northwest out of town.

11.2 Branch road crosses track to east and another leads west. Main road follows railway.

11.4 Auto Club signs. Branch road enters from south. Branch road continues along railway. Main road crosses to east side and goes due north away from track.

11.5 Government pumping plant for Cabezon Indian Reservation—a concrete pumphouse and well with weir, on right (east) side of road.

12.1 Auto Club and Goodrich signs. Turn west (left).

12.7 Railway crossing. Auto Club and Goodrich signs. Turn to right along west side of track.

14.0 Leave railway and go straight west.

14.6 Auto Club signs. Good branch road goes north half a mile to Indio. Water, supplies, repairs, hotels. To reach Banning from Indio one must return to this point and continue west.

16.1 Pavement begins. Continue west.

16.5 Paved road turns south. Branch road continues west.

17.0 Turn west, following paved road, which crosses a region of large sand dunes with heavy growth of mesquite at places.

18.5 Road turns northwest with numerous curves in next few miles.

19.8 Pass through cut in solid rock of point of Indio Mountain. General direction of road is west from cut. Region still sandy, with heavy mesquite growth.


22.0 Road leads due west. Dense mesquite wood on either side.
23.5 Ranch house on north side of road. Water. More open country.
24.5 Ranch house on north side of road. Water.
25.4 End of pavement. Good dirt road, partly graveled, from this point.
25.9 Road bears northwest near base of mountains.
27.0 Wooden sign on east side of road says "Water." Good water at Frey well, one-fourth mile east. Little used on account of being away from road.
35.1 Road turns due west. Big opening in mountain south leads up Palm Canyon.
36.8 Auto Club signs. Branch road goes south to Palm Canyon. (See p. 192.) Turn north toward Palm Springs and Banning.
38.4 Pavement begins at edge of Palm Springs.
38.7 Palm Springs post office. Water, supplies, gasoline, minor repairs, hotels.
39.9 Road bears northwest.
45.4 Rock cut at Whitewater Point. Road turns west, hugging mountain side.
45.8 Bridge over wide wash draining east. Usually dry, but Whitewater River generally discharges water about 300 feet east into this channel.
46.5 Cross Southern Pacific Railroad and turn west beside track.
47.1 Whitewater railway station, on south side of road. Good water at faucet west of station building.
55.2 Cabezon railway station and store. Water, gasoline.
60.0 Leave railway and go due west into Banning.
61.0 Banning, two blocks north of railway station. Water, gasoline, supplies, repairs, hotels.

COACHELLA—BRAWLEY.

COACHELLA TO BRAWLEY (73 MILES).

Note.—If this trip is made by way of Mecca, use Banning-Mecca log (p. 131) as far as Mecca and see appendix to this log (p. 136) for road out of Mecca.

0.0 Coachella, central business block, opposite railway station. Unless intending to pass through Mecca, take supplies for long trip. None obtainable directly on route for 64 miles, unless at small town of Thermal about 5 miles away. Go southeast out of town. Road signed.

0.3 Leave railway and turn due south.
1.8 Auto Club sign. Go 100 feet east and continue south. Numerous ranches along this portion of road.
2.7 Auto Club sign. Branch road goes west. Main road turns east (left).
4.6 Southern Pacific tracks. Auto Club and Goodrich signs. Branch road crosses to east side of railway. Turn south along track.
4.7 Thermal railway station. Water, gasoline, supplies, hotel. Continue along railway.
5.5 Turn south to avoid bad road along railway.
5.7 Crossroads. Turn east to railway.
5.8 Turn southeast along railway again.
7.1 Branch roads go east and west. Continue along railway.
7.4 Abandoned town of Arabia. Road forks here. Auto Club and Goodrich signs at fork. Turn to right, due south, to Brawley unless going through Mecca, in which case continue along tracks. The route by way of Mecca is about 2 miles longer. If desired to use that route see log for road out of Mecca (p. 136).
8.2 Branch road goes east. Continue south.
9.2 Crossroads. Continue south.
10.2 Crossroads. Auto Club sign. Road on left leads 2 miles east into Mecca. Continue south.
11.4 Branch road northeast goes to Mecca. Goodrich sign.
12.4 Branch road northeast (left) comes from Mecca. (See p. 136.) Road southwest goes to ranches. Continue straight.
13.7 Branch road goes straight west.
14.8 Ranch house on east side of road. Water.
15.0 Oasis School, on west side of road. Ranch on east side. Water at either place.
15.5 Auto Club sign. Branch road goes west.
16.0 Auto Club sign. Branch road goes west. Main road turns southeast.
16.4 Ranch house on east. Water. Follow best traveled road southeast.
   There are a number of turns and several side trails but road is adequately posted.
21.5 Geological Survey and Goodrich signs. Water at Figtree John Spring, 0.1 mile on right-hand fork, under palm trees. Turn off to this or keep in straight road. Distances about equal.
23.8 Auto Club sign. Road to left leads by Fish Spring, 0.2 mile away, and returns from there to straight road. About 0.1 mile longer by springs than straight road. Mileage measured by way of spring.
24.0 Fish Spring. Water in pool, poor quality.
24.2 Return to main road and go southwest toward base of mountains. Road rather sandy here.
25.6 Road swings southeast, away from mountains. Mostly graded and graveled or otherwise improved.
31.0 Paved crossing over bed of arroyo.
31.6 Wooden bridge over arroyo.
32.4 Cabin on west side of road, headquarters for road workers. This may have been moved since 1918.
32.5 Concrete crossing over bed of deep arroyo.
33.0 Wooden bridge over small arroyo. Trail said to lead west up this arroyo to Seventeen Palms.
36.0 Concrete crossing over bed of large arroyo.
37.7 Geological Survey sign on north bank of large arroyo with concrete crossing. Trail leads west up wash to McCain Spring, 2.4 miles. Poor water.
39.2 Cross large arroyo.
41.8 Road bends sharply east, avoiding old beach, which circles east around point of badland hills visible from road. Several large crescentic sand dunes along each side of road in next 4 miles.
44.3 Turn nearly south down slope to San Felipe Creek.
47.4 Cross culvert over bed of San Felipe Creek. Water usually running here, but do not drink this water.
47.5 Dim trail to right. Main road turns to left.
49.0 Kane Spring reservoir on east (left) side of road. Water at pipe leading out of reservoir, poor but drinkable. Geological Survey and Auto Club signs. Branch road west to Harper Well and Borego Valley. (See p. 151.) Turn east up hill.
49.1 Narrow pavement begins here. Read big red-letter sign giving road rules. Turnouts about every quarter mile.
56.1 End of pavement. Cross bridge over irrigation ditch and turn southeast along ditch. (Water for emergencies.)
57.0 Auto Club sign. Go straight east away from ditch.
58.9 Go 100 feet south and continue east. Good dirt road. Branch roads every half mile or mile serve neighboring ranches but will not be mentioned unless important. Road is adequately signed all the way to Brawley.

61.5 Good branch road north said to be short cut to Calipatria and Niland. Goodrich and Auto Club signs. Continue east.

62.5 Crossroads. Auto Club and Goodrich signs. Turn south (right).

63.0 Auto Club sign. Branch road continues south. Turn east.

63.3 Cross tracks of branch line Inter-California Railway.

63.5 Auto Club sign. Turn south (right).

64.0 Westmoreland store and post office. Auto Club signs. Water, gasoline, and provisions. Turn east. Branch roads go south and west.

66.5 Auto Club and Goodrich signs. Highway turns south at crossroads.

71.5 Auto Club and Goodrich signs. Turn east (left) down hill.

71.6 Bridge over New River.

72.0 Paved street. Auto Club signs. Continue east to railway station. Road south (right) around triangular court leads to Imperial and El Centro.

73.3 Brawley, railway crossing at station.

MECCA TO BRAWLEY.

0.0 Mecca, water fountain near railway station. Go north to post office and turn west.

0.2 Cross Southern Pacific Railroad and turn south (left). Road along railway to northwest goes to Coachella. Road to west may be used to Brawley or Coachella, connecting with highway 2 miles west.

1.2 Auto Club sign. Crossroads. Turn west.

1.9 Auto Club sign. Turn southwest. Several trails lead to left at various places, but try to keep main road going southwest.

3.6 Reach Coachella-Brawley road and turn straight south. Set to 12.4 for mileage from Coachella and use Coachella-Brawley log (p. 134). It may be possible to get astray in branch roads before reaching this point, but all lead into highway at no great distance, and some point beyond, like Oasis School or Figtree John Spring, can be identified and readings corrected to suit.

BRAWLEY TO COACHELLA (73 MILES).

Note.—An appendix to this log (p. 138) gives route into Mecca from the point where it diverges from the Coachella road. If the Mecca road is used follow Mecca-Banning log out of Mecca (p. 132).

0.0 Brawley, railway crossing at station. Go west on Main Street.

0.3 Auto Club signs. Road south (left) around triangular court leads to Imperial and El Centro. Continue west.

1.6 Bridge over New River.

1.8 Auto Club and Goodrich signs. Turn north (right). The region for next 15 miles is well settled, and branch roads every half mile or mile serve neighboring ranches. Only the important roads will be mentioned. Road is adequately posted.

6.8 Highway turns west (left) at crossroads. Auto Club and Goodrich signs.

9.3 Westmoreland, store and post office. Water, gasoline, and provisions. The last supply station for 64 miles unless passing through Mecca, which is 55 miles away. Turn north (right).

9.8 Auto Club sign. Turn west (left).

10.0 Cross track of branch line Inter-California Railway.

10.3 Auto Club sign. Turn north.
10.8 Auto Club and Goodrich signs. Turn west at crossroads.
11.8 Goodrich and Auto Club signs. Good branch road north, said to go to Calipatria and Niland.
14.4 Go 100 feet north and continue west.
16.3 Auto Club sign. Turn northwest along irrigation ditch.
17.2 Turn west across ditch and start on narrow concrete road. Read big red-letter signboard giving traffic rules. Turnouts provided about every quarter mile.
24.2 End of paved road.
24.3 Geological Survey and Auto Club signs. Turn to right around Kane Spring reservoir. Road to left goes to Harper Well, Borego Valley, etc. (See p. 151.) Water at pipe out of reservoir is drinkable but not good.
25.8 Dim trail to left. Turn right across San Felipe Creek.
25.9 Culvert over San Felipe Creek. Usually running water of bad quality. Do not drink.
29.0 Turn west around point of badland hills at foot of which lies old beach (very sandy). There are numerous isolated crescentic sand dunes along the road here.
31.5 Road turns more to north.
34.1 Cross large arroyo.
35.6 Concrete crossing over bed of deep arroyo. On north bank of this wash is Geological Survey sign. Trail leads up bed of wash to McCain Spring. 2.4 miles away. Poor water but drinkable.
37.3 Concrete crossing over bed of large arroyo.
40.3 Wooden bridge over arroyo. Trail said to lead west up this arroyo to Seventeen Palms.
40.8 Concrete crossing over bed of large arroyo.
40.9 Cabin on west side of road, headquarters for road workers. This may have been moved since 1918.
41.7 Wooden bridge over small arroyo.
42.3 Concrete crossing over bed of arroyo.
47.7 Road, which has approached base of mountains, swings northeast away from it. Rather sandy here.
49.1 Auto Club sign. Branch road to right goes to Fish Spring, 0.2 mile away, and returns to straight road farther on. Mileage was measured on this branch.
49.3 Fish Spring. Poor water in pool.
49.5 Return to straight road.
51.7 Branch road to left leads to Figtree John Spring, under palms 0.1 mile away. Good water.
51.8 Geological Survey and Goodrich signs point to Figtree John Spring. From this point road is crooked for several miles, and numerous trails turn off, but main road is distinct and easy to follow. Well signed.
56.9 Ranch house on east. Water.
57.3 Auto Club sign. Turn straight north (right). Branch road leads west.
57.8 Auto Club sign. Branch road west.
58.3 Oasis School on west side of road. Ranch house on east. Water.
58.5 Ranch house on east. Water.
60.3 Branch road northeast (right) goes to Mecca. See appendix to this log (p. 138). One may also turn off later for Mecca, but this road is shortest. Continue north to Coachella.
61.9 Goodrich sign. Branch road northeast goes to Mecca. Little traveled.
63.1 Crossroads. Auto Club sign. Mecca is 2 miles due east. Continue north to Coachella.

64.1 Crossroads. Continue north.

65.1 Crossroads. Continue north.

65.9 Southern Pacific Railroad. Auto Club and Goodrich signs. Turn northwest along track. Road from southeast comes from Mecca. Pass through abandoned town of Arabia here.

66.2 Crossroads. Roads run east and west. Continue along railway.

67.5 Turn west, away from track, to avoid bad road.

67.6 Crossroads. Turn north to railway again.

67.8 Follow railway northwest.

68.6 Thermal railway station. Water, gasoline, hotel.

68.7 Auto Club and Goodrich signs. Turn west, away from railroad. Branch road crosses to east side of railway.

70.6 Auto Club sign. Branch road continues straight. Main road turns north.

71.5 Auto Club sign. Go 100 feet west and continue north.

73.0 Turn northwest near railway into Coachella.

73.3 Coachella. Central business block, opposite railway station.

Note.—If continuing to Banning see log on page 132.

TO MECCA FROM BRAWLEY ROAD.

60.9 Take right-hand road northeast. May be several trails, but all go to the same place.

62.6 Auto Club sign. Turn straight east.

63.3 Crossroads. Auto Club sign. Turn north (left).

64.3 Southern Pacific Railroad. Cross tracks and go east into Mecca. Road along tracks here goes to Coachella and road straight west intersects Brawley-Coachella road.

64.4 Mecca. Post office and hotel. Turn south to water fountain and railway station.

64.5 Mecca railway station.

BRAWLEY—NILAND.

BRAWLEY TO NILAND (20 MILES).

0.0 Brawley. Railway crossing and station. Go east.

1.2 Auto Club signs. Turn north at crossroads.

5.7 Turn west a few hundred feet, then north again along railway. Road is signed.

7.3 Cross Alamo River and continue north along railway.

10.7 Turn west, crossing railway. Road is signed.

11.0 Turn north at crossroads. Road is signed.

12.0 Cross main street of Calipatria. Continue north.

12.5 Turn west. Road is signed.

12.8 Turn north. Road is signed.

18.8 Turn east.

18.9 Turn north again. Road is signed.


NILAND TO BRAWLEY (20 MILES).

0.0 Niland. Corner by post office, one block south of railway station. Geological Survey sign on corner. Go south. There are crossroads every
half mile or mile along this highway, but only the important ones will be mentioned.

1.5 Turn west (right). Road is signed.
1.6 Turn south. Road is signed.
7.6 Auto Club signs. Turn east.
7.9 Turn south. Road is signed.
8.4 Cross main street of Calipatria. Continue south.
9.4 Auto Club signs. Turn east at crossroads.
9.7 Cross railway and turn south along track.
13.1 Cross Alamo River and continue south along railway.
14.6 Turn a few hundred feet east, away from railway, and go due south. Road is signed.
19.2 Crossroads. Auto Club and Goodrich signs. Turn west.
20.4 Brawley, at railway crossing and railway station.

NILAND—GLAMIS—YUMA.

NILAND TO YTJMA (73 MILES).

0.0 Niland. Corner by post office, one block south of railway station. Geological Survey sign on corner. Go east.
0.2 Cross Southern Pacific Railroad and turn southeast along north side of track.
0.5 Auto club sign. Plain road leads north. Continue along track.
3.7 Turn east, away from track, crossing East Highline canal of Imperial Irrigation District, about 100 feet from the railway. A dim road leads southeast (right) along track to Flowing Well, a railway station half a mile away. Go straight ahead, up hill that marks old beach. This is very sandy. It may be necessary to deflate tires to about 35-pound pressure here.
4.5 Top of hill. Follow main road.
6.8 Plain trail turns to left up large wash. There are numerous tracks in next 3 miles that turn to the left toward the Chocolate Mountains. Some of these go to Salvation Spring. (See p. 173.) Ignore them and continue southeast on main traveled road.
8.9 Another very plain trail leads to left toward mountains. Continue straight ahead. There are bad sandy spots in next 3 miles.
14.4 Auto club sign. Cross trail running northeast and southwest. Go straight ahead.
15.5 Auto club sign. Faint trail continues straight ahead but main road turns to right, toward railway.
16.2 Railway. Cross and go southeast along track. A dim branch road comes down railway from Mammoth Wash.
19.3 Amos railway station. Water obtainable from cistern supplied by railway company. Charge of 5 cents per head for stock. Continue along south side of track.
32.7 Pass Glamis railway station, which is on north side of railway, and continue southeast 0.1 mile.
32.8 Cross to north side of track and turn back northwest to railway station.
32.9 Glamis railway station. Water can be had from railway cistern. Charge for stock. Gasoline and meals are obtainable at store. To leave Glamis go northeast, away from railway, on main road, which is well signed.
33.1 Road forks. Auto club sign. Left-hand road continues northeast to Blythe. Right-hand road turns southeast to Yuma. Road parallels railway but keeps at a distance.

37.9 Turn south toward railway.

38.9 Cross track to south side of railway. A dim branch road comes in down railway. Turn southeast beside track.

52.1 Ogilby railway station. Water is obtainable from cistern kept by railway company. Gasoline can be purchased. Continue along railway.

56.0 Branch road comes in from southwest. This is the Sand Hills or Holtville route to Yuma. Continue along railway.

58.8 Road forks. Goodrich sign. Right-hand road continues along railway into Yuma, passing close to Colorado River for last 5 miles. This road is very hilly and sandy and consequently less traveled. Left-hand road crosses railway and goes north. Optional logs given.

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Left-hand or “mesa” road.

58.8 Cross railway and go north.

59.8 Dim road goes to left. Continue to right.

61.9 Geological Survey sign. Branch road goes northwest to Blythe. Turn southeast here on main road.

65.0 Descend hill and follow sandy wash 1 1/2 miles, passing through cut in river terrace, 50 feet high.

66.5 Branch road goes southwest. Turn left (east) along irrigation ditch.

67.4 Turn south (right).

67.9 Touch railway and turn east (left). Branch road crosses railway to south.

70.1 Cross bridge over very large canal.

70.2 Bridge over large canal.

70.9 Geological Survey sign at crossroads. Turn south to Yuma.

72.4 Cross a railway track and turn east, uphill, to bridge over Colorado River. River road (right-hand branch) joins here. Fort Yuma Indian School on hill.

72.5 California side of bridge over Colorado River. Follow principal streets into Yuma.

72.9 Yuma, Ariz., at post office or railway station.

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Right-hand or river road.

58.8 Take right-hand road, continuing along track.

63.2 Turn south (right), away from railway, along levee.

64.2 Turn east, along levee. Exact course of road not known here but it goes nearly east into Yuma. Follow main road.


68.2 Pass under railway bridge and turn north, uphill.

68.3 Join left-hand road and turn east uphill to bridge over Colorado River. Fort Yuma Indian School on hill.

68.4 California side of bridge. Follow principal street into Yuma.

68.8 Yuma, Ariz., at post office or railway station.
YUMA TO NILAND (73 MILES).

0.0 Yuma. At post office or railway station. Follow principal streets to bridge over Colorado River.

0.4 California side of bridge.

0.5 Road forks. Left-hand road follows river and railway. Right-hand road crosses valley and "mesa." The right-hand road is most used. Optional logs are given.

Left hand or river road.

0.5 Turn south, pass west under railway bridge, go north a few hundred feet, then west. This route was not traversed, but goes approximately west. Follow main road.

1.5 (Approximate distance.) Winterhaven. A little village. Water, store, supplies. Continue west, taking a course along levee.

4.6 Turn north along levee.

5.6 Turn west (left) along south side of railway. Ground badly dissected, hilly, and sandy. Sand may give trouble.

10.0 Right-hand road comes in from north, across track. Goodrich sign. Set to 14.1 and follow railway.

Right-hand or "mesa" road.

0.5 Cross railway track and turn to right around hill on which is Indian school. Then go due north.

2.0 Geological Survey sign. Road north goes to Picacho (p. 179), road east to Laguna dam (p. 179). Turn west to Niland.

2.7 Cross bridge over large canal.

2.8 Cross bridge over very large canal.

5.0 Road touches railway and turns north (right). Branch road leads south across railway.

5.5 Turn west (left).

6.4 Turn north (right), passing up wash through heavy sand for 1½ miles. A branch road leads southwest at this point.

11.0 Road forks. Geological Survey and Auto Club signs. Most travelers take left-hand road to Ogilby. One may, however, continue west and make a cut-off by utilizing some good but little-traveled roads.

14.1 Goodrich sign. Cross railway and join river road.

14.1 Proceed northwest along south side of track.

16.9 Auto Club sign. Branch road goes southwest, away from track. This is the "Sand Hills" or Holtville route to El Centro. Continue along track.

20.8 Ogilby railway station. Water is obtainable from a railway cistern. Charge of 5 cents per head to water stock. Gasoline. The branch road mentioned under 11.0 on right-hand road comes in here. A number of trails lead northeast to points in the mountains and to an intersection with Tumco road. (See p. 177.) A road also goes south to Holtville road. Continue along railway.

34.0 Cross track to north side of railway. A branch road continues along track but is very sandy.

35.0 Turn west, paralleling railway but keeping at a distance.

39.8 Branch road goes northeast to Blythe. Auto Club signs. Turn southwest into Glamis.
40.0 Glamis railway station. Water obtainable from railway company. Charge for stock. Gasoline and meals obtainable at store. To leave Glamis, turn east at station along north side of railway.

40.1 Cross to south side of track and turn back northwest. Road is well signed.

53.6 Amos railway station. Water obtainable from railway company. Charge for stock. Continue along south side of track.

56.7 Cross railway and go northwest, away from track, avoiding bad sand in Mammoth Wash. A dim road continues along railway.

57.4 Auto Club sign. Faint trail southeast. Continue northwest.

58.5 Cross trail running northeast and southwest. Auto Club sign. There is some bad sand in next 3 miles.

64.0 Trail leads northeast up big wash. A great many tracks turn off in this direction in the next 3 miles, some of which undoubtedly lead to Salvation Spring. (See p. 173.) Keep the main traveled road westward.

66.1 Very plain road goes northeast, up wash. Continue west.

68.4 Top of hill marking old beach. There is very deep sand here but it is not often troublesome in descending.

69.2 East Highline canal of Imperial Irrigation District. Cross canal and take road northwest along railway, which is reached at this point. A branch road goes southeast to Flowing Wells, a railway station half a mile away, but it is very sandy.

72.4 Auto Club sign. Branch road goes northeast. Continue along railway.

72.7 Cross railway and go west into Niland.

72.9 Niland. Corner by post office, one block south of depot. Geological Survey and Auto Club signs. Main road leads south to Brawley and El Centro, from which routes lead to Los Angeles and San Diego.

**BRAWLEY—EL CENTRO.**

**BRAWLEY TO EL CENTRO (15 MILES).**

0.0 Brawley. At railway crossing and station. Go west on paved street.

0.3 Auto Club signs. Turn southwest (left) around triangular park. Road west goes to Los Angeles.

0.4 Turn due south.

0.6 Auto Club sign. Turn west off of paved streets.

0.9 Turn southwest (left).

1.1 Leave city streets and go nearly south along canal.

2.3 Road bears southwest.

3.4 Auto Club and Goodrich signs. Turn due south across canal.

9.9 Reach paved streets of Imperial.

10.4 Imperial. Main Street. Big sign in center of street crossing. Cross Main Street and continue south.

10.9 End of pavement. Continue south on good road.


14.2 Turn east on paved street.

15.1 El Centro. At railway crossing and station.

**EL CENTRO TO BRAWLEY (15 MILES).**

0.0 El Centro. Railway crossing and station. Go west.

0.9 Turn north on paved street.

1.2 Geological Survey sign. Paved street goes west to San Diego. For Brawley continue north on good dirt road.
4.2 Paved street of Imperial.
4.7 Imperial. Main Street. Cross Main Street and continue north.
5.2 End of paved street. Continue north.
11.7 Auto Club sign. Cross canal and turn northeast.
12.8 Road turns nearly north.
14.0 Auto Club sign. Turn northeast on streets of Brawley.
14.2 Turn due east (right).
14.5 Auto Club sign. Paved street. Turn north (left).
14.7 Turn to right around triangular park.
14.8 Turn due east (right) on Main Street. Road west goes to Los Angeles. (See p. 136.)
15.1 Brawley. Railway crossing at station. For Niland continue east. (See p. 138.)

SAN DIEGO–JACUMBA.

The highway between San Diego and El Centro forms a part of the coast route from Los Angeles to Imperial Valley, Yuma, and Phoenix. Several inland routes leading from Los Angeles connect with this highway near Campo and about 20 miles west of Jacumba.

The route from San Diego to Jacumba, about 76 miles, lies mainly on the Pacific slope and crosses well-settled country where agriculture and grazing are the principal industries and where water is relatively plentiful. For fruit raising or agriculture, irrigation is generally practiced, but it is only beyond Jacumba that the change from a well-watered country to a desert becomes marked. Tourists are referred to the Automobile Club of Southern California, the Goodrich Touring Bureau, and the standard guides for information about roads and places. No Geological Survey signs will be seen until the desert is reached.

JACUMBA–EL CENTRO.

JACUMBA TO EL CENTRO (46 MILES).

0.0 Jacumba. Front of hotel and camp by springs. Auto Club signs. Store on south side of road. Go east.
5.7 Cabin on south side of road. Road leading north goes to Smuggler Spring, one-fourth mile away.
8.8 Mountain Springs. Water trough. Follow down canyon.
14.0 Bridge over canyon at edge of mountains. Pavement begins.
14.8 Leave mountain wall and start over desert plain.
16.0 Pass under railway bridge.
22.9 Trail leading north goes to marble quarry.
26.1 Road turns due east.
28.8 Geological Survey sign. Branch road leading north goes to Carrizo and Julian. (See p. 157.)
30.8 Road northwest goes across desert to Carrizo. Road leading south goes to Yuha Wells. (See p. 161.)
32.1 Dixieland. Water, gasoline.
36.3 Go south 0.2 mile, then east across New River, then north to line of straight road, then east. This part not paved. When the new bridge is completed this jog will not be made.
36.8 Go east on boulevard.
37.2 South edge of Seeley. Water, supplies. Road goes northwest 1 mile.
38.2 Turn due east across railway.
44.5 Geological Survey, Auto Club, and Goodrich signs at west edge of El Centro. Go south over paved road.
44.8 Turn east to center of town.
45.4 Auto Club sign at street corner.
45.6 El Centro railway station.

EL CENTRO TO JACUMBA (46 MILES).

0.0 El Centro railway station. Go west.
0.2 Auto Club sign at street corner. Continue westward.
0.9 Turn north, following pavement.
1.1 Geological Survey and Auto Club signs. Turn west on pavement.
7.4 Cross railway. Go southwest 1 mile through Seeley.
8.4 Seeley. Water, supplies. Road turns due west again.
8.8 Go south 0.1 mile, then west over New River, then north again. This road not paved. If new bridge is completed this road will be straight.
9.3 Go west on pavement in line with Seeley.
13.5 Dixieland store. Water.
14.8 Branch road goes northwest to Carrizo, but better road to Carrizo farther on. Branch road leading south goes to Yuha Wells. (See p. 161.)
16.8 Geological Survey sign. Road leading north goes to Carrizo and Julian. (See p. 157.)
19.5 Boulevard turns southwest.
22.7 Trail leading north goes to marble quarry.
29.6 Pass under railway bridge.
30.8 Road skirts mountain walls.
31.6 Bridge over canyon. End of pavement. Follow main traveled road along canyon and over mountains.
36.8 Mountain Springs. Water trough.
36.9 Mountain Springs store. Water.
39.9 Cabin on south side of road. Branch road leading north goes to Smuggler Spring, one-fourth mile away.
44.2 Descend into Jacumba Valley.
45.6 Jacumba. Hotel, camp, and springs, on north side of road. Store on south side. Auto Club signs.

EL CENTRO-YUMA.

EL CENTRO TO YUMA (67 MILES).

0.0 El Centro railway station. Go east.
0.9 Auto Club sign. Branch road leads south to Calexico. Continue east.
2.4 Auto Club sign. Turn north (left).
2.7 Holtville Interurban Railway. Cross railway and turn east along it.
6.4 Meloland store.
8.8 Auto Club sign. Turn north, away from railroad.
9.2 Auto Club sign. Turn east to Holtville.
9.7 Bridge over Alamo River.
10.6 Holtville. Northwest corner of open square containing city hall. Turn south one block. Post office on right.
ROAD LOGS.

10.7 Turn east from post-office corner at southwest corner of square.
11.0 Auto Club sign. Turn south.
11.4 Cross canal bridge. Turn southeast.
13.1 Turn south.
13.9 Turn east.
14.6 Auto Club sign. Turn south.
15.5 Auto Club and Goodrich signs. Branch road leads south to Calexico.

Go east for Yuma.

17.5 Alamo School. Water at faucet on ground just west of elevated iron tank. Geological Survey sign on corner, also store. Continue east.
19.2 Highline canal at east edge of Imperial Valley. Cross and start east over desert. Heavy sand at first. Read big warning board of Auto Club. Many trails cross and recross over next 20 miles, but all eventually return to main road. Pick out the best or plainest road. Numerous Auto Club signs, but travelers may not pass near enough to see them.
30.9 New County Well. Windmill. Good water. Nearly all tracks pass this well. Next 10 miles very sandy.
40.4 Planked road that crosses Sand Hills.
40.6 Old County Well and roadmen's house. Good water. Electric transmission line crosses road several times in next few miles.
47.2 Planked road ends. Good road beyond.
47.3 Geological Survey sign. Road north (left) is cut-off to Ogilby. Road along electric transmission line is used by linemen and branches to right, disappearing from main road.
50.2 Southern Pacific Railroad. Auto Club and Goodrich signs. Follow railway southeast.
53.0 Goodrich sign. Road forks. Right-hand road, following railroad and river, is the shorter but is hilly and very sandy. Left-hand road is best. Optional logs given.

Left-hand or mesa road.

53.0 Cross railroad and go north.
54.0 Branch road on left. Take right-hand fork.
56.1 Geological Survey and Goodrich signs. Turn southeast. Road leading west goes to Ogilby, also to Blythe (p. 178).
59.2 Enter sandy wash.
60.7 Turn east along irrigation ditch.
61.6 Turn south.
62.1 Railroad. Turn east.
64.3 Bridge over very large canal.
64.4 Bridge over large canal.
65.1 Geological Survey sign. Road north leads to Picacho (p. 179). Road east to Laguna dam (p. 179). Turn south for Yuma.
66.6 River road comes in just west of bridge at Indian school.

Right-hand or river road.

53.0 Follow railroad southeast.
56.4 Turn south, away from railroad, along levee.
57.4 Turn east, along levee. In general, route is east into Yuma, but route was not traversed.
62.7 Railroad bridge, pass under and turn to the left. Road joins mesa road at 63.0, just west of bridge. Set gage to 66.6.
66.7 Bridge over Colorado River. Follow principal streets into Yuma.
67.1 Yuma. At railway station or post office. The two are about three blocks apart, but equal distances from bridge.

YUMA TO EL CENTRO (67 MILES).

0.0 Yuma. Post office or railway station. Follow principal streets to bridge over Colorado River.
0.4 California side of bridge.
0.5 Road forks. Left-hand road follows river and railway and is sandy and hilly. Right-hand road crosses valley and “mesa” and is most used. Optional logs given.

Left-hand or river road.

0.5 Turn south, pass west under railway bridge, go north a few hundred feet, then west. This road was not traversed but goes approximately west. Follow main road.
4.6 Turn north along levee.
5.6 Turn west (left) along south side of railway. Cross much hilly, sandy land. Sand may give trouble.

Right-hand or “mesa” road.

0.5 Cross railway and turn around hill on which is Indian school. Then go due north.
2.0 Geological Survey sign. Road leading north goes to Picacho (p. 179). Road leading east goes to Laguna dam (p. 179). Turn west for Imperial Valley or Blythe.
2.7 Bridge over large canal.
2.8 Bridge over very large canal.
5.0 Railway. Turn north (right).
5.5 Turn west (left).
6.4 Road forks. Turn north (right). Pass up wash for 1 ½ miles. Heavy sand.
11.0 Geological Survey and Goodrich signs. Turn south (left). Road leading west goes to Ogilby. Road leading west goes to Blythe (p. 178).

14.1 Turn northwest along railroad.
16.9 Auto Club and Goodrich signs. Turn southwest (left) away from railroad. Road along railway goes to Niland (see p. 141).
19.8 Electric transmission line. Geological Survey sign. Road leading north is cut off to Ogilby. Road along electric transmission line is used by linemen.
19.9 Planked road crossing Sand Hills begins.
26.5 Old County Well and roadmen’s house. Water. West edge of Sand Hills.
26.7 End of planked road. Follow best or plainest track. Many winding trails cross and recross, but all eventually unite. For this reason
traveler may not pass Auto Club signs erected at numerous places on route. In general keep west. The next 5 miles are very sandy.

36.2 New County Well. Windmill. Good water.

47.9 Highline canal at east edge of Imperial Valley. Cross and go west.

49.6 Alamo School. Geological Survey sign. Store. Water at faucet on ground west of elevated iron tank.

51.6 Auto Club and Goodrich signs. Go north (right) for Holtville and El Centro.

52.5 Road turns west. Auto Club and Goodrich signs.

53.2 Road turns north.

54.0 Road turns northwest.

55.7 Canal bridge. Cross and turn north.

56.1 Auto Club sign. Turn west and go into Holtville.

56.4 Holtville. Southwest corner of open square containing city hall. Post office is just north. Go north one block and then turn west for El Centro.

57.4 Bridge over Alamo River.

57.9 Auto Club sign. Turn south (left).

58.3 Holtville Interurban Railway. Turn west along railway.

60.7 Meloland store.

64.4 Road crosses railroad and goes south.

64.7 Auto Club sign. Turn west (right).

66.2 Auto Club sign. Road leading south goes to Calexico. Keep west for El Centro.

67.1 El Centro. At railway crossing and depot.

WARNER—BOREGO VALLEY—BRAWLEY.

WARNER TO BRAWLEY (91 MILES).

0.0 Warner Hot Springs. Post office. Take supplies enough to last 80 miles. Start east. The road has changed somewhat recently, and it may be well to make local inquiry before starting. Ascend a steep hill just east of Warner. The first 6 miles of this road is not very thoroughly known.

1.8 Cross Canada Verde, a little creek of running water.

2.9 Branch road goes east. Continue south on plainest road. There may be dim trails and tracks to either side at a number of places.

5.9 Just on top of a little granite hill the road forks. Geological Survey sign. The road southeast continues straight ahead to San Felipe Valley, etc. (See p. 154.) Turn east (left) toward Borego.

8.1 Branch road leads north (left) to a mine visible on the mountain side about a mile away. Continue east.

8.2 Pass through a gate, the boundary of Warner ranch.

8.4 Branch road goes east (left) to Montezuma. This may be better traveled than the Borego road. Turn southeast (right) to Grapevine Canyon and Borego. There are usually wooden signs at this fork.

10.2 Summit of divide. Turn down Grapevine Canyon to southeast. The road is narrow and rocky but passable.

11.5 A trail leads to the left up a side canyon. Continue southeast.

11.7 A trail leads to the left, to a cabin half a mile away. Another trail leads to this 0.2 mile farther on. Continue southeast.
11.9 A trail leads to left, to a cabin half a mile away. There is water at this cabin and the road is passable, but water is also obtainable nearer the road farther on. Continue to the right, on plainest road.

12.0 Grapevine Spring. Water about 150 feet off the road to the right in the wash, the upper part of the spring. The road goes southeast down a steep hill.

12.5 A cabin stands in the little valley on the right, and water is obtainable in the canyon. Turn to the left, continuing down the canyon.

13.9 Geological Survey sign on north side of road. Water trough at a spring 100 feet north. This is called Stuart Spring, or Sumac Spring. Continue east, down the canyon.

21.4 Geological Survey sign on north side of road. There is usually a little pool of poor but drinkable water in a hole 100 feet north. This is called Yaqui Well. Continue east, down the canyon.

22.4 The road crosses from north to south side of the big sandy wash which occupies the bed of the canyon. This is often troublesome on account of sand. Continue east, on south side of wash, on a sort of terrace.

26.0 At about this point the road descends from the little terrace to the bed of the wash and continues east.

27.0 The Narrows, a gorge about 300 feet wide, through which the road passes. Geological Survey sign at lower end of gorge. Road to Borego turns to the left out of the wash and goes north across a broken divide. A branch road, sometimes obscured at this place, leads east, down the wash (right) and reaches Brawley, effecting a cut-off of several miles. At one time this was a country road, but in 1918 it was very bad. See appendix to this log (p. 150). Take road to left and disregard a few dim trails leading east (right).

32.1 Pass little cabin on right (east) of road.

33.6 House on left (west). Water at flowing well in yard. Continue northwest.

33.9 Geological Survey sign. Road straight ahead goes to ranches in Borego Valley. Take road which turns east to go to Brawley.

36.7 Road splits around a clump of green trees and a little wire-fenced corral. Take either branch.

36.8 Borego Spring in clump of trees. Cattle trough. Good water in barrel buried in the center of the bushes. Geological Survey sign on prominent elevation 200 feet north of spring. Take main road leading southeast, ignoring several trails that lead southwest to a cabin visible half a mile away. The cabin marks the place originally known as Borego Spring, and there is water there also.

39.8 Road descends into bed of San Felipe Creek (dry). Geological Survey sign on north side of road. Continue east, following trails down wash.

41.8 About here road branches. Various tracks, much scattered, over wide silt-floored wash. Some swing east (left), passing down San Felipe Wash near Barrel Spring; others skirt Borego Mountain, a long low mountain, rising to two peaks on the southwest. Both routes bad but latter is preferable as San Felipe Wash is very sandy. Optional logs are given.
Left-hand route, by way of Barrel Spring.

41.8 Swing east (left), down broad wash.
47.8 Big board sign on white post points north to Barrel Spring, one-half mile. Tracks lead to the spring but the road is very sandy and hardly passable for automobiles. Continue east down wash. Very bad sand at places. Water poor.

53.0-54.0 The tracks leading down the wash gradually separate and no road at all is left. Turn to the right out of the wash, cross country in best way possible, following a trail if one can be found.

54.0-55.0 At this distance one should intersect the main road leading southeast and follow it. He will probably reach the Geological Survey sign at the forks and should continue southeast.

Right-hand route, skirting mountain.

41.8 Continue southeast, skirting Borego Mountain at a distance of about half a mile from base. There are sand drifts here that get worse close in to the mountain. There is almost no road at all, although tracks appear at places.

46.0 At about this point the tracks gradually converge into a plain trail and cross a small playa, then continuing southeast across broken land with sandy washes. The road is bad but mostly plain and passable.

53.8 A dim trail comes in from north, and a wooden sign points along this trail to Barrel Spring. It is part of the left-hand road. The traveler of that road may or may not find this sign in trying to return to the main road.

54.0 Geological Survey sign where road reaches old graded county road. A branch road coming in on this grade from the west is the cut-off noted at 27.0. See appendix to this log (p. 150). Road goes southeast.

55.2 Road forks. Either follow the old county graded road (left) or take a plain road leading a little more to the south and go by the old town site of San Felipe. The two roads unite about 4 miles away, and right-hand branch is 0.3 mile longer. There is nothing to note on left-hand road. Log of right-hand road is given.

San Felipe branch.

57.9 Concrete reservoir and well visible 0.1 mile southwest of road, but water not obtainable. Continue east on main road.

58.7 Old town site of San Felipe. No one living there in 1918. Several deserted houses. Well, where poor but drinkable water was obtainable in 1918. Continue east, later swinging northeast on main road. Some trails lead south (right) along this part of road.

59.6 Cabin on south side of the road. The two roads unite. Route continues east over fairly good graded road. Reading on left-hand branch 59.3. Set gage to this and continue northeast.
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SALTON SEA REGION, CALIFORNIA.

59.3 Go northeast from road junction.
61.5 Cross a large wash up which a branch road leads south, and turn nearly north on east bank of wash.
62.2 Turn east.
62.3 Harper Well, on north side of road just west of point where road crosses a bridge over wash. Geological Survey sign. Fair water. Continue east.

66.5 Kane Spring. Poor but drinkable water at pipe leading out of large earthen reservoir. Branch road coming in from north is Coachella-Brawley road. (See p. 134.) Geological Survey sign. Continue east, uphill.

66.6 Narrow pavement begins. Read big red-letter sign giving road rules. Turnouts about every quarter mile.
73.6 End of pavement. Cross bridge over irrigation ditch and turn southeast along ditch. Water in emergency.
74.5 Auto Club sign. Go straight east, away from ditch.
76.4 Go 100 feet south and continue east over good dirt road. Branch roads every half mile or mile serve neighboring ranches but will not be mentioned unless important. Road is adequately signed all the way to Brawley.

79.0 Good branch road north said to be short cut to Calipatria and Niland. Goodrich and Auto Club signs. Continue east.
80.0 Crossroads. Auto Club and Goodrich signs. Turn south (right).
80.5 Auto Club sign. Branch road continues south. Turn east.
80.8 Cross track of branch line of Inter-California Railway.
81.0 Auto Club sign. Turn south (right).
81.5 Westmoreland. Auto Club signs. Corner by store and post office.
Water, gasoline, and provisions. Turn east. Branch roads go south and west.
84.0 Crossroads. Auto Club and Goodrich signs. Highway turns south.
89.0 Auto Club and Goodrich signs. Turn east (left) down hill.
89.1 Bridge over New River.
89.5 Paved street. Auto Club signs. Continue east to depot. Road south (right) around triangular court leads to Imperial and El Centro.
90.8 Brawley. Railway crossing at station.

WARNER TO BRAWLEY BY WAY OF CUT-OFF OR COUNTY ROAD.

At the Geological Survey sign at the mouth of The Narrows (27.0) this road leads to the right, down the bed of San Felipe Creek. Only the last 2.3 miles of this road was traveled by the writer, but the approximate route is known and shown on the map. The road was reported by numerous reliable persons as being in very bad condition in 1918, but it may of course be repaired and become more traveled at any time. One should remember in starting over this road that the nearest water is 22 to 25 miles away. However, the total distance is shortened by about 10 miles on this road. The information available may be summarized as follows:

0.0 Turn right and follow down the dry creek bed at The Narrows (27.0).
2.0 At about this distance turn to the right, out of the creek bed, and ascend a grade going eastward. The road is probably plainly visible.
ROAD LOGS.

8.0 Reach summit of a divide and go east, down a long grade that is known to be very sandy.

13.0 At about this point is a graded highway, badly worn and washed out. This is the county road built by Imperial County to the San Diego County line.

15.7 (Approximate distance) A dim road goes south to Hanna Well (see p. 80), in a pass in the mountains. Continue east.

16.0 At about this distance the road reaches the road from Borego at the Geological Survey sign (54.7). Use the main log from this point east (p. 149).

BRAWLEY TO WARNER (91 MILES).

0.0 Brawley. Railway crossing at station. Go west on Main Street.

0.3 Auto Club signs. Road south (left) around triangular court leads to Imperial and El Centro. Continue west.

1.6 Bridge over New River.

1.8 Auto Club and Goodrich signs. Turn north (right). The region for next 15 miles is well settled, and many branch roads every half mile or mile serve neighboring ranches. Only the important ones will be mentioned. Road is adequately posted.

6.8 Crossroads. Auto Club and Goodrich signs. Highway turns west (left).


9.8 Auto Club sign. Turn west (left).

10.0 Cross track of branch line of Inter-California Railway.

10.3 Auto Club sign. Turn north.

10.8 Crossroads. Auto Club and Goodrich signs. Turn west.

11.8 Goodrich and Auto Club signs. Good branch road north said to go to Calipatria and Niland. Continue west.

14.4 Go 100 feet north and continue west.

16.3 Auto Club sign. Turn northwest along irrigation ditch.

17.2 Turn west across ditch and start on narrow concrete road. Read big red-letter signboard giving traffic rules. Turnouts provided about every quarter mile.

24.2 End of paved road.

24.3 Kane Spring. Geological Survey sign. Road forks beside reservoir. The road northwest goes to Mecca, Coachella, and Los Angeles. (See p. 136.) Take left-hand road leading southwest for Warner. Water at pipe out of reservoir is poor but drinkable. For several miles the road follows a graded bed made when a county road was contemplated and partly built.


28.6 Road turns nearly south.

29.3 Turn west across large wash. A branch road leads south (left), up this wash. Go straight ahead.

31.5 Road forks. The graded road lies a little north of a branch that leads through the old town of San Felipe (abandoned 1918). The two roads unite about 4 miles away. As there is nothing to note on the graded road (right) a log of the left-hand road only is given. The right-hand road is 0.3 mile shorter.
Salton Sea Region, California.

Left-hand road, by way of San Felipe.

31.5 Take left fork. A cabin stands south of the road near this point.
32.4 Pass through old town site of San Felipe. Several unoccupied houses mark the place. There is a well at which poor water was obtainable in 1918. Continue west.
33.2 A concrete reservoir and a well are visible south of the road 0.1 mile away, but water is not obtainable. Continue northwest on plain road.
35.6 Continue northwest from fork.
35.9 Return to graded road. Set gage to 35.6 to get distance on the graded road.
36.1 Geological Survey sign marks road fork. Graded road to left is a cut-off to Warner that was very bad in 1918. See appendix to this log (p. 154). Take right-hand road for Borego Valley.
37.0 A dim branch road turns northeast (right), away from main road. In 1918 a wooden sign pointing to right-hand fork said: “Borego Valley 18 miles; water 8 miles at Barrel Spring.” This road is very bad, however; almost impassable for automobiles. The other road is far from good. Optional logs are given.

Left-hand road.

37.0 Continue northwest (left) across broken country with sandy washes at places hard to cross.
44.0 Cross a small playa. At north end of playa the tracks diverge and scatter over a silt-flored wash covered with thin drifts of sand, at places very difficult to cross. There is almost no sign of a road at places. Continue northwest, keeping at a distance of about half a mile from the base of a long low mountain which rises to two peaks on the west. The drift sand is very bad nearer the mountains.
49.0 At about this point the tracks of the right fork unite and a fairly plain trail leads northwest up the wash. However, it may not be possible to identify this junction.
51.0 The road climbs a little bank onto a terrace north of the wash. A Geological Survey sign marking this spot should be found easily.

Right-hand road, by way of San Felipe Wash.

37.0 Take right-hand fork and follow tracks into San Felipe Wash about a mile away. Then continue up wash, which is very sandy.
44.0 At about this point in the wash a board sign placed on a white post points north to Barrel Spring, half a mile away. The road, however, is probably too sandy for automobiles. Water at Barrel Spring is very undesirable except in case of emergency. Continue west, up the wash, following tracks.
50.0 At about this point the road unites with the scattered tracks of the left fork and both take a plain course northward up the wash. However, it will probably be impossible to identify this junction.
52.0 (Approximate distance.) The road climbs a little bank onto a terrace north of the wash. A Geological Survey sign marking the spot should be found easily. Set gage to 51.0 if this is noted and follow plain road west.
51.0 Readings corrected to Geological Survey sign. Continue west on plain road.

53.2 Ignore a number of dim tracks leading to the left to a cabin visible on a hill south of the wash. The cabin is at the original Borego Spring, and there is water there, but the road is little used.

54.0 The road splits around a clump of bushes inclosed by a wire fence. In the corral is a cattle trough, and in the center of the bushes is a barrel sunk in the earth in which good water is obtainable. A Geological Survey sign stands on a prominent point 200 feet north. Continue west, the roads uniting around the corral. Next mile is sandy.

56.9 The road intersects a road running north and south. This is on a grassy plain in the center of Borego Valley. A Geological Survey sign stands at the fork. Turn south to reach Warner. The road north leads to houses not far away which were occupied in 1918.

57.2 House just west of road. Water at flowing artesian well in front yard. Continue south.

58.0 Pass dim road leading east, and continue south (right).

58.7 Small cabin on east side of road. Continue south over a high divide.

63.8 Turning gradually west enter The Narrows, a pass about 300 feet wide with walls 100 to 200 feet high. A Geological Survey sign stands at the entrance. The county road mentioned at 36.1 is supposed to enter here from the east, but no signs of it were visible in 1918. See appendix to this log (p. 154). Continue west, up the canyon.

64.8 At about this point the road climbs out of the sandy wash onto a terrace to the south. The Narrows is passed and a considerable little valley exists here.

65.2 The road turns north, crossing the very sandy wash again. One may have difficulty here. Continue west, up a very narrow valley which grows more and more like a canyon.

69.4 Yaqui Well. Geological Survey sign. There is usually some poor but drinkable water in a little hole 100 feet north of the road.

76.9 Stuart Spring, or Sumac Spring. Good water at trough 100 feet north of road. Geological Survey sign. The road continues up Grapevine Canyon.

78.3 Grapevine Spring. A cabin stands on the left of the road in a little valley just beyond a point where the road bends sharply to the right up a hill. Water may be had in the canyon above the house.

78.8 Grapevine Spring again. The water rises in the canyon about 150 feet south of the road under some willows.

78.9 A branch road leads east (right) to a cabin half a mile away. It is passable, and water is obtainable but will hardly be needed. Continue up canyon (left).

79.1 Another branch trail leads to cabin mentioned. Continue on plain road up canyon.

79.3 A faint trail leads east (right). Continue up canyon. Steep grades are encountered here.

80.6 Summit of divide. Go west, down gently sloping valley.

82.4 A branch road, usually well traveled, comes in on east from Montezuma. Continue west. There is probably a board sign at this place.

82.6 Pass through a gate into Warner ranch. Continue west on road.

82.7 A branch road leads north (right) to a mine visible a mile away. Continue west.

84.9 On top of a little granite hill is a Geological Survey sign. A road comes in on the southeast from Julian and San Felipe Valley. (See p. 154.)
Turn nearly north, following main road. Some changes have been made recently, and the log may not be entirely correct.

87.9 A branch road goes east (left). Continue north.
89.0 Cross the Canada Verde, a little stream, and go west, over a high hill.
90.8 Warner post office. Water, gasoline, supplies, and hotel. Good mountain roads connect with all southern California coast points.

**BRAWLEY TO WARNER BY WAY OF CUT-OFF OR COUNTY ROAD.**

At the Geological Survey sign, 36.1 miles from Brawley, this road is noted as going to the left. Only the first 2.3 miles of this road was traveled by the writer, but the approximate route is known and shown on the map. The road was reported by numerous reliable persons as being practically impassable in 1918, but may of course be repaired or become more traveled at any time, as it is approximately 10 miles shorter than the route to Warner through Borego Valley. One should remember in starting on this road that the nearest water is at Yaqui Well, 24 miles away. The information available about this road may be summed up as follows:

0.0 Go west from Geological Survey sign (36.1) where branch road leads northwest to Borego.
2.3 A rather dim branch road leads south (left), presumably going to Hanna Well, in a pass in the mountains on the south. Continue west on the old county grade, which had been badly washed out by floods.
5.0 At about this point the county grade ends, as the road was improved only as far as the line between Imperial and San Diego counties. Continue west, up a long grade that is known to be very sandy.
10.0 At about this point the summit of the grade is reached and the road goes west, down a slope toward San Felipe Creek.
16.0 At approximately this distance the road enters the dry bed of San Felipe Creek and continues west.
18.0 The road enters The Narrows at the Geological Survey sign mentioned at 63.8. Use main log (p. 153) west from this point.

**WARNER-SAN FELIPE VALLEY-JULIAN.**

A fair mountain road passable for all kinds of vehicles branches from the Warner-Brawley road 5.9 miles from Warner at a fork marked by a Geological Survey signpost and goes south (right) through San Felipe Valley and San Felipe ranch. A short cut through San Felipe Valley leads on southeast to Mason Valley, Vallecito, and the Carrizo country, and the Julian road continues south and west through Banner into Julian.

**JULIAN-VALLECITO-CARRIZO-EL CENTRO.**

**JULIAN TO EL CENTRO (75 MILES).**

Note.—This road is seldom used as a direct route from Julian to El Centro because the longer mountain roads are better. It is important, however, as being the only way of access to Mason Valley, Vallecito, and Carrizo from the west or east. For the last 16.8 miles the road follows the San Diego-Imperial Valley highway.

0.0 Post office at Julian. Go east.
0.2 Road forks. Auto Club and Goodrich signs. Right-hand road: goes to Descanso, Jacumba, and El Centro. Take left-hand road for Vallecito and Carrizo. Follow main road east over divide.
1.0 Summit of Peninsular Range. The road descends Banner grade, a hill over 3 miles long, dropping 1,200 feet. Drive carefully, as road is very narrow.
ROAD LOGS.

4.4 Bottom of grade. Turn north, across little creek.

4.8 **Banner. Good water.** A family living here usually serves meals and may keep gasoline for sale.

5.0 **Road forks.** Left-hand road leads through San Felipe Valley, Blair Valley, and down a very sandy box canyon, rejoining right branch at Mason Valley. The right-hand road goes east across the mountains and down Rodriguez Canyon into Mason Valley. In 1917 travelers going east usually took the left-hand road, which is several miles longer, because a hill on the right-hand road was impassable for automobiles. This was improved in 1918, however, and is said to be passable. Inquiry may be made at Banner concerning the roads. Optional logs are given.

**Left-hand road, by way of San Felipe Valley.**

5.0 Continue to left, passing down canyon along Banner Creek, which is crossed several times in next mile. **Good water in creek.**

6.0 Pass through gate, boundary of San Felipe ranch.

6.5 **Road forks.** Left-hand road goes north to ranch house and to Warner. Take right-hand road leading northeast.

8.3 to 8.8 Cross over low ridge which divides San Felipe Valley into upper and lower portions.

10.1 Branch road comes in on north from Warner ranch. Continue east.

10.7 Pass out of San Felipe ranch, through gate.

11.2 **Windmill on east side of road. Fair water.**

12.1 House on east side of road. **Water.**

13.5 Small playa on east side of road.

16.1 Cross over low ridge dividing San Felipe Valley from Blair Valley. Turn west across Blair Valley.

18.6 Enter Box Canyon, a narrow and very sandy pass through mountains.

20.0 Emerge from canyon into Mason Valley.

20.8 Join right-hand road at Geological Survey sign and proceed southeast, setting gage to 13.8.

**Right-hand road by way of Rodriguez Canyon.**

5.0 Turn to right, passing up a canyon over steep hills. Follow best traveled road. Road has recently been changed considerably, leaving portions of the old road abandoned.

7.2 Near this point there is a **spring** on south side of the road; a mining cabin, on north side, usually unoccupied. To the north one looks down upon San Felipe Valley.

8.3 Summit of divide. The road turns southeast and starts down Rodriguez Canyon.

13.0 Emerge into Mason Valley.

13.8 Road coming in from north is left-hand branch. Geological Survey sign. Proceed southeast.
13.8 Go southeast from signpost.
14.1 Ranch house on right; well with windmill. **Water.** Pass through gate and continue southeast. Several trails turn off at places to homesteads, some of which were occupied in 1918. Continue on main road toward lower end of valley.
17.0 Cross over ridge separating Mason Valley from Vallecito Valley. Descend a very steep hill on the lower (east) side of this ridge.
17.5 Foot of hill. A branch road leads south (right) to a ranch 0.8 mile away. Continue to left.
18.2 Another branch road leads southwest to ranch mentioned. Continue east.
21.9 Pass water trough at Vallecito. **Good water.** Continue east, passing down dry bed of Vallecito Creek, which is very sandy at places.
25.2 After having turned a little south, around the point of a mountain, a branch road leads south to **Agua Caliente Springs,** three-fourths mile away. **Good water.** There may be water at the trough 500 feet east. Turn left unless going to Agua Caliente.
25.3 Water trough on south side of road. May or may not contain water. Geological Survey sign. Continue east, going down sandy wash after about a mile.
28.3 A branch trail leads down the main wash to Carrizo but is rather bad. Try to keep well to the right (west) and follow a road that climbs out of the wash and goes southeast near the base of the mountains. If one inadvertently continues down the big wash no harm will result, as it leads into the road above Carrizo, about 8 miles away. It is necessary to use this left-hand road to reach a place called Palm Spring. (See p. 276.)
30.9 A branch road turns west to an abandoned cabin, about a mile beyond which is a place called **The Canebrakes,** where a stream of **good water** runs in a mountain canyon amongst a tangle of cane, etc. To follow main road continue straight (left).
31.2 Another branch road goes back northwest to cabin. Continue southeast.
34.2 At about this point the road swings east, down a sandy wash. At 3 or 4 miles to the southwest a clump of green palms is plainly visible on the mountain side. This is **Mountain Palms Spring.** Good water is found at the place, which is said to be approachable by wagon or automobile.
37.7 Geological Survey sign on north side of road. A big wash comes in from the northwest, and stray tracks from that direction mark the branch road noted at 28.3. Continue east. There is very bad sand in the next 14 miles, and it may be necessary to deflate tires. (See p. 121.)
39.2 **Carrizo.** Geological Survey sign. An adobe house, occupied in 1918, stands on north side of road. Well, on south side, on bank of Carrizo Creek, which flows at the surface for about a mile. **Water,** either in well or in the creek, is drinkable. Continue east.
40.0 A road turns to the southwest, going down to the bed of Carrizo Creek. Continue east, later following down dry, sandy floor of creek, several hundred feet wide. Old iron signposts, with two iron plates set at right angles, will be seen nearly every mile. They were once painted signs marking an old stage road but now serve only to assure the traveler that he is on the right track.
46.0 Turn to the right and ascend a steep hill, out of Carrizo Creek. Proceed southeast.
ROAD LOGS. 157

50.0 Geological Survey sign. A branch road goes east (left) into Imperial. (See p. 159.) Continue southeast (right).

51.6 In this vicinity a number of tracks lead west to a marble quarry at the east end of Carrizo Mountain. Continue southeast, over plain road.

55.7 Cross a wide and rather sandy wash.

57.2 A branch road goes southeast, but main road turns nearly south (right). Either of these roads leads into El Centro, but the left-hand one crosses the sandy beach line a mile away.

58.2 San Diego-El Centro highway. Geological Survey sign. Turn east on paved road.

60.2 Branch road noted at 57.2 joins highway from north. A branch road going south is remains of old highway to San Diego and affords access to Yuha Wells. (See p. 161.) Continue east.

61.5 Dixieland. Water, gasoline, and supplies. Continue east, through settled country. Branch roads turning off every mile or half mile will not be noted unless important.

65.7 Turn south 0.1 mile, then east across New River, then north 0.1 mile, then east again. This part not paved. When new bridge is completed this jog will not be made.

66.2 Start east on pavement after turn just described.

66.6 Turn northeast, through south edge of Seeley.

67.6 Turn east again, crossing railway.

73.8 Crossroads. Geological Survey sign. Road north goes to Imperial and Brawley. Turn south, on paved street.

74.1 Turn east on pavement, which is main street of El Centro.

75.0 El Centro. At railway station.

EL CENTRO TO JULIAN (75 MILES).

Note.—The road from El Centro to Julian follows the San Diego highway for 16.8 miles west of El Centro, and then turns northwest, passing up the valleys of Carrizo Creek and Vallecito Creek. It is seldom used as a direct road, the longer route by way of Jacumba, Buckman, and Descanso being preferred because it is much better. This route is of importance, however, as a means of access to Carrizo, Vallecito, and Mason valleys from the west or east.

0.0 El Centro. Railway station. Go west on Main Street, which is paved.

0.9 Following pavement, turn north.

1.2 Crossroads. Geological Survey sign. Road north goes to Imperial and Brawley. Turn west on paved road. Branch roads turn off every half mile or mile through settled country, but only the important ones will be mentioned.

7.4 Cross railway and turn southwest through south edge of Seeley.

8.4 Turn straight west again.

8.8 Turn south 0.1 mile, then west over New River, then north again to line of road from Seeley and continue west. This part is not paved. When the new bridge is completed this jog will not be made.

9.3 Pavement starts west, on west side of New River.

13.5 Dixieland, on north side of highway. Water. Last supply station until Julian is reached (61.5 miles).

14.8 Branch road turns northwest, to Carrizo. Continues west to 16.8, as this road crosses old beach (very sandy). Another branch road turns south at this point. It is the remains of a former highway to San Diego and affords an approach to Yuha. (See p. 161.)
16.8 Geological Survey sign. Turn north from highway on fair road.
17.8 Branch road noted at 14.8 comes in from southeast.
19.3 Cross a wide and rather sandy wash. Old iron signposts with two iron plates crossed at right angles and usually bearing no letters whatever are passed about every mile along road to Carrizo. They were once painted signs marking the old stage road, but now serve only to assure the traveler that he is going in the right direction.
23.4 In this vicinity a number of wagon tracks turn west to a marble quarry at the east end of Carrizo Mountain. Ignore them and follow the plain road.
25.0 Geological Survey sign. A branch road comes in from the east, from Imperial. (See p. 160.) Continue northwest.
28.8 Descend a steep hill into the bed of Carrizo Creek, which is a sandy flat one-quarter to one-half mile wide. Follow the plainest or easiest track west up this channel. It is very sandy at places. At about 32.0 or 33.0 the road climbs out of the main wash upon a little terrace on the north side and continues west.
35.0 A road turns to the left, going back to the bed of the creek. Continue west (right), bearing away from creek. Pass over a little clay ridge to a grassy plain about 1 mile wide.
35.8 Carrizo. Geological Survey sign. Adobe house on north side of road, occupied in 1918. Water may be had at well on bank of creek 50 feet south or in bed of creek, which flows here for about a mile. Water is of fair quality. Continue west. Bad sand in the next mile. Deflate tires if necessary. (See p. 121.)
37.3 Geological Survey sign on north side of road. A big wash comes from northwest, and tracks turn up this wash at places. It is possible to take this route and reach Vallecito, but the better road continues west, up a large sandy wash.
40.8 At about this point the road swings northwest over a slope covered with coarse sand and gravel, leaving the valley of Carrizo Creek. At 3 or 4 miles southwest and several hundred feet up on the mountain side a clump of green palms is plainly visible. This is Mountain Palms Spring. There is good water there, and it is said to be approachable by wagon or automobile.
43.8 Branch road turns west (left) to an abandoned cabin about a mile away. Continue straight (right).
44.1 Another branch road turns west to cabin, about a mile west of which is the Canebrakes, a narrow mountain canyon in which there is a considerable stream of good water and a dense growth of cane. To follow main road continue straight (right).
46.7 A branch trail comes from the southeast at a point where the road descends into a sandy wash. This comes up the wash noted at 37.3. Continue northwest, following tracks up sandy wash.
49.7 Geological Survey sign. Water trough on south side of road. It may or may not contain water. Good water is obtainable at Agua Caliente Springs, three-fourths mile southwest.
49.8 A branch road goes south to Agua Caliente Springs. To follow main road turn north (right) and go around point of mountain, following up sandy bed of Vallecito Creek. Use plainest tracks.
53.1 Vallecito water trough. Good water. Turn north about 200 feet, then west, following road.
53.2 Old adobe stage station of Vallecito on north side of road. Geological Survey sign. Continue west.
56.8 Branch road leads southwest to Campbell ranch, 0.8 mile away. Continue straight (right).

57.5 A road leads south to Campbell ranch. Main road turns north, climbing very steep hill over ridge separating Vallecito Valley from Mason Valley. This is a very hard climb.

57.8 Top of hill. Go down on other side into Mason Valley and continue west over plainest road. A number of trails turn off and several roads lead west, but by keeping the best road through the center of the narrow valley the traveler should have no trouble. The road may be closed at places by gates. Several homesteaders lived in the valley in 1918.

59.2 Road forks. Either road leads out of valley, but right-hand branch is shorter and better.

60.9 Ranch, on left side of road. Windmill. Water. Gate across road in 1918. Continue northwest.

61.2 Road forks. Geological Survey sign. Take left-hand road to Julian. Right-hand road comes from San Felipe Valley but goes up a sandy canyon that is impassable for automobiles going out of Mason Valley, although passable in opposite direction. The road log from here to Julian is only approximately correct. In general the road passes northwest up a narrow mountain gorge called Rodriguez Canyon.

66.7 Summit of divide. The road bends north, then west around a hill. The valley plainly visible to the north is San Felipe Valley. Follow the main traveled road, which has been changed at several places recently, leaving portions of the former road abandoned.

67.8 Near this point there is a spring on the south side of the road, and a miners' camp, usually unoccupied on the north side. The road passes down some very steep grades.

70.0 A branch road comes in on east from San Felipe Valley. Go southwest (left).

70.2 Banner. Good water. A family living there usually serves meals and may keep gasoline. Continue south on main road.

70.6 The road crosses a small creek and turns sharply northwest, up the Banner grade, which is a steady climb, rising 1,200 feet in 3 miles. Drive carefully, as the road is very narrow.

74.0 Summit of Peninsular Range. Follow main road west into Julian.

75.0 Julian post office. Water. Hotels and garages. Good roads lead to San Diego, Los Angeles, and nearly all points south or west.

CARRIZO–IMPERIAL.

CARRIZO TO IMPERIAL (33 MILES).

Note.—This log covers a road that branches from the Julian-El Centro route (see p. 154) at a point 11 miles east of Carrizo and goes nearly due east into the town of Imperial.

0.0 Carrizo. Water in well on creek bank south of road or in creek bed, poor but drinkable. Geological Survey sign on north side of road. Start east at house of C. A. Strabley.

0.8 Branch road goes southwest toward bed of creek. Continue east, getting down into dry bed of Carrizo Creek, a mile or two east. This is a flat wash, several hundred feet wide. The road is sandy at places.

6.8 Turn to right, ascending a steep hill out of Carrizo Creek, and go south-east over broken country.
10.8 Road forks. Geological Survey sign. Right-hand road leads to El Centro. (See p. 154.) Turn east on left-hand road for Imperial. This road leads over a flat, barren plain and is marked at places by large white posts, usually with no sign whatever on them. It is not a bad road until the old beach is crossed.

19.6 At about this point the road crosses the old beach, and traveler may have trouble with sand. The sandy spots cover nearly a mile here. Farther on the road passes cleared land that was being made ready for irrigation in 1918.

20.7 Goodrich sign on north side of road. Continue east.

23.3 Goodrich sign. Continue east. Several houses not far away.

23.8 West side main canal of Imperial Irrigation District. Goodrich sign just west of this canal, which runs northeast. Cross canal and turn due south beside small irrigation ditch. A branch road goes southwest, along the east side of the canal, to Dixieland.

24.5 Goodrich sign. Turn east across irrigation ditch. A branch road goes west to Dixieland. The main road for the next 2 miles runs near the north bank of a deep erosion channel known as Salt Creek, or Salt Slough, which may contain a little water.

25.2 A branch road goes south across Salt Creek and turns back west. It is said to afford a way of reaching the San Diego-El Centro highway. Continue east.


26.6 Sharp crook in the road; which descends the west bank of the New River channel.

26.8 Bridge across New River. Continue east.

27.3 Crossroads. Goodrich and Auto Club signs. Road south intersects San Diego-El Centro highway. For Imperial continue east through well-settled country. There are crossroads every mile or less, but the main road leads due east to Main Street, Imperial.

33.3 Imperial. Big sign in center of street crossing, about one-fourth mile west of railway station. The paved cross street leads north to Brawley or south to El Centro.

IMPERIAL TO CARRIZO (33 MILES).

0.0 Imperial, at intersection with Brawley-El Centro road. Big sign in center of street crossing. Start west on Main Street. The first 6 miles is through a well-settled country, and branch roads turn off every mile or less. Go straight west. The road is well marked by Auto Club and Goodrich signs.

6.0 Goodrich and Auto Club signs mark the last good crossroads. It is possible to go south to a junction with the El Centro–San Diego highway. Continue west for Carrizo.

6.5 New River. Cross the bridge. After a sharp, short crook in the road go nearly west along north bank of deep channel of Salt Creek, which may contain a little water.

7.5 Goodrich sign. A branch road leads north. Continue west.

8.1 Branch road goes south across Salt Creek and is said to connect with El Centro-San Diego highway. Continue west.

8.8 Goodrich sign. A branch road continues west to Dixieland. For Carrizo turn north (right) beside small irrigation ditch.

9.5 West Side main canal of Imperial Irrigation District runs northeast. A road follows canal southwest to Dixieland. For Carrizo turn west (left),
crossing canal. On west side of canal is a Goodrich sign. For a short distance west the land was being prepared for irrigation in 1918, but beyond that the desert begins.

10.0 Goodrich sign on north side of road. Continue west.

12.6 Goodrich sign on north side of road. Continue west.

13.5 At about this point the road crosses the old beach. Bad sand, continuing bad in spots for nearly a mile, then fairly good road. A number of white posts without any signs whatever will be seen along the road.

22.5 Geological Survey sign. Branch road coming in from southeast is El Centro-Julian route. (See p. 157.) Road leads northwest over a somewhat broken country.

26.3 Descend steep hill to flat dry floor of Carrizo Creek, which is several hundred feet wide. Follow the wash westward, using best road available and finally climbing out on a little terrace north of the creek bed. Very sandy at places.

32.5 A branch road turns southwest (left) toward the bed of the creek. Continue west (right), coming upon a small grassy plain not far away.

33.3 Carrizo. House of C. A. Strabley, on north side of road. Geological Survey sign. Water at well or in bed of creek on south side of road, poor but drinkable.

Note.—Persons wishing to continue to Vallecito, Mason Valley, or Julian from this point consult the El Centro to Julian log (p. 157).

DIXIELAND TO YUHA AND COYOTE WELLS.

On the San Diego-Imperial Valley highway, 1.3 miles west of Dixieland, an old macadam road turns south and takes a somewhat southwesterly course into Coyote Wells, 13.7 miles away, as measured on this road. The road is an abandoned portion of a former highway that was much used before the construction of the present concrete road. Part of it is surfaced and part dirt road, but most of it was fairly good in 1918 and easily passable for automobiles, although seldom used by anyone.

West of Dixieland 5.8 miles and east of Coyote Wells 7.9 miles, on the old road just described, a faint branch road turns south. It passes the old Yuha Well, drilled for oil, 1.7 miles from the turn, and continues southwest, toward the water hole known as Yuha Wells, for a mile or two more, finally disappearing in a maze of dim wagon tracks and becoming impassable for cars because of sand. It might be possible to reach the Yuha water hole by automobile, but it is hardly worth the effort. It can easily be reached by walking the last half mile.

The “Yuha oil well” is an abandoned drill hole at which there is some camp débris and a 14-inch well casing protruding above the ground. There was water at a depth of about 400 feet in this hole. The Yuha water hole was once a place where teams watered frequently but is now entirely abandoned. Seeps of bitter water in the surrounding arroyos are common, and some can be uncovered by digging with a stick or with the hands, but at present these are unimportant as watering places.

MECCA—BLYTHER—EHRENBERG (MAIN ROUTE).

MECCA TO BLYTHE (95 MILES).

0.0 Mecca. Water trough one block south of post office. Start east. Big warning signboard established by Automobile Club of Southern California. Read and heed.
0.9 Geological Survey and Auto Club signs. Road south goes to Dos Palmas, Niland, etc. (See p. 166.)

3.2 Pass Auto Club sign.

3.9 Turn northeast. Pass under electric transmission line. Road along electric line is property of Coachella Valley Ice & Electric Co. but is sometimes used as alternate route to Dos Palmas. (See p. 171.)

6.0 Enter Shaver Canyon and follow through badlands.

12.1 **Shaver Well**, on north side of road in canyon. Auto Club signs. Last dependable water supply for 75 miles.

12.6 Auto Club signs. Take right-hand road. Left-hand road goes to Cottonwood Spring. (See p. 184.)

22.2 Auto Club sign. Dim trail southeast is old road to Blythe.

29.0 Auto Club sign. Dim trail goes southeast.

30.6 Auto Club sign. Trail crosses road leading southwest and northeast. On the northeast (left) it goes to abandoned cattle camp half a mile away.

30.9 Trail leads north to the cattle camp.

32.6 Dim trail to southeast (right) probably goes to cattle trough in center of dry lake.

34.3 Geological Survey sign. Pipe line crossing road comes from small spring in Eagle Mountains to the north and goes to cattle trough in dry lake 1 mile away. In emergency **water** is usually obtainable at faucet by following pipe line half a mile southwest.

35.5 Auto Club sign.

38.9 Road fork. Auto Club sign. Left-hand road is old road to Blythe by way of Gruendike Well. Right-hand road does not pass Gruendike. Old road is a little longer but more traveled on account of water being obtainable. Mileage by way of Gruendike is adopted, but optional log is given.

**Left-hand route.**

38.9 Start northeast.

41.3 Auto Club sign. Take right-hand road. The trail to left goes to Boulder Well. (See p. 166.)

46.7 Cabin one-fourth mile south, usually unoccupied. No water.

49.6 Keep left to house and well.

49.8 Gate at house by **Gruendike Well**. Auto Club signs. **Water** at faucet north of house.

53.2 Road forks join. Auto Club sign. Go southeast from forks.

58.0 Geological Survey sign. Road west goes to Corn Spring. (See p. 165.)

61.1 Auto Club sign. Road to left goes to McCoy Spring. (See p. 165.) Very sandy. Trail west is said to go to Corn Spring.

66.2 Left fork is short cut-off. Continue straight on right fork.

66.3 Auto Club sign. Turn left. Road southeast to Wiley Well (see p. 165) is probably very bad.

66.5 Geological Survey and Auto Club signs. Either road equal distance to Blythe, but left-hand road passes wells and right-hand road does not. Optional logs.

**Right-hand route.**

38.9 Start east.

41.3 Geological Survey sign. Road south goes to Granite Mine Well. (See p. 195.)

48.9 Geological Survey sign. Trail north to Gruendike Well very bad for automobiles.

51.9 Road forks join. Set gage to 53.2 to get mileage by way of Gruendike.
**ROAD Logs.**

<table>
<thead>
<tr>
<th>Left-hand route.</th>
<th>Right-hand route.</th>
</tr>
</thead>
<tbody>
<tr>
<td>66.5 Keep to left.</td>
<td>66.5 Turn to right.</td>
</tr>
<tr>
<td>70.6 Hopkins Well, on south side of road. Iron pump.</td>
<td>70.7 Auto Club sign. Road north to Hopkins Well, one-half mile.</td>
</tr>
<tr>
<td>74.2 Ford Well. Windmill and cattle camp.</td>
<td>73.9 Trail north goes to Ford Well, 1 mile. Keep east.</td>
</tr>
<tr>
<td>75.2 Geological Survey and Auto Club signs. Forks join. Go east.</td>
<td>74.6 Go northeast.</td>
</tr>
</tbody>
</table>

**Left-hand route.**

66.5 Keep to left.  
70.6 Hopkins Well, on south side of road. Iron pump.  
74.2 Ford Well. Windmill and cattle camp.  
76.2 Road crosses sand dune ridge. May have trouble here.  
77.0 Auto Club sign.  
82.8 Auto Club sign.  
83.3 Auto Club sign.  
84.6 Road skirts point of McCoy Mountains.  
86.6 Patterson ranch. Auto Club sign. Good water.  
91.5 Auto Club sign. Roads branch. Route optional. One goes south one-half mile and east 2 miles; the other east 2 miles and south one-half mile. Former usually preferred. This brings reading to 94.0.  
94.0 Crossroads at west edge of Blythe. Geological Survey and Auto Club signs. Road south goes to Imperial Valley and Yuma. (See pp. 174-177.) Road north goes to Blythe Junction. (See p. 179.) Road east goes to Blythe and Ehrenberg.  
94.5 Blythe post office. Water. Hotels, garages, and supplies.  

**BLYTHE TO EHRENBERG (4 MILES).**

0.0 Blythe post office. Go east.  
2.5 Road leads northeast, then southeast over low swamp through thick jungle.  
4.2 Ehrenberg Ferry over Colorado River.  

**EHRENBERG TO BLYTHE (4 MILES).**

0.0 Ehrenberg. At west bank of Colorado River.  
1.7 Come out of lowland thicket to straight west road.  
4.2 Blythe post office.  

**BLYTHE TO MECCA (96 MILES).**

0.0 Blythe post office. Go west.  
0.5 Geological Survey and Auto Club signs. Read big warning board. Road north goes to Blythe Junction. (See p. 179.) Road south goes to Yuma and Imperial Valley. (See pp. 174-177.) Road west goes to Mecca. In going to Mecca one may also go one-half mile north and then turn west. Log is for road going west.  
2.5 Auto Club signs. Turn north.  
3.0 Auto Club signs. Turn west.  
7.9 Patterson ranch. Auto Club sign. Good water. Last reliable supply of water for 75 miles.  
9.9 Road skirts tip of McCoy Mountains.  
11.2 Auto Club sign.  
11.7 Auto Club sign.  
17.5 Auto Club sign.
18.3 Road crosses sand-dune ridge. May have trouble here.
19.3 Geological Survey and Auto Club signs. Road forks. Both roads lead to Mecca, equal distance, but only right-hand road passes water. Optional logs given.

**Left-hand road.**

19.9 Turn west.
20.6 Trail north to Ford Well, 1 mile. Keep west.
23.8 Auto Club sign. Trail north to Hopkins Well, one-half mile.

28.0 At Geological Survey sign. Right-hand road, leading west, is short cut-off, usually sandy. Take left-hand road.
28.2 Auto Club sign. Turn northwest. Road southeast to Wiley Well is probably very bad. (See p. 165.)
28.3 Cut-off comes in from east. Keep straight ahead.
33.4 Auto Club sign. Trail crosses road. Northeast it leads to McCoy Spring. (See p. 165.) Southwest it leads to Corn Spring, but a better road to Corn Spring turns off farther on. Keep straight ahead.
36.5 Geological Survey sign. Road west goes to Corn Spring. (See p. 165.) Keep straight road.
41.3 Road forks. Auto Club signs. Either way to Mecca but right-hand road passes water; left does not. Right-hand mileage by way of Gruendike Well adopted but optional logs given.

**Right-hand road.**

20.3 Ford Well. Windmill and cattle camp.
23.9 Hopkins Well. Iron pump.

41.3 Go northwest.
44.5 Road to left is cut-off. Keep to right, toward house.
44.7 Gate at Gruendike Well. Water at faucet behind house. Last water for 40 miles.
44.9 Cut-off comes in from east.
47.8 Cabin one-fourth of a mile south of road. Usually unoccupied. No water.
53.2 Auto Club sign. Road north-east goes to Boulder Well. (See p. 166.)
55.6 Auto Club sign. Roads join.

55.6 Leaving forks the road goes west.
59.0 Auto Club sign.
60.2 Geological Survey sign. Pipe line crossing road comes from small spring in Eagle Mountains and leads to cattle trough on dry lake, 1 mile away. In emergency water is usually obtainable at faucet by following pipe line one-half mile southwest.
61.9 Dim road on left.
63.6 Road north (right) goes to abandoned cattle camp, one-half mile away.
63.9 Auto Club sign. Dim crossroad. To north this leads to cattle camp mentioned above.

65.5 Auto Club sign. Dim road on left.

72.3 Auto Club sign. Dim road on left.

81.9 Auto Club sign. Road on right goes to Cottonwood Spring. (See p. 184.)

82.4 Shaver Well, in canyon on north side of road.

88.5 Leave Shaver Canyon and reach point overlooking the Salton Sea.

90.6 Pass under electric transmission line and turn due west. Road along electric line is private property of Coachella Valley Ice & Electric Co. but is sometimes used as route south to Dos Palmas, etc. (See p. 171.)

93.6 Geological Survey sign. Road south goes to Dos Palmas, Niland, etc. (See p. 166.)

94.5 Mecca. Water trough one block south of post office.

**McCoy Spring from Mecca-Blythe Highway.**

At 61 miles from Mecca on the main road to Blythe (see p. 161) is a dim crossroad, marked by Auto Club and county signposts, which crosses Chuckwalla Valley eastward to McCoy Spring* (see p. 172) and westward to Corn Spring. It is little used on the west, as other roads are more convenient. On the east it crosses a wide waste of heavy sand and is said to be practically impassable for automobiles. It is passable for wagons. Its exact course and condition were not ascertained. Both springs are old and reliable watering places.

**Wiley Well from Mecca-Blythe Highway.**

From the Mecca-Blythe road, 66.3 miles from Mecca and 28.2 miles from Blythe (p. 161), a dim road goes southeast to Wiley Well. It has not been traveled much recently and is reported as probably impassable for automobiles. The country intervening is known to be very sandy. Good water can be obtained at Wiley Well with rope and bucket, which were provided in 1918.

**Corn Spring from Mecca-Blythe Highway.**

At 58 miles east of Mecca and 36.5 miles west of Blythe, on the Mecca-Blythe road (p. 161), a branch road marked by a United States Geological Survey sign goes southwest to Corn Spring. The first 8 miles of the road is fair and easily passable, but beyond that the road enters a sandy canyon bed, which at times is very difficult for automobiles. The total distance to Corn Spring from the fork is about 10 miles. There is a little cienaga in the mountains at Corn Spring, where grass and vegetation and good water are found. A dim wagon road continues west through a pass in the Chuckwalla Mountains to Aztic Well and Mill Camp. This road was said to be nearly impassable in 1918.

Aztic Well is near the southeast corner of T. 6 S., R. 15 E., about 5 miles from Mill Camp and 3 miles from Corn Spring. It is about 15 feet deep, and the water stands about 10 feet below the surface. It was in good condition in 1917.

**Mill Camp Roads.**

Several dim trails traverse the country between the Oroopia and Chuckwalla mountains, usually passing Mill Camp, an abandoned (1918) mine in the west end of the Chuckwalla Mountains, probably in sec. 5, T. 7 S., R. 15 E. Some of these roads run south from the Hayfields; others go north from the Dos Palmas-Chuckwalla Well country. They are probably passable for any vehicle,
as this country is rough but not sandy. Mill Camp is said to be a reliable watering place.

**BOULDER WELL FROM MECCA-BLYTHE HIGHWAY.**

At 41.3 miles east of Mecca on the road to Blythe by way of Gruendike Well (p. 161) a branch goes northeast to Boulder Well, 7 miles away, in sec. 31, T. 4 S., R. 16 E. The road is passable for automobiles and continues to mining properties in the eastern Eagle Mountains. Another road goes to Palen Well, in sec. 35, T. 4 S., R. 16 E., and Packard Well but is probably impassable for automobiles.

The Boulder Well was a fairly reliable watering place in 1918, but the Palen Well was reported to be dry. The Packard Well contained water in 1918 but was in a very filthy condition.

**MECCA—DOS PALMAS—CHUCKWALLA WELL—BLYTHE.**

**MECCA TO BLYTHE (103 MILES).**

*Note.—* This road should not be confused with the ocean-to-ocean highway connecting Mecca and Blythe by way of Shaver Well and the Chuckwalla Valley. (See p. 161.) The road here described serves a large territory lying between the Chuckwalla and Chocolate mountains but is little used except by local people and prospectors. It is extremely bad at places and is not recommended as a route for the through traveler.

0.0 Mecca. Public fountain just north of railway station. Start east.

0.9 Geological Survey sign. Turn south (right). Road leading east is highway to Blythe through Chuckwalla Valley. (See p. 161.)

1.4 North side of date orchard on Government experimental farm. Turn east beside farm.

1.7 Corner of date farm. Turn southeast and go over sandy road across barren desert.

2.9 Southern Pacific Railroad. Turn east along north side of track. A little-used branch road comes in down the track.

3.1 Branch road crosses railway to south. Continue east.

4.7 Branch road crosses railway to south. Continue east. The road is very sandy at places and it may be necessary to deflate tires to 35 or even 30 pounds pressure.

8.7 Leave railway, which turns southeast, and continue in more easterly direction.

8.8 Geological Survey sign. Branch road turns south along railway to Mortmar, a station 1 mile away. Take left-hand road leading to Dos Palmas.

9.5 Pass under power line. A branch road following this line is used by linemen, but its use as a public road is discouraged by the company. It is sometimes used as a route to Dos Palmas by going southeast from this fork about 4 miles and then turning away from power line. (See p. 171.) Main road continues east (left), climbing a steep sandy slope.

12.0 In the next half mile the road crosses the old beach twice, and the sand is very bad. The road then cuts across a point of clay hills.


15.8 **Dos Palmas. Poor water** obtainable by following a path into the center of tule patch and dipping from the open pool. A branch road goes southwest to Salton. An old county signpost marks the fork. Continue east.
16.6 Cabin on north side of road. Water. A dim trail turns south to an intersection with the power-line road. Continue east.

17.2 County signpost. Branch road turns to right, leading to Frink Spring and Niland. (See p. 171.) Continue straight (left).

23.2 County signpost, on north side of road. Road drops into wide sandy wash here. Many tracks lead up this wash, and there is no distinct road. Pick out firmest road and continue northeast up wash.

25.4 Clemens Well, on south bank of wash in ravine. Good water. Geological Survey sign in the wash 50 feet in front of the well should be visible from most parts of the wash. Continue up wash.

26.9 Cabin and ruins of old Canyon Spring stage station. A county signpost stands near the place. The spring is 1 mile north, up the tributary canyon opposite the house. (See p. 248.) Road to spring very sandy and seldom used. Continue east, up wash, watching for main tracks, which gradually gather into a plain road on south side of wash.

31.0 County signpost, on north side of road. A branch road goes north up the main wash 100 feet east of this sign but is usually dim. It leads to Mill Camp (p. 165). Main road turns nearly east, up a branch wash, and farther on bends southeast, passing over a much dissected alluvial plain.

34.9 Geological Survey sign. Branch road goes south to Tabaseca Tank, 1 mile away. The road is rough, but passable for automobiles. Water might be had at the tank in emergency. (See p. 248.) Main road continues east.

41.0 A dim branch road goes to the left, up a big wash. It rejoins the main road 0.8 mile farther on. Take right-hand road, passing to the south, over a low granite hill.

41.8 Branch road reenters in big sandy wash. Follow the plainest road southeast, crossing numerous sandy washes.

44.7 Geological Survey sign. Branch roads go north and south. Water 3½ miles north (on left) at Gulliday Well. The road south goes to Niland but is very bad. Continue east (straight).

45.9 Another branch road leads north (left) to Gulliday Well. Continue east.

48.0 Summit of divide between drainage basins of Salton Sea and Colorado River. A very extensive view is obtainable from this point. Road continues east, then southeast, passing down a wide sandy wash.

56.0 At about this point the road emerges from the wash and turns sharply north.

56.8 County signpost 100 yards south of Chuckwalla Well, which may be reached by walking north to opening in a little wash coming out of the hills to the north. Water of fair quality. Turn southeast for Blythe.

57.7 Dim trail turning south (right) is said to lead to Salvation Spring. It is impassable by automobile. Continue on main road (left), which leads east, down a rather sandy wash.

64.0 to 67.0 Road in this stretch passes down a wash through a gap between the Chuckwalla Mountains and the Black Hills. Many little lava hills along the way. The road then emerges upon a hard, smooth, gravel plain and goes northeast.

70.8 A plain but little-traveled road leads south to Salvation Spring and Niland. (See p. 173.) Continue northeast.

72.0 Pass ruins of an old stone house, the Mule Springs stage station, on north side of road. A well once existed 100 feet north in the wash, but there is no water at the place now.
77.6 Faint trail leads east. It is a cut-off avoiding Wiley Well. Take main road (left).

77.8 Wiley Well. Good water obtainable with rope and bucket, which were provided in 1918. County signpost at well. Go east on main road, which is sandy, passing over a high and much dissected alluvial plateau lying on the south flank of the Mule Mountains.

81.0 Summit of pass through south end of Mule Mountains. Road drops down a canyon to east, very rough and rocky.

82.0 Climb out of canyon and go east across small level plain.

83.8 Pass down a very sandy wash through some scattered granite hills, the south end of the Mule Mountains, emerging on sandy plain above the low Colorado River valley.

85.0 Branch road goes northwest to mine visible on side of mountains. Continue east.

86.6 Edge of terrace overlooking Palo Verde Valley.

86.9 Foot of terrace. County signpost. Go east over mesquite-covered lowland.

87.3 Irrigation ditch, go east on north side of it.

88.8 Blythe-Glamis road. (See p. 174.) Geological Survey sign. Turn north (left) to Blythe. Water and supplies may be obtained at Rannells, 0.2 mile south of this corner.

91.4 Road turns northeast, across mesquite thicket. The soil is a soft silt that wears quickly into deep ruts, so that innumerable trails have been made which cross and recross in a bewildering manner. All of them eventually lead to Blythe. Use best and plainest tracks. Numerous signposts along the way.

92.8 Cross over fill in channel of bayou full of clear water.

95.6. Branch road leads north. Turn straight east on good road through cultivated land.

96.6 Neighbor School. Continue east.

97.6 Auto Club sign. Turn north (left).

98.6 Auto Club sign. Turn east (right).

100.6 Auto Club sign. Turn north (left).


102.6 Blythe. At post office, two blocks east of railway crossing.

BLYTHE TO MECCA (103 MILES).

Note.—This road should not be confused with the ocean-to-ocean highway connecting Blythe and Mecca by way of Chuckwalla Valley and Shaver Well. (See p. 163.) The road here described serves a large territory lying between Chuckwalla and Chocolate mountains but is little used except by local people and by prospectors. It is extremely bad at places and is not recommended as a route for through travelers.

0.0 Blythe. Post office, two blocks east of railway crossing. Start west.

0.5 Crossroads. Geological Survey sign. Road north goes to Blythe Junction (p. 179). Road west is main road to Mecca (p. 163). Turn south for road to Mecca by way of Chuckwalla Well and Dos Palmas.

2.0 Auto Club sign. Turn west (right).

4.0 Auto Club sign. Turn south (left).

5.0 Auto Club sign. Turn west (right).
6.0 Neighbor School. Continue west.
7.0 Branch road leads north. Turn southwest across uncultivated desert, mostly mesquite thicket. The soil is soft silt which quickly wears into deep ruts, and hence roads wind in every direction in a bewildering way. Pick out the best and plainest. All lead to right place. Auto Club signs are numerous.

9.8 Cross over fill in channel of slough of fresh water.
11.2 Road turns straight south and passes by some cultivated land.
13.8 Geological Survey sign. The road south continues to Glamis and Yuma. Kannells, 0.2 mile south of this corner, is last supply station for 89 miles. For Mecca turn to the right, crossing bridge and going west on north side of irrigation ditch.

15.3 End of irrigation ditch. Continue west over mesquite-covered lowland.
15.7 County sign, on north side of road. Go west, uphill. Very sandy.
16.0 Edge of terrace overlooking valley to the east. Continue west over sandy plain.

17.6 Branch road turns to right, leading to a mine visible on mountain side. Continue straight (left).

18.8 Pass up a very sandy wash through low granite hills at south end of Mule Mountains. Emerge on a small plain and continue west.
20.6 Descend into canyon and go west. Very rough and rocky.
21.6 Summit of pass in Mule Mountains. Go west, descending long alluvial slope, much dissected, to sandy plain.

24.6 Dim trail turns left. This is a cut-off avoiding Wiley Well. Take main road (right).
24.8 Wiley Well. Good water obtainable with rope and bucket, which were provided in 1918. County sign by well. Turn slightly south, then west across some sandy washes and then ascend long gravel slope going southwest.
30.6 Ruins of old stone house—Mule Springs stage station—on north side of road. A well once existed 100 feet north of this place, but no water is now obtainable.
31.8 A plain but little traveled road leads south to Salvation Spring and Niland. (See p. 173.) Continue southwest (right) on main road.
39.0 to 42.0 Road in this stretch passes up a sandy wash, through a gap between the Chuckwalla Mountains and the Black Hills. Many little lava-capped hills along the way.
44.9 Dim trail leading south (left) is said to go to Salvation Spring. It is impassable by automobile. Continue west.
45.8 County sign 100 yards south of Chuckwalla Well. Fair water may be had by walking north to opening of wash leading out of hills. Turn sharply south for Mecca.
46.6 Road curves westward into a wide sandy wash and follows it for several miles.
54.6 Summit of divide between drainage basins of Colorado River and Salton Sea. A very extensive view is obtainable here. Continue west over an alluvial plateau badly dissected by washes, many of which are sandy and difficult to cross.

56.7 A dim branch road leads north (right). It is said to go to Gulliday Well 3½ miles north, but another road is available a mile farther on.
57.9 Geological Survey sign. A branch road leads north to Gulliday Well, 3½ miles. It is passable and water could be had if needed. Another
branch road leads south to Niland but is very bad. (See p. 142.) Continue west.

60.8 A faint branch road continues west (right), down a sandy wash, and presumably rejoins the main road 0.8 mile west. Keep to the left, climbing out of wash and passing over a low granite hill.

61.6 Branch road rejoins main road. Continue west.

67.7 Geological Survey sign. A branch road, rough but passable, goes south to Tabaseca Tank, 1 mile away. Water in emergency. Continue west.

71.6 County sign on north side. Road enters wide sandy wash and goes southwest. A branch road follows up this wash northeast to Mill Camp. (See p. 165.) Follow main road southwest. The tracks gradually spread out all over the width of the wash but any path that is good may be used.

75.7 Cabin and ruins of old Canyon Spring stage station, on south side of road. County sign. The spring is 1 mile north, up a branch canyon opposite the cabin, but is hard to reach and an unsatisfactory waterhole. Continue west. Good water at Clemens Well is only 1/2 miles away.

77.2 Clemens Well, on south side of wash. Good water. A Geological Survey sign 50 feet in front of well should be visible from most parts of wash. Continue down wash, keeping near north wall.

79.4 County sign on north side. Road climbs out of wash. Continue west.

85.4 County sign. Branch road turn southeast to Frink Spring and Niland. (See p. 171.) Continue west.

86.0 Cabin on north side of road. Water. A dim trail leads south to various roads going to Niland. Continue west.

86.8 Dos Palmas. County sign. Poor water is obtainable by following path through tules to pool. A branch road leads southwest (left) to Salton. Continue west (right) for Mecca. Occasionally persons go south on the Salton road to the power line (see p. 171) and turn north along power line to Mecca.

89.0 Cross old beach. Deep sand may cause trouble. Deflate tires to 35 pounds if necessary. After crossing the beach the road passes through clay hills and crosses beach twice more. It then descends a long, sandy slope to west.

93.1 Power line. A branch road following this line is used by linemen, but its use as a public road is discouraged by the company. Nevertheless, persons sometimes use it going south to Niland or north to Mecca. (See p. 171.)

93.8 Geological Survey sign about 0.1 mile east of Southern Pacific Railroad. A branch road goes south along railway to Mortmar, a station 1 mile away. Continue west to Mecca.

93.9 Reach railway and follow west along north side of track. Parts of the road are very sandy.

97.9 Branch road crosses railway to south. Continue west.

99.5 Branch road crosses railway to south. Continue west.

99.7 Turn northwest, away from railway. A dim road continues along railway into Mecca, but is little used.

100.9 Corner of date garden at Government experimental farm. Go west, along north side of farm.

101.2 Turn north, away from date farm.
101.7 Main Mecca-Blythe road. (See p. 161.) Geological Survey sign. Turn west.

102.6 Mecca. Water fountain just north of railway station, 1 block south of post office. Water, gasoline, supplies, and hotel.

MECCA TO NILAND, ON EAST SIDE OF SALTON SEA.

GENERAL OUTLINE.

East of the Salton Sea a number of very bad roads go southeast to Dos Palmas, Frink Spring, Niland, and intermediate points along the Southern Pacific Railroad. Natural difficulties such as deep arroyos and bad sand, combined with little travel, are the worst features of the roads, and by all but a few local residents they are considered practically impassable for automobile. The writer has traveled no one route consecutively all the way, but parts of all of them. The combinations of cross trails used in endeavoring to find a passable way through this uninhabited area are a source of much perplexity to travelers unacquainted with the country.

There is a legitimate desire on the part of the citizens at Mecca and Niland to have the road improved, and undoubtedly if it were easily passable it would be valuable to travelers going from Los Angeles to Yuma, as it is about 20 miles shorter than the present road around the west side of the Salton Sea.

The distance by various routes from Mecca to Niland is 40 to 45 miles. No supplies are obtainable between these points, but water can be had at any of the five or six stations along the Southern Pacific Railroad and also at Dos Palmas and Frink Spring. The latter places, however, furnish very poor drinking water.

There are three general routes available, which are described in turn. They are (1) the road along the railway, (2) the road along the power line, and (3) the road passing through Dos Palmas and Frink Spring.

ROAD ALONG SOUTHERN PACIFIC RAILROAD.

A road follows the Southern Pacific Railroad nearly if not quite all the way between Mecca and Niland. So far as known it is never used by automobiles between Mortmar and Wister, but it is passable from Mecca to Mortmar. From Wister a very good road leads south and east along section lines to Niland. Automobilists from Niland are advised to use this road as far as Wister (9.3 miles from Niland) and to cross the railway and turn east to the power line or to other roads at a point 1½ miles northwest of Wister (10.7 miles from Niland). In 1917 there was no crossing provided at the railway, and it was difficult for automobiles to get over.

ROAD ALONG POWER LINE.

Along the electric transmission line of the Coachella Valley Ice & Electric Co., which runs from San Bernardino to Imperial Valley, there is a road used by linemen and company officials. This road is private property of the company, which has posted signs discouraging its use by the public. However, it is used considerably by local residents and is easily followed. It crosses many deep gullies and is exceedingly rough but nevertheless is probably the safest of the possible roads.

ROAD THROUGH DOS PALMAS AND FRINK SPRING.

Two miles east of Dos Palmas, on the road from Mecca to Blythe by way of Dos Palmas, a road turns southeast (right) to Niland. The first 6 or 8 miles
of this is across bad sand but could probably be traveled by any automobile which succeeded in getting to Dos Palmas. The distance from Dos Palmas to Frink Spring is about 12 miles and that from Frink Spring to Niland by way of Wister is 16 miles. This makes the total distance between Mecca and Niland 44 miles. By using the road southeast of Frink Spring to its junction with the power-line road, 8 miles away, and then following the power line, the distance into Niland is reduced to only 13 miles. This road follows an abandoned railway grade for a long distance and is in places fairly good.

NILAND TO GULLIDAY WELL.

[Distances are approximate from Niland.]

GENERAL OUTLINE.

North and slightly east of Niland is a great, conspicuous embayment in the southern wall of the Chocolate Mountains, known as Iris Pass. This affords a natural roadway through the range and has occasionally been used by stages, freighters from mines to the north of Niland, and prospectors. The road is at present almost unused and is really no road at all, but a very bad, rough, sandy passage by which wagons and even automobiles occasionally enter the area to which it offers access. There are no habitations and no watering places along the way, and it is so little traveled that the dim tracks observed may be a year old and usually wander about in widely divergent directions. As an automobile road this is practically impassable, particularly going north, which is a continuous ascent. Only an approximate log and general description of the area can be given.

NILAND TO CHOCOLATE MOUNTAINS (12.5 MILES).

The road starts at the Geological Survey sign on the corner by the post office at Niland and goes straight north across the railway (0.1) at the station, turning to right for a little way at a road fork (0.2) where a branch road goes northwest to Frink Spring, Dos Palmas, and other places. The road here considered goes north under a transmission line (0.5 approximate) to the Highline canal of the Imperial Irrigation District (1.5). Crossing a wooden bridge at the canal, a fairly plain trail goes northeast up a sandy wash over the unimproved desert. Gradually the wash deepens until it is an arroyo, 200 to 300 feet wide, with vertical walls cut in soft clay and sandstones and ramified by extensive tributary arroyos.

At about 4.0 miles a number of tracks go east (right), up one of the tributary arroyos, and are said to continue to a gap in the Chocolate Range known as Surveyor Pass, which is less prominent than Iris Pass, farther east. To reach Iris Pass continue (left) up the main arroyo, where guiding tracks will usually be seen, toward the big and unmistakable gap ahead.

The road is rough, gravelly, and sandy; it climbs over little arroyos and gullies into others similar and more misleading; in short it is very bad, being scarcely a road at all, until finally the tracks gather together again into a fairly well defined trail at the south edge of the Chocolate Range (12.5, approximate).

IRIS PASS.

At its entrance Iris Pass is 2 or 3 miles wide, and the road is near the west wall. A wide sandy wash flanked on the west by steep mountains and bordered on the east by low hills that gradually rise into mountains, is fol-
lowed northward. At 15.5 miles, the pass narrows to a canyon from 100 to 300 feet wide, and beyond this point it increases in narrowness and steepness. The whole road through this part of the pass is very sandy. Automobile tires will probably have to be deflated in going up. The road finally ascends an exceedingly steep but firm hill and emerges on a plateau at the north side of the Chocolate Mountains (20.0), from which a magnificent view is obtainable.

MECCA-BLYTHE ROAD CROSSING.

From the north edge of the Chocolate Mountains the road is very good and descends a gentle slope northward over rolling gravelly hills until at about 22.0 miles from Niland it reaches a crossroad that leads west to Dos Palmas and Mecca, east to Chuckwalla Well and Blythe. There is a Geological Survey sign at the crossing. This gives the distance south to Niland as 25 miles, that distance not having been accurately known when the sign was established and an error in favor of greater length being preferred to the danger of giving too little.

GULLIDAY WELL.

The portion of the road from the crossing northward to Gulliday Well is little traveled except by prospectors interested in the Chuckwalla Mountains. It is about 3½ miles from the Geological Survey sign to the well, and the road is rather stony and rough, the last half mile especially so. It is possible to approach within about 100 feet of the well by automobile, and at this point the road ends beside a little arroyo near the base of the Chuckwalla Mountains.

Gulliday Well is a shallow hole in granite beside this arroyo and contains good water at all times unless polluted by surface trash. The well is used chiefly by prospectors and miners in near-by territory.

SURVEYORS PASS ROAD.

The Surveyors Pass road is only a dim wagon trail that leaves the Niland-Gulliday Well road 4 miles north of Niland and goes nearly east, farther on turning northeast toward a noticeable pass in the Chocolate Range east of Iris Pass. The road was used about 1912 or 1913 by a party of land surveyors who camped somewhere in the pass and from whom local residents have attached the name given. The road is probably too bad for automobile travel and is said not to lead entirely through the mountains. It is of interest chiefly to prospectors. Springs or water holes are not certainly known to exist in the mountains but may possibly be found there. The road extends 16 or 18 miles from Niland.

NILAND-SALVATION PASS-BLYTHE.

About 8 miles east of Niland, on the road to Yuma, a number of trails turn off to the left toward the Chocolate Mountains. They unite and go through a break in the mountains known as Salvation Pass. The road then continues northeast to a junction with the road between Mecca and Blythe by way of Dos Palmas. This junction is 7 miles west of Wiley Well. The road was not traversed, but its location as shown on this map is fairly accurate, especially in the mountains, having been taken from a recent township survey. The road is very bad and difficult to travel by automobiles, being both rough and sandy. Travelers unacquainted with the country are not advised to attempt it. The only water along the road is at Salvation Spring or the Peg Leg Well, and
these places are off the road and may be hard to find. The road shortens the
distance between Niland and Blythe very materially, and so there is some talk
of improving it. At present it is seldom used.

Salvation Spring is near the center of sec. 36, T. 10 S., R. 16 E., and is
about a mile southeast of the main road in a side canyon. The Salvation
Spring Pass follows a deep canyon that originates as a dry wash in an
elevated plain east of the range and cuts directly across the main chain
southwest. Usually tracks or a board sign or something else is visible, indicat­
ing the turnout to Salvation Spring on the east. There is said to be only a
small seep of water at the spring, and it may be necessary to dig a little in
the sand of the wash to uncover it. Somewhere near the spring is a miner's
cabin, occasionally occupied by prospectors, and trails connect the place with
the Peg Leg mine (abandoned in 1918) and well, a mile or two away.

In the eastern part of the Salvation Spring Pass through the Chocolate
Mountains a trail turns southeast up a tributary arroyo to the Peg Leg Well
and mine. The road was not traversed nor the well visited by the writer and
information about it was obtained from local residents and from recently sur­
veyed township plats. The mine is near the southwest corner of T. 10 S., R. 17
E., a mile or two east of Salvation Spring, and about 2 miles from the Niland
Blythe road through the pass. It is not definitely known whether the well is at
the mine or farther down the wash nearer the main road. It is described as 100
feet deep, 60 feet to water, and equipped with windlass and bucket. A board
sign generally indicates the turnout. This mine should not be confused with the
mythical mine of Peg Leg Smith.

BLYTHE-GLAMIS ROUTE TO YUMA AND IMPERIAL VALLEY.

BLYTHE TO GLAMIS (59 MILES).

0.0 Blythe. Post office, two blocks east of railway crossing. Start west.
0.5 Crossroads. Geological Survey sign. Road north goes to Blythe Junc­
tion (p. 179). Road west goes to Mecca (p. 163). Turn south for Glamis.
2.0 Auto Club sign. Turn west (right).
4.0 Auto Club sign. Turn south (left).
5.0 Auto Club sign. Turn west (right).
6.0 Neighbor School. Continue west.
7.0 Branch road leads north. Turn southwest across uncultivated desert,
mostly a mesquite thicket. The soil is soft silt which quickly wears
into deep ruts, and the roads wind everywhere in a bewildering way.
Pick out the best and plainest. All lead to right place. Auto Club
signs are numerous.
9.8 Geological Survey sign. Cross over fill in slough of fresh water.
11.2 Road turns straight south and passes cultivated land.
13.8 Branch road crosses irrigation ditch and goes west to Wiley Well, Dos
Palmas, etc. (See p. 163.) Continue south.
14.0 Rannels. Store and post office (combined). Water and gasoline. Con­
tinue south. The road at places passes through mesquite thickets.
Numerous trails lead away, but main road is easily distinguished and
well marked with signs.
17.1 Auto Club sign. Branch road goes east. Continue south.
18.5 Road emerges into open space and turns due south into Palo Verde.
18.7 Palo Verde. Store and post office (combined). Water and gasoline.
Continue south.
18.8 Palo Verde School. Turn west.
19.2 Auto Club sign. Branch road continues west. Turn south.
22.3 Ascend out of valley to terrace overlooking valley.
23.1 Road forks. Mileage is given over left-hand road. The straight road is 0.4 mile shorter but crosses two bad hills.
23.8 Auto Club sign. Roads unite and continue south.
26.0 Enter canyon and follow it south through pass in Palo Verde Mountains.
27.8 Summit of pass. Road continues south down another canyon.
30.0 Emerge from canyon upon large gravel-strewn plain. The road from this point to Glamis is over hard gravel plain most of the way.
30.4 Auto Club sign.
30.9 Road forks. The two branches run parallel to each other, about half a mile apart, and reunite 5.3 miles away. There is nothing to note on right-hand (west) branch, so only log of left-hand (east) branch is given. This fork is in a large wash called the Arroyo Seco. Numerous other big washes cross the road in the next 5 miles but none are difficult to pass.
34.9 Auto Club sign. Plain road turning east leads to a manganese mine 5 miles southeast. Continue south.
37.3 Smith Well. Water of fair quality obtainable by windlass. A mining camp was being started here in 1918, and a mill was being erected on the hillside east of road opposite well. Continue south.
37.4 Plain road leads west to Paymaster mine, 3 miles away. Continue south (left).
41.1 Road forks. Both roads lead to Glamis. Left-hand road probably preferable. Right-hand road leads over rolling hills and down a canyon pass, rejoining left-hand road 9.2 miles away (50.3 on right-hand road). Auto Club sign points to right-hand road for Glamis but need not be heeded. Log is for left-hand road.
44.2 Geological Survey sign. Plain road going south (left) leads to Yuma by way of Tumco. Persons going to Yuma on this road should turn to the left here and use the log of the Tumco cut-off (p. 177). Take right-hand (west) road for Glamis.
47.1 Dim trail leads south. Continue southwest.
49.3 Branch road noted at 41.1 rejoins. Go south.
53.3 Pass through group of low lava hills.
58.3 Auto Club sign. Branch road leads southeast to Yuma. Continue southwest for Glamis.
58.5 Glamis railway station. Water is obtainable from railway cistern. Charge of 5 cents a head for stock. Gasoline and meals can be had at store.

GLAMIS TO BLYTHE (59 MILES).

0.0 Glamis railway station. Start northeast on main road, away from railway. Road runs over hard gravel plain and is generally good for nearly 35 miles.
0.2 Road forks. Auto Club signs. Right-hand road turns east to Yuma. Continue northeast for Blythe.
5.2 Pass through a group of low lava hills.
9.2 Road forks. West (left) branch goes up sandy canyon and over a rolling plateau and rejoins the east fork (at 18.4 measured on west road). Log is for east (right) branch, which is a mile shorter and is more traveled.
11.4 Dim trail leads south. Continue northeast over rolling plain covered with low lava hills.

14.3 Geological Survey sign. Branch road enters from south. This road comes from Yuma by way of Tumco mining camp. (See p. 177.)

17.4 West branch noted at 9.2 rejoins. Go north.

21.1 Plain road leads west to Paymaster mine, 3 miles away. Continue north.

21.2 Smith Well. A mining camp was being established here in 1918, and a mill was being erected on the hillside east of the road, opposite the well. Water of fair quality was obtainable by a windlass. Continue north.

22.3 Road forks. The two branches run nearly parallel and about half a mile apart, rejoining 5.3 miles away. Distance equal. Only log of east (right) branch is given. Auto Club sign points to Blythe along east branch.

23.6 Auto Club sign. Plain road turning east leads to a manganese mine 5 miles southeast. Main road continues north. Several large washes cross the road in the next few miles, but none are difficult to pass.

27.2 Enter Arroyo Seco, the largest wash of all.

27.6 West branch noted at 22.3 rejoins. Go north.

28.1 Auto Club sign.

28.5 Road enters winding canyon and follows it up northward, through pass in Palo Verde Mountains.

30.7 Summit of pass. Road goes down another canyon, leading north.

34.7 Road forks. Both roads lead to Blythe. The left-hand road, going straight ahead, is 0.4 mile shorter but has two bad hills. Most travelers take right-hand road, which turns east. Log is for right-hand road.

35.4 Branch road noted at 34.7 rejoins. Continue north.

36.2 Descend from terrace into Palo Verde Valley, a low, flat plain along Colorado River.

36.7 Auto Club sign. Branch road goes east to Cibola Landing. Continue north. Numerous trails leave the main road in this region, which is largely a mesquite swamp, but the main road is easy to follow and well marked with signs.

39.3 Auto Club sign. Branch road goes west. Turn east (right).

39.7 Palo Verde School. Turn north to town.


40.0 Road turns sharply northeast through dense thicket of mesquite. Numerous trails turn to either side, but main road is plain and well marked with signs.

41.4 Auto Club sign. Branch road goes southeast. Continue north.

44.5 Rannells. Store and post office (combined). Water and gasoline. Continue north for Blythe.

44.7 Geological Survey sign. Branch road that turns west across irrigation ditch leads to Wiley Well, Dos Palmas, etc. (See p. 168.) Continue north.

47.3 Road turns northeast across mesquite thicket. The soil is a soft silt that wears quickly into deep ruts, so that innumerable trails have been made which cross and recross in a bewildering manner. All of them eventually lead to Blythe. Use best and plainest tracks. Numerous signposts along the way.

48.7 Cross over fill in slough full of clear water.
ROAD LOGS.

51.5 Branch road leads north. Turn straight east over good road through cultivated land.

52.5 Neighbor School. Continue east.

53.5 Auto Club sign. Turn north (left).

54.5 Auto Club sign. Turn east (right).

55.5 Auto Club sign. Turn north (left).

58.0 Crossroads at west edge of Blythe. Geological Survey sign. Road west goes to Mecca (p. 163). Road north goes to Blythe Junction (p. 179). Turn east (right) into Blythe.

58.5 Blythe. Post office two blocks east of railway crossing. Water. Hotels, garages, and supplies.

BLYTHE-YUMA ROUTE BY WAY OF TUMCO.

GENERAL STATEMENT.

Most persons making the trip between Blythe and Yuma go by way of Glamis, using the Blythe-Glamis road (p. 174) and the Niland-Yuma road (p. 139). The road here given leaves the Blythe-Glamis road 44.2 miles from Blythe and joins the Niland-Yuma road 11 miles from Yuma, effecting a saving of about 15 miles in the total distance as ordinarily traveled. This road is generally known as the Tumco road or the Tumco cut-off, because it passes near the deserted mining camp known as Tumco, formerly called Hedges. As it is one of the best desert roads found anywhere, it deserves a more general use than it has at present.

BLYTHE TO YUMA (83 MILES).

See page 174 for the road from Blythe to the Geological Survey sign, 44.2 miles from Blythe and 7 miles south of the Smith Well, where the Tumco cut-off branches from the road to Glamis.

44.2 Take left-hand road. Proceed south down a wide wash in which ironwood grows abundantly and finally emerge after about 6 miles on a smooth gravelly plain. There are few landmarks, but the road is excellent.

61.2 A branch road leads north to a place on Colorado River known as Hoges Ferry. There was a board sign at the fork in 1918. Continue on the main road, which leads southeast.

62.7 The road crosses a wash in the foot of the mountains north of Ogilby. A branch road leads up the wash to the deserted city of Tumco, which is plainly seen about a half mile away. Continue southeast without passing through the town. Usually no one lives at the place, and there is no water there.

63.2 Some branch roads turn to the right, away from the mountains, and lead to Ogilby. There are innumerable tracks leading over the desert in the next 3 or 4 miles, but it should not be difficult to follow the main road southeast near the base of the mountains but not actually within them. The traveler need not fear getting lost, as it is impossible to go far to the left into the mountains, and all roads turning to the right (south or west) lead to Ogilby, on the Southern Pacific Railroad, from which it is possible to go to Yuma.

68.0 Plain road coming from the west from Ogilby. Auto Club sign at the fork. Continue nearly east toward Yuma.
69.7 A branch road leads southeast (right) to the railway. Take the left-hand road.
71.7 The road joins the Niland-Yuma road, which enters from the south and continues southeast. Geological Survey sign at the fork.
74.8 Descend into a sandy wash 50 feet or more in depth across the river terrace and follow it for about 1½ miles, emerging on the lowland known as Yuma Valley.
76.3 Turn east (left) along irrigation ditch. A branch road goes southwest.
77.2 Turn south (right).
77.7 Touch railway and turn east. A branch road goes south across the railway.
79.9 Cross a bridge over a very large canal and just east of it a bridge over a smaller canal.
80.7 Crossroads. Geological Survey sign. Turn south (right) to Yuma.
82.2 Cross a railway and turn east up a hill. Yuma Indian School on left.
82.3 Reach bridge over Colorado River. Cross and follow principal streets into Yuma.
82.7 Yuma. At post office or railway station.

YUMA TO BLYTHE (83 MILES).

0.0 Yuma post office or railway station. Follow the principal streets to the bridge over Colorado River.
0.3 Bridge over Colorado River. Cross and go west downhill by Yuma Indian School.
0.5 A branch road leads to the left and offers a possible route to Imperial Valley points. Continue straight ahead, crossing a railway track and turning north.
2.0 Crossroads. Geological Survey sign. Turn west (left) for Blythe.
2.7 Cross a bridge over a large canal, and a little farther on a bridge over one much larger. Continue west.
5.0 Road reaches railway and turns north (right), away from it. A branch road goes south across the railway.
5.5 Turn west (left).
6.4 Turn north (right) and go about 1½ miles up a deep sandy wash to terrace above. A branch road leads southwest (left) at the turn.
11.0 Road forks. Geological Survey sign. The road going south (left) goes to Ogilby, Glamis, and Imperial Valley. To take Tumco cut-off to Blythe continue northwest.
13.0 A branch road enters from the southeast (left). Continue west.
14.7 Auto Club sign. A plain road leads to the west (left) directly into Ogilby. Take right-hand fork. There are tracks and trails leading over the desert in every direction for the next 3 or 4 miles, but it should be easy to find the main road leading northwest. It passes near the base of the mountains but does not enter them. Roads leading to the south or west go to Ogilby.
20.0 The road crosses a wash in the foot of the mountains, and a branch road leads east (right) up the wash to Tumco, whose deserted houses are conspicuous half a mile away. Usually there is no one at that place, and no water can be obtained. Continue northwest without passing through Tumco.
21.5 A branch road leads to the right, going to a place called Hoges Ferry, on Colorado River. There was a board sign at the fork in 1918. Take left-hand road, passing northwest across a smooth gravelly plain with few landmarks.
33.0 At about this distance the road enters a large wash in which ironwood trees are abundant. The wash is a little sandy but should not be difficult for automobiles.

38.5 A good road entering from the southwest is the Glamis-Blythe road. Geological Survey sign at the fork. For a detailed log of the road from this point into Blythe set gage to 14.3 and use the Glamis-Blythe log (p. 175). As the road is easy to follow nearly all the way into Blythe, the following continuous readings out of Yuma may be sufficient for many persons.

45.4 Smith Well. Mining camp. Fair water.

54.8 Summit of pass in Palo Verde Mountains.

64.0 Palo Verde. Store and post office. Water and gasoline.

68.7 Rannells. Store and post office. Water and gasoline.

82.7 Blythe. Water, supplies, and hotels.

YUMA TO PICACCHO.

The road north of Yuma, in Yuma Valley, a road goes north from a corner marked by a Geological Survey sign. This is the road to Picacho. Three miles north of the corner the road crosses a bridge over the Highline Canal in Yuma Valley, and about a mile farther north ascends a bluff out of Yuma Valley and continues north over the "mesa" and through the Picacho Hills into Picacho, the total distance being probably less than 20 miles from Yuma, although locally called 25 miles. The road has seldom been traveled by automobiles and is almost impassable because of sand along the terrace bluff 5 miles from Yuma. The rest of it is reported as fair. The road was not traveled and no accurate description can be given.

Water for domestic use at Picacho is said to be derived from wells in a little valley called Picacho Wash. Water for mining has been obtained from Colorado River.

YUMA TO LAGUNA DAM.

Several dirt roads of fair quality lead northeast through Yuma Valley, on the California side of the river, to Yuma dam, or Laguna dam, as it is now named. One road goes east from the same corner, where the Picacho road goes north, 2 miles north of Yuma. The distance is about 11 miles. There is a little settlement called Potholes at the dam, and a few caretakers live there.

BLYTHE-BLYTHE JUNCTION.¹

BLYTHE TO BLYTHE JUNCTION (41 MILES).

0.0 Blythe. Post office, two blocks east of railway crossing. Start west.

0.5 Geological Survey and Auto Club signs. Turn north (right). Road west goes to Mecca. Road south goes to Yuma and Imperial valleys.

1.0 Crossroads. Road going west may be taken for Mecca. Continue north, ignoring branch roads, which serve near-by ranches.

5.5 Auto Club sign. Cross large canal and take left-hand road. This continues nearly straight north from canal for about 300 feet and then turns sharply west. Next mile is sandy. Road to right goes to Blythe Intake. (See p. 181.)

6.1 Cross railway and turn north, climbing sandy grade to terrace.

6.4 Edge of terrace overlooking Palo Verde Valley. Go northwest. A telephone line runs near the road most of the way to Blythe Junction.

13.4 Branch road enters from south. It is another route leading from Blythe by way of Graham Well but is very sandy and little used.

¹The name of Blythe Junction has been changed to Rice since this guide was written.
18.5 Trail leads northeast to mining prospect. Continue straight.
20.0 Geological Survey sign. Branch road turns west to Mineral Switch, 500 feet away, on railway, and continues to Chandler Well, Adams Well, McCoy Spring, etc. (See p. 182.) Water may be obtainable at Mineral Switch in emergency, as it is hauled there for mine supply. Continue straight.
22.2 Branch road west paralleled by telephone line goes to gypsum mines 2.8 miles away. Continue straight.
23.2 Crest of low pass between Maria and Little Maria ranges.
23.4 Cross the railway.
25.5 Branch road turns to left at small angle. This leads to Gyp Well, 1 mile away, derrick over which is visible from this point. Mileage given on straight (right-hand) road.
26.3 Geological Survey sign. Branch road goes west to Gyp Well, one-fourth mile away. This may also be followed 3½ miles west to Mohave Tank, in the pass plainly visible in the Little Maria Mountains. Water is obtainable at Gyp Well when the gypsum mines are being worked. Continue northwest.

![Sketch map of vicinity of Blythe Junction, Calif.](image)

26.6 Branch road returns from Gyp Well.
26.9 Road forks. Both roads lead to Brown Well and Blythe Junction and both are bad. Right-hand road is very sandy and at places planked. Left-hand road is crooked, crosses many washes, and is 1 mile longer. Mileage is given over left-hand road, which is probably preferable.
34.4 Brown Well. Roads rejoin. Mileage over east branch is 33.4. Water at faucet from tank beside well. Branch road turns northwest, around a house, and leads to mine in Arica Mountain. Main road goes north-east.
36.3 Trail leads east to Gray's mill and well (abandoned).
37.1 Planked road over bad sand begins. A road leads southwest to Priest Well and a mine in Arica Mountain.
39.1 End of planked road.
39.5 Cross California Southern Railway.
40.6 Geological Survey sign. Branch road goes east to Parker.
40.8 Blythe Junction. Branch road goes west, along railway, to Cadiz, Barstow, etc. (See fig. 11.)
ROAD LOGS.

BLTHE JUNCTION TO BLYTHE (41 MILES).

0.0 Blythe Junction. Post office. Start south. Telephone line runs along road most of way. (See fig. 11.)

0.2 Branch road turns east to Parker. Continue on right-hand road, leading south.

1.3 Cross California Southern Railway.

1.7 Planked road across drift sand begins.

3.7 End of planked road. Branch road goes west (right) to Priest Well and to mine in Arica Mountain.

4.5 Trail leads east to Gray's mill and well (abandoned).

6.4 Brown Well. Water at faucet from tank beside well. A branch road comes in on northwest from mine in Arica Mountain but is hardly noticeable. The main road forks here; one branch goes slightly southwest (right) over crooked road that crosses numerous washes, and the other southeast (left) along telephone line. The left-hand road is 1 mile shorter but very sandy. Both roads are bad. Mileage was measured over right-hand road.

11.9 Branch road rejoins (mileage 10.9 on left branch). Continue southeast.

14.2 Road forks. Road to right goes by way of Gyp Well, derrick of which is visible. Mileage given on straight road (left).

14.5 Geological Survey sign. Branch road west to Gyp Well, one-fourth mile away. May also be followed to Mohave Tank, 3½ miles west, in pass visible in Little Maria Mountains. Water may or may not be obtainable at well. It is always obtainable when gypsum mines are being worked and may be drawn from tank through faucet.

15.3 Branch road returns from Gyp Well.

17.4 Cross the railway.

17.6 Summit of pass through Maria Mountains.

18.6 Branch road west paralleled by telephone line leads to gypsum mine, 2.8 miles away.

20.8 Geological Survey sign. Branch road turns west to Mineral Switch, 0.1 mile away, on railway. It leads westward to Chandler Well, Adams Well, McCoy Spring, etc. Water may sometimes be had at Mineral Switch in emergency, as it is hauled there for mine supply.

22.3 Trail leads northeast to mining prospect.

27.4 Branch road goes south (right). It is a little-used road to Blythe by way of Graham Well. It is passable but sandy. Water not obtainable at Graham Well in 1918. Use left-hand road.

34.4 Edge of terrace overlooking Palo Verde Valley.

34.7 Cross railway and turn east, over sandy road.

35.3 Auto Club sign. Turn due south across large canal. Ignore branch roads, which serve near-by ranches.

40.3 Geological Survey and Auto Club signs. Turn east (left). Road west goes to Mecca. Road south goes to Yuma and Imperial Valley.

40.8 Blythe. Post office, two blocks east of railway crossing.

BLTHE TO BLYTHE INTAKE.

About 5 miles north of Blythe a branch road goes northeast from the Blythe Junction road. It leads to Blythe Intake, which is about 7 miles from the road fork. The road is passable, at least for wagons, but is said not to be very good.
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SALTON SEA REGION, CALIFORNIA.

BLYTHE INTAKE TO PARKER.

There is an ancient trail along the river from the Blythe Intake north as far as Parker, Ariz. It is probably not passable for vehicles. C. H. Baldwin, of Blythe, describes it as follows: "For a few miles north of Blythe Intake the trail passes through some rough 'badland' hills, the border of the Maria Mountains. Later it crosses swampy land between the mountains and the river, there being a big slough on the east. An abandoned limekiln is along this part of the road. Not far from the limekiln a canyon comes from the west, and up it a burro trail leads to Willow Spring and on across the Maria Mountains. The river trail continues northward to Parker."

McCOY SPRING, ADAMS WELL, CHANDLER WELL, AND McCOY TANKS, FROM BLYTHE AND BLYTHE JUNCTION.

Note.—The only reasonably good way of reaching the places named above from Blythe is to use the main Blythe Junction road as far as Mineral Switch, a siding on the California Southern Railroad, 20 miles from Blythe. The traveler is therefore referred to the log on page 179 for the first 20 miles of the route. Persons going from Blythe Junction to any of these watering places will also turn off at Mineral Switch, which is 20.8 miles south of Blythe Junction. (See log, p. 181.)

MINERAL SWITCH TO McCOY SPRING (22 MILES).

0.0 Geological Survey sign, 0.1 mile east of Mineral Switch. Turn west toward railway.

0.1 Mineral Switch (formerly English Siding). This is a shipping point for mines in the near-by mountains, but usually no one lives here, and there are no buildings. Water is hauled here by the railway company for miners' supply and is sometimes obtainable. Cross railway. Continue west then southwest.

1.2 Road forks. Take either branch. Distance was measured on right-hand road.

2.7 The two branches unite, and road leads southwest through a group of scattered hills at the south end of the Little Maria Mountains. On leaving the hills the road turns west.

9.2 Crossroads. Geological Survey sign. To reach Chandler Well turn north and follow the road 4 miles. This well is 17 feet deep, and yields good water. The road south leads to McCoy Tanks. (See appendix to this log, p. 183.) To reach McCoy Spring continue west.

10.2 Another branch road leads south to McCoy Tanks. Continue west.

10.8 Three-way fork. Geological Survey sign. The left-hand road leads to Black Jack Camp, where some manganese mines, visible about a mile away on the mountain side, were being operated in 1918. The right-hand road goes to Adams and Packard wells. (See appendix to this log, p. 183.) The middle road leads to McCoy Spring.

12.5 At about this point the road crosses some sandy washes, branches out in several ways, and becomes rather indefinite. There is a Geological Survey sign at the most doubtful point. Go south from the sign, keeping from 1 to 2 miles west of the McCoy Mountains but east of the wide wash draining south toward Ford Dry Lake. The road is very dim at places and is badly washed out along numerous gullies.

15.3 A plain road leads east (left) to an abandoned mine in the mountains. Continue south.
16.2 A county signpost stands on the west side of the road, where a dim trail leads west (right). Continue south.

19.8 County signs and a Geological Survey sign mark dim crossroads. The trail that continues south leads to Ford Well but is impassable for automobiles. The road west joins the Mecca-Blythe road about 14 miles away but is known to be very bad. Turn east (left) to reach McCoy Spring.

22.1 The road ends at a little flat bench on the south side of a gully at the west base of the McCoy Mountains. McCoy Spring is about 150 feet east in the bed of the main gully. The water is good if clean from the surface filth.

MINERAL SWITCH TO McCoy TANKS (11 MILES).

From Mineral Switch go over McCoy Spring road, as indicated in preceding log, to Geological Survey sign at crossroads (9.2).

9.2 Geological Survey sign at crossroads. Turn south (left).

10.3 Crossroads. County sign. The road that is crossed comes from the north and leads southeast to Blythe. It is little used and in bad condition. For McCoy Tanks go southwest into the mountains on a dim road that leads toward a large canyon.

11.1 McCoy Tanks. End of the road at north edge of canyon. One of the tanks is a few hundred feet east (down the canyon); the other is about half a mile west. Both of the tanks are often dry in summer.

MINERAL SWITCH TO Adams Well.

From Mineral Switch go over McCoy Spring road, as indicated in preceding log, to Geological Survey sign at three-way fork (10.8).

10.8 Geological Survey sign at three-way fork. For Adams Well turn to the right. The road leads northwest over badly dissected desert basin. It is rather dim and bad at places but generally passable.

21.6 A Geological Survey sign stands at the entrance to a canyon which once afforded a pass for a wagon road through the Palen Mountains. A wagon or possibly even an automobile might proceed as far as Adams Well, but it is best to walk the rest of the way if traveling in a car. The distance to Adams Well is about 1 mile. Packard Well is about 3 miles farther on the west side of the mountains, but not even a wagon could have traveled the dim canyon trail in 1918. Adams Well is about 43 feet deep, and has water 20 feet below the surface. The Packard Well is said to go dry sometimes.

OLD ROUTE FROM McCoy Tanks TO Patterson and Graham Wells.

A practically abandoned trail leads southeast from the old county sign, half a mile north of McCoy Tanks and in various ways connects with Patterson Well and Graham Well. Portions of it were traveled by the writer. The distance from McCoy Tanks to Graham Well is 19 miles, but McCoy Wash is so sandy as to be practically impassable for cars. Branch roads lead southeast, avoiding the wash, and an automobile could probably get through safely from McCoy Tanks to Patterson Well. The Graham Well was abandoned in 1917 and no water was obtainable.
MECCA TO COTTONWOOD SPRING, IRON CHIEF MINE, DALE, ELDORADO MINE, PINYON WELL, AND INDIIO.

MECCA TO DALE BY WAY OF COTTONWOOD SPRING.

0.0 Mecca. Public water fountain just north of railway station. Start east.
0.9 Geological Survey sign. A branch road leads south to Dos Palmas, etc. (See p. 166.) Continue east.
3.2 Auto Club sign.
3.9 Turn northeast, passing under electric transmission line. A branch road following the transmission line is used chiefly by linemen but occasionally by travelers who go southeast (right) at this point to Dos Palmas. (See p. 171.) Continue northeast, up a sandy slope.
6.0 Enter Shaver Canyon and pass through an area of badlands several miles wide.
12.1 Shaver Well, on north side of road. Good water. Continue northeast, up canyon, which becomes merely a wash half a mile farther on.
12.6 Road forks. Auto Club signs. Right-hand road goes to Blythe. Take left-hand road for Cottonwood Springs and Dale. For several miles it leads up a rather sandy wash.
16.2 County sign. A branch road that continues east is the old road to Blythe. Turn to the left on plainest road, passing up the slope of a steep alluvial fan.
20.4 The road enters a canyon at the edge of the mountains, crossing the very sandy canyon bed at this point.
20.8 County sign. The road turns north up the east side of the canyon avoiding the deep sand in its middle.
22.0 The road takes the center of the very sandy canyon bed. Autos may have difficulty here. Continue up the canyon between low granite walls. At one place the road goes over a short steep cut in rock at the side of the canyon.
23.5 Branch road leads east (right) to Cottonwood Spring, visible about 100 yards away, where there is excellent water. Near spring is a house and a grove of cottonwood trees. Road to Dale continues up the canyon until it emerges from the mountains upon a rolling upland.
25.0 County sign. A dim branch road leads northwest (left) to Pinkham Well. Take right-hand road for Dale.
31.3 Branch road turns west (left) to Twenty-nine Palms, Pinyon Well, etc. (See p. 185.) About 100 feet farther north another branch road turns east (right) to the Iron Chief mine. Both forks are posted with county signs. Use the center road to reach Dale.

The road from this point to Dale was not traveled by the writer. It is known to pass first over a long, broad desert basin. About 15 miles from this fork (approximately 46.0) it reaches the Brooklyn mine, in the south edge of a low mountain range. If a watchman is present at the place water may be obtainable. From the Brooklyn mine the road goes northwest through the mountains to New Dale, a mining camp, once prominent but abandoned in 1918, about 4 miles away (approximately 50.0). No water is obtainable at New Dale. From New Dale a road leads northwest across a sandy desert basin to Old Dale, 6 miles farther. It is probable that a road also leads north from New Dale to a pumping plant 6 miles away, in the edge of a "dry lake."

At Old Dale will be found an abandoned well with a broken windmill, an unused pumping plant, and a few ruined adobe huts. A road leads northeast to Amboy, and 24 miles away on this road is a well with windmill at which
water was obtainable in January, 1918. A road leads west from Old Dale into Banning. (See p. 187.) An automobile may approach within about a mile of this well, but for the rest of the way the drift sand is deep and almost impassable.

IRON CHIEF MINE.

At 31.3 miles from Mecca a branch road goes east (right) to the Iron Chief mine, a noted but lately inactive property in the Eagle Mountains. This road is reported to be passable by automobile. There is a county sign at the road fork. Water hauled or pumped from Cottonwood Spring may be obtainable at the Iron Chief mine when the mine is operated.

ROAD WEST FROM COTTONWOOD SPRING.

At 1½ miles north of Cottonwood Spring (25.0) a branch road marked by an old Riverside County sign goes west (left) to various portions of the Cottonwood Mountains and is reported to end somewhere about 10 miles west. Its location as given on the map is adopted from recent Land Office surveys and is probably reliable. It serves prospectors in the region west of Cottonwood Spring. Its condition was not ascertained, but from the nature of the country it ought to be good for several miles.

COTTONWOOD SPRING TO ELDORADO MINE AND PINYON WELL (31 MILES).

0.0 Cottonwood Spring. Go north, up a sandy canyon, emerging in an upland region.

1.5 County sign. Branch road turns left. Take right-hand road.

7.7 A county sign marks a road fork turning to the left, and another marks one leading to the right about 100 feet away. Turn left on a dim road at the first sign. The road straight ahead leads to Dale, and the right-hand road goes to the Iron Chief mine.

7.9 to 10.5 The road passes through an upland from which rise a great many isolated granite peaks and hills. The road is rough but easily traversable. On emerging from the hills the road for several miles skirts some low broken mountains which lie a short distance west and then leads northwest, across a basin several miles wide lying south of the Pinto Mountains.

17.7 A dim trail comes in from the east. In January, 1918, it was marked by a small board sign that pointed along it to the Brooklyn mine and Dale. Nothing more is known of it. The road to Eldorado leads nearly west, across a rather sandy basin.

20.2 Road fork. The right-hand branch leads northwest to Twenty-nine Palms and does not pass the Eldorado mine. Its condition was not ascertained, but it could probably be used as a cut-off to Twenty-nine Palms. It intersects the road from Eldorado to White Tanks and Twenty-nine Palms, about a mile away. (See p. 187.) There was a small board sign in 1918. Take left-hand road for Eldorado mine.

21.3 A road leads north, around the mountain, to White Tanks and Twenty-nine Palms. (See p. 187.) For Eldorado mine continue west, entering a canyon.

21.8 Eldorado mine. House and other buildings in canyon. Water piped from Pinyon Well is obtainable when the mine is worked. For road to Banning, see log (p. 187). To reach Pinyon Well continue west. The road leads up a small narrow canyon and crosses a low divide.

24.5 A cut-off leads straight ahead (west) but is rough and rocky. Just north of the road fork is a faucet in the pipe line leading from Pinyon
Well to the Eldorado mine, and good water may be had when the mine is worked. Turn left (south).

24.8 The road turns west, up a wash, around an abandoned cabin and mill.

25.4 The branch road noted at 24.1 enters from the east. Continue west, up the wash.

26.3 Road fork. The right-hand road is the best route to Banning. One may also follow it to the Geological Survey sign at the Gold Coin mine 1.6 miles from this fork, and then turn southwest to Pinyon Well. The left-hand road is given because it is equally good and is shorter.

28.8 Road from Gold Coin mine enters from northeast. Continue southwest.

29.9 Enter canyon in Little San Bernardino Mountains. A county sign points north on a dim branch road to Twenty-nine Palms. Continue up the canyon, which is sandy at places.

30.6 Pinyon Well. Two dilapidated cabins and the ruins of a stamp mill indicate the place. Good water can be had at well between the road and the cabins. If it is desired to continue up the canyon to Indio, see log below.

PINYON WELL TO INDO (21.7 MILES).

Note.—The road from Indio to Pinyon Well was originally made to connect Indio with mining properties in the vicinity of Pinyon Well and Pleasant Valley, but in 1918 it was almost unused for any purpose. It is practically impossible for automobiles to travel from Indio to Pinyon Well on account of sandy grades and very steep hills; but they can safely go from Pinyon Well into Indio, as the road is nearly all downhill. Accordingly the log and description are given in this direction. It may accommodate persons either from Banning or Cottonwood Spring who wish to use a short cut into Indio from Pleasant Valley.

0.0 Pinyon Well. Start southwest, up a sandy canyon. There is a county sign near the well.

1.3 A large tributary ravine enters the main canyon, which swings west at this point, and a dim trail leads over the hill between the two canyons to Henson Well, about three-fourths mile south. Continue west, up the main canyon.

1.7 Summit of the pass over the Little San Bernardino Mountains. Continue west, down a very steep hill along a deep canyon with sandy bed.

6.8 County well, on south (left) side of road. Water is obtainable with rope and bucket, which are usually provided, and is of good quality. There is a county sign opposite the well. Continue down the canyon.

10.5 The road emerges from the canyon upon a rocky slope and turns southeast, down a sandy wash, passing between the base of the Little San Bernardino Mountains on the east and an isolated mountain ridge on the west. This ridge on the west gradually diminishes toward the south and ends in a strip of clay hills.

17.9 The road turns suddenly southwest, ascending a very sandy slope, passing through a gap in the clay hills mentioned above, and emerging upon Coachella Valley in sight of Indio.

19.1 The road branches at about this point, and a fork leads to the right, directly toward Indio. Use the road to the left (south), which is probably better.

19.9 Ranch house. Go due south.

20.2 Crossroads. Turn west (right), along telephone line, on good dirt road.

21.2 Crossroads. County sign. Turn south (left) to Indio.
21.7 Indio. Railway station. Water, hotel, supplies. To reach the highway leading to Los Angeles or Imperial Valley continue south half a mile.

ELDORADO MINE TO TWENTY-NINE PALMS BY WAY OF WHITE TANK.

0.0 Eldorado mine. Go east, down the canyon.
0.5 Road fork. Right-hand road leads east to Cottonwood Spring. Turn left, crossing about 3 miles of very rocky alluvial slope.
2.0 A branch road enters from the south, coming from Cottonwood Spring. Continue north, up a wide pass between the Hexie and Pinto mountains.
3.5 Road becomes very dim and crosses a sandy wash for about a mile.
4.0 A dim branch road leads west (left) toward Keys ranch. Continue northwest, up the main pass. A county sign marks this fork.
7.5 The road here has reached a high upland plain and passes a number of huge white granite masses that rise as smooth isolated blocks. The scattered rubbish left by campers is usually to be seen around these rocks. About half a mile east is White Tank, in a small gorge that passes through these granite masses at the west base of Pinto Mountain. Only cattle trails lead in that direction, indicating its location. Water most of the year. Continue north for Twenty-nine Palms. The route is not definitely known to the writer beyond this point, but the road is easily passable for automobiles and reaches Twenty-nine Palms about 9 miles away (total reading approximately 16.5). About 4 or 5 miles beyond the vicinity of White Tank it joins a road from the west that comes from Quail Spring and Keys ranch.

BANNING TO DALE.

[See fig. 12.]

0.0 Banning. Two blocks north of railway station. Start east over paved road.
1.0 Southern Pacific Railroad. Go east along track.
5.8 Cabezon railway station and store. Water and gasoline. Continue east along railway.
12.9 Geological Survey sign. Dale road turns northeast (left), away from the main road, which continues southeast to Coachella Valley. It is sandy at first.
13.1 Turn straight east. There are numerous signposts recently erected by the Automobile Club of Southern California along this portion of the route, but their exact location is not given.
13.8 Turn north.
13.9 Turn northeast, up a sandy and rocky slope. There are a number of houses in this vicinity.
14.4 A branch road leads south (right) to Whitewater. Continue northeast.
14.8 Cross bridge over Whitewater River.
14.9 A branch road to the right at the foot of a hill leads to Palm Springs station. Take the left-hand road, which is cut in the side of the steep hill. An Auto Club sign has been erected here. The road reaches the top of the steep grade not far away and turns northeast over a sandy table-land.
18.3 A dim trail leads to the left. Continue on plain road (right).
Figure 12.—Sketch map showing roads in vicinity of Dale, Twenty-nine Palms, and Pinyon (Pillon) Well, Calif.
20.4 Crossroads. Auto Club and private signs. Road northwest (left) leads to Mission Creek; road southeast leads to Palm Springs station. Continue straight ahead, northeast. The road is sandy and difficult at places.

21.5 A branch road leads northwest (left). In January, 1918, a board sign directed along this road to the T+K ranch, 1½ miles away. Continue northeast (right).

22.6 Enter canyon passing through foothills of San Bernardino Mountains. The road goes north up the gorge.

23.4 Water runs in the canyon at this point during most of the year.

25.1 On a steep grade an Auto Club sign points west along a footpath to Hole-in-the-wall Spring. Water is obtainable about 100 yards away on this path.

25.3 Summit of pass through San Bernardino Mountains. Overlook Morongo Valley, which lies north.

25.5 Road turns straight east, passing a house at which is a well not far away.

26.0 Road turns due north.

26.2 Turn straight east. A branch road continues north.

26.5 Pass through a gate on the ranch of W. V. Covington, formerly called Warren ranch.

26.8 Covington ranch (Warren ranch). Good water. Small stock of provisions and a supply of gasoline—probably the last available on this route. Continue north from ranch.

27.0 Cross Big Morongo Creek, a small stream of good water.

27.1 Pass through gate, out of Covington ranch. Continue northeast, over main road, which is at places sandy and rocky but a fair automobile road.

29.7 A branch road leads to the right to a house about one-fourth mile away. Continue north on main road, finally ascending a long grade out of Morongo Valley.

34.0 Crest of divide at northeast end of Morongo Valley. The road descends a short steep slope into another valley, sometimes called Yucca Valley.

35.4 A crossroad leads north and south, but main road goes straight ahead toward east. The road leading north is an old wagon road to The Pipes, but it was not passable in 1918. The road to the south is said to lead to a place called Warren Tank, about 2 miles away, where water is obtainable in a small tunnel.

38.2 Geological Survey sign. A branch road turns north to The Pipes. A house stands 0.1 mile east, and a well with windmill is in front of the house. This is the Warren Well.

38.3 Warren Well. Good water is kept in a reservoir. A road is said to turn to the left (just east of this well) and to go north to Surprise Spring, but nothing could be seen of it. Continue east, across a small playa, on the main road, which for the next 20 miles is excellent desert road. A few trails lead north and south in the next 3 miles, but the main road is unmistakable.

43.0 Road forks. Geological Survey sign. Right-hand branch leads southeast to Quail Spring and Pinyon Well. (See p. 190.) For Dale continue east on right-hand road.

47.2 A branch road turns left, leading to Coyote Well, one-fourth mile away, over which a windmill is visible. Water. For Dale continue east (right).
48.0 Branch road returns from well. Continue east.

58.7 House on north side of road, sometimes occupied by miners. Wells, on north and south sides of road, where water is obtainable, but it is only a mile to Twenty-nine Palms. Continue east.

59.0 A branch road leads southeast (right). Continue east (left).

59.5 A branch road leads northeast (left) to Mesquite Spring. Continue east (right).

59.7 Twenty-nine Palms. The palms stand in a long row south of the road. There is a house at this point and two or three springs within a few hundred feet. Paths lead to the springs, which can be found easily. Any one that is in good condition is satisfactory. Continue east for Dale. A branch road also leads north from the house to Mesquite Spring, but it is not plain.

59.9 A branch road leads south to Eldorado mine and other points. (See p. 187.) Continue east.

61.9 Enter a small canyon, which affords a pass through a low ridge of granite.

62.9 Emerge from pass through granite ridge.

67.0 The road is very sandy for the next 2 miles.

69.0 A branch road turns southeast (right). Continue on left branch. The road becomes less sandy for a distance.

72.0 Sand becomes very bad again. Deflate tires if necessary.

73.8 Old Dale (also called Old Virginia Dale). The remains of a few adobe houses, a broken windmill over a well that is badly caved, and a pump house on a little eminence to the east indicate the place. To reach New Dale, the mining camp, continue east, over the hill by the pump house, and then follow the road southeast. This road was not traveled by the writer. It is known to be sandy. The distance from Old Dale to New Dale is reported to be 6 miles. There was no one at New Dale in January, 1918. From Old Dale a road goes north to Amboy, about 40 miles away on the Atchison, Topeka & Santa Fe Railway. It is very bad—almost impassable for automobiles. One may get water, however, at a well 2 1/4 miles northeast of Old Dale on this road. It is possible to approach safely by automobile within about a mile of this well, but in the last mile the sand is deep and very difficult to cross. There is a windmill over the well, which supplied water to range cattle in 1918.

BANNING TO QUAIL SPRING, KEYS RANCH, PINYON WELL, AND ELDORADO MINE.

[See fig. 12.]

This road branches from the Banning-Dale route 43 miles east of Banning and 4.7 miles east of Warren Well. It will generally be used by persons coming from the west. Distances are therefore made to read from Banning, and the traveler is referred to the Banning-Dale log (p. 187) for the route as far as the road fork.

43.0 miles from Banning (4.7 miles east of Warren Well). Road forks. Geological Survey sign. Take the right-hand road to Quail Spring. The left-hand road continues east to Dale. Proceed southeast, up a long wash that is rather sandy at places.
50.5 Geological Survey sign. Branch road goes south (right) to **Quail Spring.** Good water in a reservoir 0.1 mile away. For Keys ranch and Eldorado mine turn east (left) over main road.

51.5 A plain but little-used road leads south (right) to a cabin about 2 miles away. Continue east.

53.3 Geological Survey sign. A plain road leads to the right, going to Lost Horse Well and Lost Horse mine. Continue east (left).

55.7 A plain road branches to the left, going to Keys ranch, half a mile away. There is another branch a little farther on. Continue to the right.

55.9 Geological Survey sign. A branch road goes north to Keys ranch, visible about half a mile away, where good water can be obtained. For points beyond follow the main road southeast.

56.0 Road forks. One branch leads east, the other southeast. The two reunite not far away. Take the southeast (right) branch, which is less sandy and usually better.

57.0 A dim road goes south to Lost Horse Well. (See p. 275.) Continue on plain road to left.

58.2 Branch road noted at 56.0 enters from the west. At nearly the same place a branch turns northeast (left) to a windmill which can be seen about half a mile away. This is the **Desert Queen Well,** where water was not obtainable in January, 1918. For points beyond, continue east (right).

58.7 A branch road returns from windmill noted above. Continue east.

60.0 A branch road leads east to the Desert Queen mine, 2 miles away. Turn to the right and go southeast. The road is not much used and is rather sandy at places in the next few miles.

60.7 A faint cross trail leads east and west. Continue southeast, straight ahead.

61.8 County sign. A branch road leads east to Twenty-nine Palms. Go southeast (right).

63.2 County sign. A branch road leads east (left) to Cottonwood Spring. Continue south (right).

65.7 County sign. A branch road coming from Twenty-nine Palms enters on the left. Continue south.

67.5 The main road swings east (left) into a little basin called Pleasant Valley. A very faint trail may be seen leading south. It is a short cut to Pinyon Well and is probably passable but was not traveled by the writer. Continue east, as there is a good road not far away.

68.7 Point is on a small playa in the center of Pleasant Valley. Geological Survey sign. Abandoned buildings of the Gold Coin mine are conspicuous 0.1 mile east. The road continues east to the Eldorado mine. (See log, p. 192.) To reach Pinyon Well turn southeast (right). The Geological Survey sign at this point gives 28 miles as the distance to Indio, but it really is only 25, the road not having been measured when the sign was erected.

69.9 Going southwest on road to Pinyon Well. A branch road enters from the east, coming from the Eldorado mine. Continue southwest.

71.0 The road enters a canyon in the Little San Bernardino Mountains. County sign, on the north side of the road, directs north along a dim trail to Twenty-nine Palms this being the other end of the branch road mentioned at 67.5.

71.7 **Pinyon Well.** Two tumble-down cabins and the wreck of a stamp mill identify the spot. The well is on the left (east) of the road, be-
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tween the road and the houses. A rope and bucket were provided in 1918 and good water was obtainable. To reach Indio from Pinyon Well, see log of Pinyon Well to Indio road (p. 186). This road continues up the canyon from Pinyon Well, and a county sign stands near the well.

Road to the Eldorado mine.

68.7  Geological Survey sign on playa in Pleasant Valley, near Gold Coin mine. From this point, in the above log, continue east to reach Eldorado mine.

68.8  Pass by buildings of Gold Coin mine, which was abandoned in 1918.

70.3  A plain road enters from the west (right), coming from Pinyon Well. Continue east, down a sandy wash.

71.2  Road forks. A plain road leads to the left over a hill. It is a small cut-off but is rocky and little traveled. Continue to the right, down the wash.

71.8  Pass an abandoned cabin and mine building and turn north (left), out of the wash.

72.1  The branch road noted at 71.2 enters from the west. Road turns abruptly east. About 20 feet north of the road at this turn there is a faucet in a pipe line which is buried near the road. The pipe line leads water from Pinyon Well to the Eldorado mine. Good water is obtainable at the faucet when the mine is worked. Continue east over a hilly country, later going down a small canyon leading east.

74.8  Eldorado mine. House and mine buildings are conspicuous in canyon. Water piped from Pinyon Well when mine is operated. A road goes east to Cottonwood Spring (p. 185) and another goes north to Twenty-nine Palms (p. 187).

WHITEWATER TO PALM SPRINGS STATION.

From a point 1 mile west of Whitewater, or 12.9 miles east of Banning, a road goes northeast from the Banning-Coachella highway. (See Banning-Dale log, p. 187.) From it a branch road leads east to Palm Springs station (Gray post office), on the Southern Pacific Railroad, 6 miles east of Whitewater. The road is sandy and rather bad but passable, although rarely used by automobile. A log is hardly necessary but the route may be summarized as follows:

0.0  Geological Survey and Auto Club signs on Banning-Coachella highway, 1 mile west of Whitewater. Take the Banning-Dale road leading northeast.

2.1  Auto Club sign. Take right-hand road at foot of hill just east of White-water River. Follow a power line east for several miles.

7.0  Crossroads. Road north leads to Morongo Valley and Dale. Road east leads to ranches of the neighborhood. Road south leads to Palm Springs railway station, which is easily seen.

7.4  Palm Springs railway station, consisting of one or two houses and a station.

PALM SPRINGS TO PALM CANYON.

From the resort at Palm Springs, Riverside County, a road goes south to Palm Canyon. It leaves the main Coachella Valley highway 1½ miles southeast
A STREAM OF THE PENINSULAR MOUNTAINS.

Diversion dam for Garden of Eden Indian Reservation in Andreas Canyon, near Palm Springs. Photograph by United States Indian Service.
A. FIRST SIGN ERECTED BY UNITED STATES GEOLOGICAL SURVEY IN DESERT REGION.
Placed by C. P. Ross in Arizona. Photograph by C. P. Ross.

B. GROUP OF SIGNPOSTS IN COACHELLA VALLEY.
\( a \), Sign of Automobile Club of Southern California; \( b \), sign of Goodrich Touring Bureau; \( c \), local advertising sign.
A. BATHHOUSE AT PALM SPRINGS.

To the right is a clump of wild palms denoting the original Agua Caliente Spring. Photograph by United States Indian Service.

B. FISH SPRINGS.

Typical of artesian springs in valleys well supplied with ground water.
A. CREST OF PENINSULAR MOUNTAINS WEST OF JACUMBA.

Photograph by W. C. Mendenhall.

B. TYPICAL ADVERTISING SIGN ON THE MOUNTAIN SIDE BETWEEN SAN DIEGO AND EL CENTRO.
of Palm Springs and goes south (right). The road is adequately posted with private signs and is a fair automobile road. It is considerably used by tourists and sightseers, especially by patrons of the resort at Palm Springs. It ends 6.1 miles from Palm Springs, where the canyon becomes impassable for vehicles.

About 3 miles from Palm Springs on this road there is an irrigated oasis, known as the Garden of Eden, which belongs to Indians of the Agua Caliente Reservation. They obtain water from Andreas Canyon by a diversion dam and conduit (Pl. XIII).

Palm Canyon is a scenic attraction of much beauty. There is running water along a narrow canyon valley for several miles, and extensive groves of stately native palms. The canyon is walled by jagged and precipitous mountains on each side and extends back nearly to Toro Peak, 8,000 feet high. At the entrance to the canyon is a unique hermitage. A footpath extends for a considerable distance beyond the road into the more attractive scenic area.
DETAILED DESCRIPTIONS.

In the following pages a cross reference to the log is given at the head of each description, and as a means of tying the descriptions more closely to the logs the log distance is stated in parentheses for many of the points described. If the log is given in both directions two distances are stated. The first figure indicates the distance from the point named first in the heading and the second figure the distance from the point at the other end of the route. For example, "Coachella (50.2, 10.8)," under the heading "Banning to Mecca," means that Coachella is 50.2 miles from Banning and 10.8 miles from Mecca; and this point will be found at mile 50.2 in the log from Banning to Mecca and at mile 10.8 in the reverse log from Mecca to Banning.

LOS ANGELES TO BANNING.

No work was done on the route from Los Angeles to Banning, and the material here presented is largely compiled from existing reports. Such casual observations are added as the writer was able to make in traveling very hurriedly over the route described.

All roads from Los Angeles to Banning lead nearly due east across the thickly settled portion of southern California. Paved streets connect almost all the towns, and the network of good roads is probably unequaled anywhere else in the United States. This fact, added to the genial climate and the natural and artificial beauty of the developed areas, combine to make the region very attractive to tourists. The Automobile Club of Southern California has spent much labor and money in this territory, and its road signs are seen at nearly every turn and corner. It is impossible to get lost if these signs are heeded, and the consequences of going astray or suffering a breakdown are not serious, as help is never far away, and supplies and water are accessible nearly everywhere.

Three general routes are available for the trip, all of which correspond in certain parts. There is no great difference in length, and each one offers scenic attractions of much merit. The central route, which follows rather closely the line of the Southern Pacific Railroad, is probably most used and will be briefly described. It is 88 miles long, medium in length between the other two, and is perhaps more attractive than the others because the country along it is better developed agriculturally. The northern route passes from Los Angeles through Pasadena, Monrovia, Azusa, Glendora, Claremont, and San Bernardino and joins the central route between San Bernardino and Redlands. It is an excellent paved road and, because it lies near the base of the San Gabriel Mountains, is called the Foothills Boulevard. The distance from Los Angeles to Banning over this road, the longest of the three, is 94 miles. The southern route is the same as the central from Los Angeles to Ontario but at that point turns southeast to Riverside, whence it goes east through Moreno and rejoins the central route at Beaumont. It is an excellent automobile road and is the shortest of the three, the distance being 83.5 miles. The central road, nearly all of which is paved, passes from Los Angeles through El Monte, Puente, Pomona, Ontario, Colton, Redlands, and Beaumont into Banning.

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From the corner of South Seventh and Main streets the route leads northeast on Main Street past the Federal Building (1, 87) and toward the northeast end of the city, where it turns east across Los Angeles River (2, 86), beyond which it is known as the El Monte road. For a mile or two the land is rather hilly, and only dry farming is practiced. A few oil derricks in this vicinity indicate wells that constitute part of an eastern extension of the Los Angeles City field, which lies mainly to the north and west.

The road emerges from these hills and goes nearly east across a large level plain, the lower part of San Gabriel Valley. The land is largely in cultivation, and fields of barley and alfalfa, vegetable gardens, poultry farms, and fruit orchards are scattered along the way. El Monte (13.4, 74.6) is a prosperous little town in the heart of this valley. The road follows the Southern Pacific Railroad from El Monte up the valley of San Jose Creek, a small tributary of San Gabriel River. Groves of orange and lemon trees are common in this region, and there are many acres of English walnut trees. All the crops are irrigated, chiefly by water pumped from wells. The supply of ground water in the lower part of this valley, together with surface supply from the mountains to the north, serves to irrigate a great part of the desirable land.

East of a little town called Walnut (25.4, 52.6), which consists only of a store and a few houses, the country is rather broken for a few miles in what are known as the Puente Hills. The road emerges from this group of hills into a much larger valley than that of San Jose Creek, generally known in its western part as the Cucamonga Plains and in its eastern part as the San Bernardino Valley. The northern boundary of this valley runs nearly due east at the foot of the San Gabriel and San Bernardino mountains, from which the ground slopes southward to Santa Ana River, which forms the southern limit of the valley. This is the heart of the citrus fruit area of California, and nearly all the desirable land is devoted to orchards. Walnuts, olives, figs, and other fruits, however, occupy a share of the territory, and farm crops are not uncommon. All the cultivated land is irrigated, and nearly every ranch has its pumping plant. There is a very large supply of ground water, which is maintained by the run-off from the high mountains to the north. Most of this water comes down in winter, sinks into the porous gravel at the mountain border, and percolates through the valley fill, where it is drawn upon heavily in summer for the growing crops and maturing fruits. At the south side of the valley some flowing wells are obtained, and in the northern part the surface flow of mountain streams is utilized; but the great central portion depends largely on ground water. The water supply of this area is discussed by Mendenhall.

Across the Cucamonga Plains the road runs nearly east, passing several towns and cities, the largest of which are Pomona (33, 55) and Ontario (39, 49), beautiful cities of several thousand people. About 4 miles east of Ontario is sandy land, most of which is not irrigated but is given over to dry farming. Wine grapes are a prominent crop, as they do very well without irrigation, and in this territory is a single vineyard of 4,000 acres, the largest in the world.

Colton, San Bernardino, Redlands, and Riverside are important cities in San Bernardino Valley. The road passes through Colton (57.5, 30.5) and Redlands. About a mile west of Colton, on the side of a high hill about half a mile south of the road, is a conspicuous quarry and tunnel, part of the rock quarry of the California Portland Cement Co., organized in 1892, the first of its kind on the Pacific coast. This

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company quarries limestone and clay for making cement from the hillside, and the cement industry has spread southward to Riverside, where there are other large plants. The Southern Pacific Railroad turns southeastward at Colton and passes up San Timoteo Canyon, taking advantage of the best grade up to San Gorgonio Pass and avoiding the city of Redlands.

Redlands (66.5, 21.5) is at the east end of the valley. The land around it is well adapted to oranges and other citrus fruits and is devoted almost exclusively to their culture. The elevation of the town above the valley bottom accounts for its equable temperature and its greater freedom from frost than the lands either above or below. In mountainous regions cold air has a tendency to blow from high elevations toward the lowest places during the night. The warmer air of the valleys is displaced and rises; so that the mornings may be frosty in the lowlands and much warmer at elevations several hundred feet higher. In addition to possessing this climatic advantage, the soil at Redlands is a porous sandy loam, especially well drained and not subject to any of the harmful effects of alkalinity produced by irrigation in more compact soils with poorer drainage. The city itself, because of its attractive climate and scenic beauty, has become a favorite place of residence for persons of means, and its residential districts are especially pleasing in appearance.

There are two roads from Redlands to Beaumont. One leads east out of town, turns southeast up Reservoir Canyon, where there are some steep grades, and reaches the level of Yucaipa Valley, a rolling upland at the foot of the San Bernardino Mountains. This road is paved through Reservoir Canyon and is a good dirt road beyond. The other road leads southeast out of Redlands on Cajon Street and descends a steep grade into San Timoteo Canyon. It turns east by the side of the Southern Pacific Railroad and climbs with an even grade nearly to Beaumont. This road is a dirt road to San Timoteo Canyon but has been surfaced up the canyon, although much of it was in rather poor condition in 1918. It was probably a little better than the other road. The distances are approximately equal.

Beaumont (82, 6) is at the summit of the divide between the Pacific Ocean drainage and that of the Salton Basin and is 2,500-feet above sea level. North and west of it is the main portion of the Yucaipa Valley, which is crossed by the northern road out of Redlands. The water supply of Beaumont and the valley is obtained in part from wells but mainly from streams in the canyons of the San Bernardino Mountains. It is insufficient for the irrigation of most of the valley, and dry farming is practiced widely, barley, wheat, and grains being favorite crops. The land and climate are not adapted to citrus fruits, but peaches, apples, apricots, and other deciduous fruits are raised extensively here and as far east as Banning.

The road from Beaumont to Banning runs east down a gradual slope at the western entrance to San Gorgonio Pass. The country takes on the appearance of desert rather rapidly, and the chief native vegetation is sage and small brush. To the left San Gorgonio Peak and to the right San Jacinto Peak, which have been visible half the way from Los Angeles, loom up conspicuously as majestic sentinels guarding the gateway between two very different worlds—the gardens of the west and the deserts of the east.

BANNING TO MECCE.

[For log see pp. 131-134.]

The road from Banning to Coachella is the second link in through travel from Los Angeles eastward and the first that may properly be said to lie within the desert. It leads through San Gorgonio Pass and Coachella Valley, where only relatively small areas are reclaimed from the unproductive waste. Settlements are so distributed that the intervals between supply stations and watering places are not great. Moreover, the road is either paved or surfaced with gravel for nearly its entire length and may be considered a good road for all vehicle traffic.
Banning to Whitewater.—Banning (0, 61) is the only town of any size between Beaumont and Indio and Coachella, 47 and 50 miles away, respectively. At Banning repairs, supplies, and hotel accommodations are available. There is also good water from San Gorgonio River, which rises in the mountains on the north and sinks almost completely into the sandy soil of the pass 2 miles from Banning. The Banning Water Co. has a canal from the river to the city and states that it distributed an average flow of 800 miner's inches (16 second-feet) in the three years preceding 1918. Most of this was used in the irrigation of the farms and orchards around Banning. The town is 13 miles west of Whitewater and outside the area shown on the map (Pl. II) but marks approximately the limit of the desert as locally defined. For persons going to Twenty-nine Palms, Dale, or Pleasant Valley it is the best supply station.

At 1 mile due east from Banning (mileage given from a point on the highway in the center of town two blocks north of the railroad station) the road approaches the Southern Pacific Railroad, beside which it continues eastward. It is all hard-surfaced road, but part of it was badly worn and was being repaired in March, 1918. The descent is rather steep, as is apparent from the Southern Pacific freight trains, which roll eastward down the pass without steam but require two or three laboring engines puffing slowly up the grade on the westward trip. At 3 miles from Banning the road crosses a little stream channel that at times contains some water, all that is left of San Gorgonio River. The little town of Cabezon contains a store, a station, and a few houses. Good water is obtainable at a faucet in front of the store. The road continues east over sandy ground covered mainly with creosote bush, a true desert plant. A branch road turning northeastward (left) to Twenty-nine Palms, Dale, and other points is designated by Geological Survey and Auto Club signs (12.9, 48.1). Continuing east along the railroad the main road reaches Whitewater (13.9, 47.1), where there is a railroad station and good water, but no supplies. The water is piped by the railroad company from Snow Creek, which descends in the canyon visible southwest of Whitewater as a deep furrow in the north side of San Jacinto Mountain. It is one of the most torrential streams in the United States, having a fall of nearly 10,000 feet in a length of about 5 miles.

San Gorgonio Pass.—Although the existence of San Gorgonio Pass was known to white settlers at an early date, its discovery as an economic gateway was made by the Williamson expedition in 1853 in its search for a railway route to connect the Mississippi Valley with the coast of California. Lieutenant Williamson's report, together with the observations of William Phipps Blake, geologist and mineralogist of the expedition, form the first accurate account of the Colorado Desert. 3

This great mountain pass is one of the most remarkable features of southern California. Between San Gorgonio Peak, 11,485 feet above sea level, on the north, and San Jacinto Peak, 10,805 feet above sea level, on the south, 21 miles away, the great gap takes an east-west course, breaking the mountains squarely in two, its summit at Beaumont being only 2,570 feet above sea level, or 1/2 miles lower than the tops of the two lofty peaks.

Whitewater to Palm Springs.—From Whitewater the road continues along the railway for nearly a mile, then crosses and goes south away from the track (14.5, 46.5). It descends toward a dry wash that drains the pass and crosses a bridge over this wash near the mountain wall (15.2, 46.8). Just south of the bridge the road turns east and for a short distance is cut in solid rock along the mountain side. About 300 feet east of the bridge a stream of water from the north empties into the dry wash noted, and a rude wooden headgate diverts part of the flow into a small ditch running by the side of the road. This stream is Whitewater River. About half a mile farther east it sinks into the sand. Only in times of heavy floods does it run far into the desert, but it is reported to have flowed as far as the Salton Sea on one or two occasions.

The road turns through a small rock cut in a jutting ridge of gneiss at Whitewater Point (15.6, 45.4). The ditch previously noted passes through the point by a tunnel and emerges near the road, which it follows for a mile or two, later turning east to obtain a suitable grade where the road crosses some high alluvial fans. The ditch water goes to Palm Springs, where it is used for domestic supply and for the irrigation of a few plots of land.

The road continues southeastward from Whitewater Point, skirting the base of San Jacinto Mountain. About 3 miles from the point two lone masses of metamorphic rocks protrude from the valley floor on the right side of the road. The drawing of these masses made by Blake and given on page 234 of his "Geological report of California" will be recognized easily by any traveler. An excellent asphalt road continues southeastward over rather sandy desert to the little oasis of Palm Springs (22.3, 38.7).

Palm Springs is a village at the east base of San Jacinto Mountain and was formerly known as Agua Caliente (Spanish for hot water). It has a few stores, some hotels, including a pretentious and attractive resort for health seekers, a garage, and several accessory businesses. The place was originally an agricultural settlement but has been converted into a health resort, for which it has climatic advantages that appeal particularly to consumptives. There have also been Indian settlements grouped about the place since the earliest days of history. The spring, really one spring despite the plural name, is about a block east of the present main road, so that travelers rarely see it. It yields a small flow of tepid water that has a noticeable sulphurous odor and is reputed to have medicinal virtues. The Indians, who own it, conduct a bathhouse (Pl. XV, A) and also use the water for irrigation. The town is now supplied with water for irrigation and domestic use through a ditch from Whitewater River and a canal from Tahquitz Canyon. The spring water is seldom used for drinking, although the spring constituted a valuable watering place in former days. The water of the spring bubbles up in an area about 60 feet in diameter covered with rushes and grass and forms a pool that is partly covered by the bathhouse. The flow is perhaps 10 gallons a minute. Analysis No. 38 (see p. 283) indicates a water of low mineral content for the region. The hydrogen sulphide, which had all disappeared before analysis, makes the water poor for drinking, although judged by other constituents it would be considered good. The chief mineral constituent is alkali carbonate. The water undoubtedly rises under pressure, but the condition creating this pressure at a point so high on the border of Coachella Valley is obscure. It may possibly be due to a local approach of the buried crystalline rocks to the surface and impounding of a reservoir of ground water near the surface or the water may rise along a fault plane at the east side of San Jacinto Mountain.

Near Palm Springs is part of the Agua Caliente Indian Reservation, and another part is 3 or 4 miles south, at a place called the Garden of Eden. About 50 Indians live on the reservation. The Garden of Eden is irrigated from Andreas Canyon. (See Pl. XIII.)

Palm Springs to Frey Well.—At the south edge of Palm Springs the paved road ends and a fair dirt road continues south. This is slightly sandy for a mile but good thereafter. At 2 miles south of Palm Springs (24.2, 36.8) the road turns east, but a branch road continues south up the wide embayment in the mountains that leads back to Palm Canyon, and some branch roads lead to Andreas Canyon and other places on the south and west. Palm Canyon separates the San Jacinto Mountains from a long range trending southeastward known as the Santa Rosa Mountains. This range forms the west wall of the Coachella Valley. Near its base the road runs east and southeast for many miles, in places cutting across large alluvial fans that lead back into the mountain range, in other places touching the very points of metamorphic rocks, chiefly gneiss and schist, that constitute the mountain range.
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Frey Well (pronounced fry), in the SW. ¼ sec. 18, T. 5 S., R. 6 E., is a quarter of a mile east of the road. A wagon road marked by a board sign with the inscription "water" (34.0, 27.0) turns aside to the well, which has a windmill and pump house easily visible from the road. A covered box equipped with a faucet provides drinking water, and a trough for stock is kept full. The owner, W. S. Frey, is paid a monthly stipend by Riverside County to provide water for travelers. He reports the well as 114 feet deep, the water level at 70 feet below the surface, and the yield of the well as 6 or 7 miner's inches. The quality appears to be good, as might reasonably be expected from the well's location. There are several ranches not far away.

Frey Well to Indian Wells.—About a mile from Frey Well the road turns due east, and half a mile farther on it is paved. It passes several ranches, all mentioned in the log, at which water is obtainable. Some land in this vicinity was being prepared in 1918 for irrigation. The dry wash of Whitewater River is here near the road, and ground water occurs at increasingly shallow depths, being from 50 to 100 feet below the surface from this point on to Indian Wells. Large sand drifts have collected in this part of the desert, and but for the paved road passage would be difficult. At many places thickets of mesquite, of a peculiar knotted creeping variety sometimes locally called running mesquite, are seen along the roadway and cover the billowy sand dunes. This kind of mesquite is believed to indicate water at moderate depths. (See p. 114.)

Indian Wells, in sec. 24, T. 5 S., R. 6 E. (40.6, 20.4), is a little village about 6 miles west of Indio at which there is a filling station for automobiles and a small store containing also a post office. One or two dwellings complete the town, though there are several ranches near by. The postmaster has a well which is equipped with a windmill and keeps a supply of water pumped which is available to travelers at a faucet by the roadside. There is also a trough for stock. Water is shallow in this area, which is the flood channel of Whitewater River. About half a mile below Indian Wells a jutting spur of the Santa Rosa Mountains known as Indio Mountain projects into the desert and partly obstructs the underground drainage in its passage southeastward, creating a shallow ground-water area around Indian Wells. Much of the land, however, is a mass of sand dunes covered by rank mesquite timber and worth little for agriculture. The water obtained is of good quality for almost any use. (See p. 78.)

Indian Wells to Indio.—The road leads eastward, approaching Indio Mountain, and passes through a small cut in solid rock (41.2, 19.8). It then turns southeastward and crosses a desert land of sand hills and mesquite brush. A little more than a mile from this point it turns due east, and the sand hills diminish in size and ranches here and there take the place of the areas of wild brush. Finally a large, well-kept date ranch (44.4, 16.6) is seen on the north side of the road. The road continues eastward toward Indio, passing numerous ranches on the way, most of which have at least a small planting of dates, and a branch road (46.4, 14.6) turns north to Indio, which is half a mile from the main road. Indio is the most important town of Coachella Valley, being a railroad division point. All kinds of supplies are available there. The principal industries, aside from those dependent on the railroad, are date growing and other branches of farming. Date culture is known in the United States only in the Salton Sea region and in a few places in Arizona. As the greatest progress in cultivation of this fruit has been made in Coachella Valley, it seems appropriate to give at this place a short sketch of the industry.

Date culture in Coachella Valley.—Experimental work in Coachella Valley looking to the introduction of date culture into the United States was begun about 1903 by the Department of Agriculture. The results indicated that the climate, soil, and water supply were favorable, and cultivation was begun as soon as plants could be imported.
The results of these preliminary experiments are described by Swingle. Two experimental farms were started in the valley—one at Mecca, the other near Indio—and soon private orchards were set also, so that now a large acreage is devoted to this industry. The following memorandum outlining the history and results of this work was kindly prepared by S. C. Mason, who has had charge of the Government's experimental farms.

**GOVERNMENT DATE GARDENS AT INDO AND MECCA.**

The Mecca date garden, which is conducted in cooperation with the University of California, is 2 miles from Mecca railroad station; the Indio garden is a Government station purely and is about 2 miles west of Indio station. Both gardens are under the same management.

Initial plantings were made at Mecca in 1904. This garden is 185 feet below sea level. At the time of the advance of the Salton Sea in 1907, it was feared that this garden would be submerged, and provisions were made for the removal of the date palms there to a tract donated by Mr. Fred N. Johnson, about 25 feet above sea level, 2 miles from Indio station.

As the advance of the Salton Sea was checked when the water was within a few feet of the level of the Mecca garden, it was decided to retain this garden and also begin work at Indio, there being a very important difference in the quality of the soil of the two places.

In both these gardens, but especially at Mecca, have been planted a large number of varieties representative of the principal date-growing regions of the Old World—Algeria, Tunis, Egypt, Sudan, and the Persian Gulf.

The sole source of water supply in this valley consists of artesian wells bored to depths ranging from about 100 to more than 1,000 feet. The water so obtained is of exceptionally fine quality, nearly pure by chemical analysis, but rising at temperatures varying from 72° to 90° F. and exceptionally more than 100°.

In the lower part of the valley, where the Mecca garden lies, the artesian pressure is heavy; in the upper part, from Coachella northward and westward, the artesian pressure does not bring the water to the surface, and pumping with lifts varying from 20 to 50 feet is necessary. The original source of power for pumping was gasoline engines, but at present this is largely superseded by electric power transmitted from plants in the Sierra.

The Indio date garden has water from a 12-inch well 550 feet deep, in which the water rises within 15 feet of the surface but is drawn down to about 40 feet under continuous pumping. This supply seems to be unlimited, no further reduction being observed during the longest run. It is delivered by means of an electric motor and rotary pump at a cost of about 16½ cents an hour for a flow of 50 miner's inches (about 560 gallons a minute).

The valley is practically rainless, the mean rainfall not exceeding 2½ inches annually. During a greater part of the year the relative humidity is low, a dew point seldom being reached. Minimum temperatures ranging from 32° to 18° and occasionally 15° F. are experienced during December and January; light frosts seldom continue beyond February. Maximum temperatures of 100° or more are usually encountered from May through September and occasionally into October; extremes of 120° to 122° have sometimes been reached in June and July. Maximum temperatures above 100° for 100 consecutive days have been observed both at Indio and at Mecca.

The climatic conditions at these gardens are thus ideal for the date palm, both in vegetative growth and in the perfection of its fruit. As most varieties of dates are injured by the slightest rainfall or even by the formation of dew at the ripening season, the dry atmosphere prevailing at these gardens from August to November is especially favorable to the successful maturing of the crop.

The soil at the Mecca garden is a coarse beach sand from the ancient fresh-water lake whose shore line lies considerably above this track. As it contains very little underlying clay or silt, the problem of maintaining sufficient humus and fertilizer for successful date growth is a serious one. Manuring and the growth of cover crops must constantly be resorted to, both to maintain fertility and to keep sufficient humus in the soil to prevent the too rapid sinking of the irrigation water.

At the Indio garden the soil is much more favorable, being made up of a combination of fine sand or silt brought down by flood waters from the mountains surround-
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ing the upper end of the valley and wind-blown sand and particles of mica, the product of disintegrated granite of the mountain formation. Soil of this quality retains moisture and humus remarkably well and responds quickly in the growth of such nitrogen-fixing crops as alfalfa and other legumes.

Out of a wide variety of imported date offshoots planted in these two gardens comparatively few have shown themselves perfectly adapted to the climatic and commercial conditions of this region. With the high price of labor and water entailed by expensive irrigation from artesian wells, only the production of the choicest fruit, bringing the same prices as high-grade candies and confections, can be made commercially profitable. Again, although some varieties of dates are of very superior flavor, they are so soft and sirupy as to render it impracticable to place them on the market.

The most serious problem confronting the date grower in this region has been that of saving the imported offshoots and the succeeding generations of offshoots cut from the imported trees. Through lack of experience, the outlook at one time was very discouraging, but persistent experimentation has evolved a system of rooting the offshoots under cheaply constructed but tight canvas-covered sheds in which the temperature and humidity can be maintained at proper degrees. As a result of the demonstrations by the Government's representatives in this matter, nearly all date growers in the valley are erecting their own sheds, and the percentage of offshoots saved and successfully rooted is becoming very high.

Owing to the high cost of planting lands to imported offshoots, and especially to the difficulty of procuring offshoots during the World War, many plantations of seedling trees have been made from the bred-up seed of the choicest varieties furnished by the department to ranchmen under special agreement. Although the percentage of valuable fruiting trees obtained from a lot of this seed is small, many choice varieties are being originated and a considerable production of excellent dates of a highly miscellanious quality has resulted. The recent invention of machinery for separating the seeds from dates of this class and grinding the flesh to a homogeneous pulp, later to be pressed into cubes similar to certain sugared confections, has created a product that gives promise of putting seedling-date orchards on a fairly paying basis.

It has been ascertained that in the oriental date-growing regions the fruit designed for long keeping and export is seldom allowed to become fully ripe on the tree but is picked in a semidry condition and sun cured in specially prepared drying yards. After much experimental work at the Indio garden, a method of processing the semiripe fruit in curing chambers has been perfected that produces a highly sanitary and attractive product, which when packed in fancy boxes commands a ready market at prices similar to those paid for the best confections.

On the whole, as a result of the Department of Agriculture's work, the outlook for a permanent date industry has become so promising that orchards of the choicest varieties are being planted as fast as the offshoots can be procured.

Seedling dates are about 50 per cent males, the rest females, and only the females bear fruit, so that all excess males above the number necessary for pollination of the blossoms are discarded as soon as they can be distinguished, usually at an age of 3 or 4 years. Pollination is best accomplished by artificial means, a frond of flowers being taken from a male plant and shaken over a bunch of female flowers or tied beside it so that the wind may effect the desired result.6

The trees usually begin to bear fruit in four years. They bear small amounts, at first but increase in size and productiveness for many years. The fruit hangs in great clusters about the stalk of the tree and ripens in September, October, or November.

Indio to Coachella and Mecca.—The road from Indio to Mecca runs near the Southern Pacific Railroad most of the way. It is a dirt road, and as the soil is a soft silt it wears badly into ruts when much used and is rather rough and disagreeable to travel. Just north of Coachella on the north side of the railroad a neat pumping plant with concrete housing is passed (49.5, 11.5). This is on the Cabezon Indian Reservation, which embraces isolated sections of Indian lands scattered over several miles from Indio to Mecca. The pumping plant is maintained by the Government and supplies water for agricultural and domestic uses.

6 For an excellent account of the methods of cultivation see Popenoe, P. B., Date growing in the Old World and the New, Los Angeles, 1913.
The land along the road between Indio and Mecca, in the heart of Coachella Valley, is the best soil in the valley, and a large area is under cultivation. Besides dates a few figs, oranges, and other fruits are raised. Cantaloupes have been a very important crop for a number of years. Other vegetables are raised, and alfalfa is a staple crop. Some milo maize and small grain together with alfalfa support a considerable stock-raising industry. The water for irrigation in Coachella Valley is derived only from wells, many of which in the area south of Indio are artesian. A discussion of the water supply of Coachella Valley is given under "Hydrology" (pp. 73-78).

Coachella (50.2, 10.8) is a town of several hundred people and the most important place on the direct road between Banning and Brawley. It has several hotels, numerous stores, and a number of garages and other shops. Thermal (54.9, 6.1) is a small town on the road not far from Coachella, where garage and hotel accommodations are obtainable. Between Thermal and Mecca the road branches (57.6, 3.4), and travelers to Brawley and Imperial Valley take the right-hand road south; those going to Mecca, Blythe, and beyond continue along the railroad southeastward.

The first artesian water developed by drilling in Coachella Valley was obtained at Mecca in a 500-foot flowing well completed by the Southern Pacific Co. in 1894 at great expense. Better methods of drilling made more extensive development possible, and a number of wells were drilled soon afterward. At present the railroad has four wells which supply water for its use locally and for tank cars that carry water for use along the road as far south as Glamis, a distance of 75 miles. Residents of Mecca get their supply from a group of wells just west of the station from which the water is piped underground to the store, hotel, public fountain, and other places. Mecca is the last point for a long distance at which provisions, automobile supplies, or hotel accommodations are available for persons going south or east.

COACHELLA TO BRAWLEY.

[For log see pp. 134-138.]

The road from Coachella to Brawley connects Coachella and Imperial valleys and forms a link in the inland route from Los Angeles to Imperial Valley or to Phoenix. It passes through 50 miles of utterly uninhabited barren waste but is a main line of travel and is a fair road. Except for 7 miles of narrow pavement it is all dirt road, but 17 miles of dirt road through Imperial Valley is excellent. The rest is sandy and is liable to be badly cut up by much travel, but it is all easily passable for automobiles or other vehicles, and the traveler usually sees numerous persons on the way who might lend aid in case of trouble.

Coachella to Fish Springs.—From Coachella to Fish Springs the road traverses the lower part of Coachella Valley. (See pp. 73-78.) The soil is a soft silt which is easily loosened by any pressure or even by the wind, and the dry desert climate is favorable for transforming this soil into dust. Whenever any wind is blowing dust settles on everything within reach, and the country has a dirty and ill-kept appearance. The unirrigated desert, which is much more extensive than the reclaimed part, is covered by a more or less dense growth of salt bush, salt grass, mesquite, and other small brush. Between the wild wastes of this material are irrigated areas that are especially inviting by contrast. Most of these areas are date gardens or fields of alfalfa or grain.

Water for irrigation is obtained entirely from wells, all of which flow but some of which are pumped to increase the yield. These wells are seen at nearly every house and at many places along the road.

At Thermal (4.7, 68.6), on the Southern Pacific Railroad, hotels and garage service, the last for 60 miles, are available. About 3 miles from Thermal the Brawley road turns to the right and goes due south, away from the railroad, continuing in
that direction for nearly 10 miles. Several ranches and houses are near the road along the way, and water is obtainable at any of them. The Oasis School (15.0, 58.3), on the west side of the road, is a new and attractive building in the center of a rather populous community. There are numerous date gardens, some thriving orange orchards, and fields of farm crops in the neighborhood.

The traveler will also note, if he looks carefully, numerous clumps of wild palms and isolated trees. These are near springs, which are common along the way, and around nearly every palm is a seep or pool of water. Before the days of artesian wells these springs were of much importance as watering places on the desert and were the centers of Indian settlements. Such names as Alamo Bonito and Agua Dulce were given to them, and the roads all passed by them for water. Two springs of this kind are still important sources of drinking water—Figtree John Spring (21.5, 51.8) and Fish Springs (24.0, 49.3).

Figtree John Spring, in sec. 33, T. 8 S., R. 9 E., received its name from an Indian who lived there until a few years ago and cared for some fig trees, reported to have been planted by himself. The spring is due to the escape of ground water under artesian pressure. This gives rise to a marshy pool surrounded by cat-tails and a thicket of brush, in addition to which there are several palm trees. The spring is about 500 feet west of the main road but is accessible by a turnout and is posted with United States Geological Survey and other signs. Three miles southeast, at Fish Springs, is the last water obtainable this side of Imperial Valley, and that of Figtree John Spring is so much superior in quality (see analysis No. 18, p. 282) that it has been thought advisable to add to the sign the inscription “Last good water before Imperial Valley.” The water can be dipped from a little pool at the east edge of the thicket. The flow is only a few gallons a minute and disappears very quickly.

Fish Springs (24.0, 49.3; see Pl. XV, B) are very similar to Figtree John Spring and are about 3 miles to the southeast, less than a mile west of Salton Sea (1918). The springs were submerged several feet deep by the filling of Salton Sea in 1906 but have resumed much of their former appearance with the recession of the water, though numerous dead trees in the neighborhood attest the submergence. The springs are about 0.2 mile off the main road but are reached by a turnout and are posted by signs of the Automobile Club of Southern California. They furnish the last water for 25 miles going south and the first coming north after leaving Kane Spring, whose water is of poor quality. Fish Springs also yield very poor water (see analysis No. 19, p. 282), which should be used for drinking only in case of need. Nevertheless, the water is considerably used.

Fish Springs are artesian springs fed by the escape of Coachella Valley artesian water. The main spring occupies an open pool about 40 feet in diameter and 20 feet or more in depth, fringed by a growth of marsh vegetation, which also borders the course of the escaping water as it flows eastward to Salton Sea. Mr. H. J. Sternberg, of Mecca, reports having measured at the spring a flow of 25 miner’s inches (280 gallons a minute). A considerable stream, the course of which is so choked with vegetation that little estimate of the volume can easily be made, flows eastward from the springs. The springs represent apparently very nearly the southern limit of artesian conditions in the Coachella Valley. The water is poor in quality for irrigation, but better water is obtained in wells not far away. The springs receive their name from the fact that a certain kind of fish has long lived in the tepid water, which has a temperature of about 90°. Orcutt describes catching Cyprinodon californiensis there and gives the temperature of the water as 100°. Natives report that the spring makes an excellent swimming pool.

No absolute condition governing the origin of springs of this type, particularly with such large vents, is apparent. They may be due either to the softening and

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carrying upward of the fine silty soil by the rising currents of water, and the rims of elevated earth about their banks may be only the result of decay of a rank fringe of vegetation. Or the springs may represent dying phases of vents similar to the mud volcanoes south of Salton Sea, and their openings may have a more truly explosive origin. Fish Springs constitute the best example known of the type, but Figtree John, Doe Palmas, and certain less prominent springs are of the same type. The first hypothesis is probably more logical, because the mud volcanoes, so far as known, usually occur in groups in a small area.

Water line near Fish Springs.—From Fish Springs the road bends westward for a mile or more, approaching very near the mountains. A peculiar long white band, apparently perfectly horizontal, girdles the mountains at their base for several miles, finally being obscured toward the south at a place where the alluvial débris rises to a higher elevation. Toward the north it is last seen on an isolated hill of granite, about 2 miles northwest of Fish Springs, which it encircles at a distance said to be about 15 feet below its summit. This peculiar marking is the “water line” at the level of the water of the ancient Lake Cahuilla, which in recent geologic time occupied the basin of the Salton Sea. (See pp. 32-33.) The water line is really an incrustation of considerable width and at some places as much as 2 feet thick, of travertine or precipitated calcium carbonate that was evidently carried in solution in the water of the ancient lake.

Fish Springs to Arroyo Grande.—After approaching the foot of the mountain southwest of Fish Springs, the road swerves southeastward and continues in that general direction with only minor turns for the next 25 miles. This part of the road is entirely without water and crosses some of the driest desert land in California. The road has been laid out in long straight lines and is generally kept in good repair for a dirt road over such difficult country. Many deep gullies or arroyos coming in from the mountains on the west cross the road at intervals and were once very troublesome for persons traveling over this portion of the desert. Most of these have been rendered easily passable, however, either by bridges or by what may be called “overflow culverts”—concrete paving conforming to the surface of the arroyo, over which the flood waters flow harmlessly. The banks of the gullies, many of them 10 or 15 feet high, have been cut down to a suitable grade. There is some tendency for the water to dig a pit where it tumbles over the lower edge of the culvert, and rocks are sometimes placed on that side for protection.

For several miles south of Fish Springs the road crosses a large alluvial slope covered with boulders, and the chief work of road building has been to pick these large rocks out of the roadway. Next the road crosses a plain of clayey or sandy soil dissected by deep arroyos. A narrow road bed has been graded along this portion of the road and surfaced with “adobe” clay from near-by pits. A United States Geological Survey sign standing on the north of one of the largest arroyos, Arroyo Grande, points west to McCain Spring.

McCain Spring.—McCain Spring is in T. 11 S., R. 10 E., probably in sec. 7 or 18. It can be reached by following Arroyo Grande 2.4 miles westward from the Coachella-Brawley road. The water, however, is so poor (see analysis No. 33, p. 282) that it should be used only in case of necessity, and the sign bears the inscription “Poor water.” Prospectors and accidental travelers who pass occasionally use the water for drinking and for stock. It is salty to the taste, and analysis shows it to be very high in mineral content, particularly chlorides and carbonates of soda.

The spring occupies a small mound a foot or two high in the bed of the arroyo, whose banks are vertical walls 10 or 20 feet in height. There is a small patch of tules around the pool of water, and arrow weed grows at numerous places in the wash. The water flows about 100 feet and sinks. It bubbles slightly as it rises and is said to contain carbon dioxide. Arroyo Grande is several miles in length and drains a large area of the badlands south of the Santa Rosa Mountains. The water of McCain
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Spring is evidently underflow brought to the surface by structural conditions. The walls of the arroyo consist chiefly of nearly horizontal soft sands and clays, but beneath these beds at places are exposures of the much folded Tertiary beds, which are harder and better stratified. About 400 feet below the spring certain of these strata cut across the arroyo and stand in a vertical position. It is probable that impervious layers in these vertical folded strata force the seepage water to rise at the spring. There is another small seep of water about a mile east of McCain Spring.

The position of McCain Spring is indicated by two very large crescentic sand dunes which are on the south side of Arroyo Grande about a mile west of the spring. These dunes have remained nearly stationary for many years.

Arroyo Grande to San Felipe Creek.—Along the road south of Arroyo Grande the traveler obtains a better general view of Salton Sea than can be had from any other automobile road in this region. The sea is at present 8 to 10 miles wide and about 30 miles long and forms a placid lake that might be regarded as a great mirage because of its anomalous surroundings.

From a point not far south of the Geological Survey sign pointing to McCain Spring may be seen, 2 or 3 miles to the west, the tops of the two conspicuous sand dunes mentioned above. A little farther south the road swings eastward around a mass of low badland hills. The old beach curves eastward around these hills and very nearly touches the road in places, which are very sandy as a result. From this point of hills southward to San Felipe Creek large, isolated sand dunes appear on either side of the road. These are crescentic dunes or barchans (see p. 30) and are one of the unique features of the region, being found at no other places in this part of California.

After descending a long slope the road crosses a culvert (47.4, 25.9) under which there is usually a thin stream of running water, clear and inviting. This is San Felipe Creek, sometimes called Carrizo Creek, as the two creeks join a few miles above this point and there is some divergence of usage in naming the lower portion. The water is extremely disappointing to taste, however, being the bitterest found on the desert. (See analysis No. 45, p. 283.) It is not advisable to drink any of this water or to give any to animals, especially as somewhat better water is obtainable at Kane Spring, only 1 1/4 miles away.

The stream occupies a sandy channel about 300 feet wide, but only a little thread of water runs in it except at times of flood. Even this is intermittent and sinks out of sight in the stream gravel in most of its course, rising to the surface only at short stretches considerable distances apart. The presence of ground water at shallow depth under a narrow belt along the stream course seems to be indicated by a rather heavy growth of mesquite for a mile or more on either side. The mesquite usually grows in isolated clumps, and around each clump is a mound of sand. It might appear that the mesquite grows only on sand dunes, but probably the better explanation is that the sand accumulates around any obstruction offered to the wind.

San Felipe Creek to Imperial Valley.—The road ascends a gentle slope from San Felipe Creek to Kane Spring (49.0, 24.3). At Kane Spring there is a rectangular earthen reservoir about 40 by 100 feet which contains several feet of water and overflows through an iron pipe. On the opposite side, west of the road, is a small plot of ground planted to cottonwood trees, which in 1918 were being irrigated from the reservoir. The water in the reservoir comes by a pipe line from a spring almost on top of a small hill to the east. From the spring a small flow of water seeps away eastward and maintains a little plot of salt grass, cane, and arrow weed, but this is not visible from the road. The flow westward through the pipe line is about 5 gallons a minute. The hill on which Kane Spring is situated is the best example in this region of a spring-formed sand dune. (See p. 30.) The water of the spring is very high in mineral matter (see analysis No. 28, p. 282) and is salty to the taste, but it can be used for drinking.
About 100 feet south of the reservoir at Kane Spring a very good branch road turns southwest. A Geological Survey signpost is erected at this fork. The branch road leads to Harper Well, Borego Valley, and Warner. (See p. 220.) The road to Brawley climbs a little slope, and at the top, 0.1 mile from the reservoir, a narrow concrete road about 10 feet in width is reached. A large white signboard in red letters gives traffic rules for the road. Northbound traffic has the right of way, and southbound cars are expected to use the turnout provided every quarter of a mile or less, as the road is too narrow for two vehicles to pass without getting off the pavement, and at most places the sand is very bad on either side. Men with wagons, however, usually pay no attention to turnouts, as the difficulties with sand are not so serious for them as for automobiles. The land on either side of the road is bare desert, usually with a reddish clay soil, at places covered with sand and everywhere dissected by deep gulches.

To the southwest, about 10 miles away, is a lone low mountain rising from the desert plain like a cloud of smoke. This is Superstition Mountain, a ridge of granite about 750 feet high. It is supposed by many to be an old volcano and at times is said to give off fumes, noises, and mysterious signs. The writer has walked its crest for several miles and found it to be composed entirely of a uniform gray biotite granite. Some curious sand dunes have accumulated on its crest. (See p. 31.) The only evidence of anything volcanic consists of a bed of vesicular basalt and a bed of tuff, each about 200 feet thick, interbedded with Tertiary sandstone that flanks the mountain on its north side and is reported to occur at other places.

At 7 miles from Kane Spring the pavement ends (56.1, 17.2), and the road crosses a bridge over an irrigation ditch of the Imperial Valley system. Not far away are a few ranch houses, although for a mile or two but little land had yet been irrigated in 1918. The road from this point to Brawley is a well-kept dirt road maintained by the system of flooding used all over the valley. This consists of having two parallel roadways with a ridge between and a bank of earth on either side. One side is irrigated from the ditches and thereby wet down while the other is in use, and the two sides are thus used alternately. The great difficulty in road maintenance is to keep the fine soil from wearing into dust. The dust, in fact, is the most disagreeable feature of an ill-kept road, as it rises in choking clouds on the passing of every vehicle.

Farther along the country becomes well settled, and some very attractive fields and ranches are passed. Roads running on land lines form a network over the country, but the traveler can not go astray, as road signs are present at practically every corner.

Westmoreland (64.0, 9.5) is the only town passed before reaching Brawley. It is a pretty place with numerous streets shaded by stately trees but has only a few dwellings and one store. Water and gasoline are obtainable.

Just west of Brawley the road descends a steep bank (71.6, 1.7) to a bridge over New River. The deep chasm in which this relatively diminutive stream flows was eroded at the time of the overflow in 1905-1907 and is more fully described elsewhere (pp. 215-216).

Brawley.—Beyond New River the road leads east along a street lined by ornamental palms into Brawley, a very pretty city of a few thousand people in the heart of some of the best agricultural land in Imperial Valley. It is especially famous for the quantities of early cantaloupes and garden truck which it places on the market. Accommodations, services, and supplies of every kind are obtainable, and the place is a most delightful one at which to tarry after the long desert journey.

BRAWLEY TO NILAND.

[For log see pp. 138-139.]

The road from Brawley to Niland threads the north end of Imperial Valley. It is maintained in good condition at nearly all times by the same method as the other
roads in the valley, that of dividing the road into two parallel parts, one of which is in use while the other is being wet down and cared for. It is an excellent dirt road all the way.

Around Brawley the land is all under cultivation, but some waste land is crossed about 7 miles farther north, where Alamo River has ruined it. The Alamo (7.3, 14.1), like New River, flows in a chasm 50 feet or more deep and in places several hundred feet wide, excavated during the inundation of 1905 and later. The amount of water it carries at present is not great and is fed to it largely by waste ditches. An idea of its destructiveness during the flood, however, may be gained by observing the deep-cut bank, just north of the crossing, around which the railway makes an irregular curve. The river ate away this bank during the overflow to such an extent as to necessitate the shifting of the formerly straight track to its present course.

Calipatria (12.0, 8.4) was a very new town in 1918. It appeared to be the future center of a promising district in the north end of Imperial Valley, which was just then being developed.

North of Calipatria much of the surrounding land was either waste or being made ready for irrigation. With the proper water supply all this area will undoubtedly become a prosperous farming region. Niland is the junction point of the main line of the Southern Pacific Railroad and the Calexico branch, which serves the Imperial Valley. It contains two or three stores, a hotel, a garage, a blacksmith shop, and a busy railroad station.

NILAND TO YUMA.

[For log see pp. 139-142.]

Yuma is reached from Imperial Valley by a road from Niland and by another from El Centro through Holtville. Both roads are bad. The Holtville route is especially dreaded, as it is very sandy, but from El Centro it is 40 miles shorter and therefore is usually taken in spite of its difficulties. Persons traveling inland from Los Angeles reach Brawley without going through El Centro, and for them the Niland road is only about 10 miles longer and is probably preferable. Except for 1 mile of very bad sand at the old beach 4 miles east of Niland, the road is nearly all easily passable. It is crossed by numerous little washes coming from the Chocolate Mountains for many miles of its length and is therefore very disagreeable traveling for motorists. The roads from all Imperial Valley towns as far as Niland are good and are adequately marked by signs. Persons going east from Niland should take supplies and water for a long journey, as water is available only at railroad cisterns, and the stock of supplies kept at stations along the railroad is small. Gasoline and a small stock of provisions are usually kept at Glamis and Ogilby but are not obtainable anywhere else between Niland and Yuma.

Niland to the old beach.—From Niland the road goes southeastward along the Southern Pacific track for nearly 4 miles. The land is partly under irrigation and the road is fair. Near the point where it leaves the railroad (3.7, 69.2) the road turns northeast, crosses the East Highline canal, the last irrigation ditch of the valley to be crossed on this road, and continues on a sandy plain. Half a mile southeast of the railroad crossing is a station called Flowing Well. The station once maintained at this place was not being used in 1918, and the only residents were a number of Mexican section hands. The station derives its name from a watering place existing near it before the railroad was built. This is described as having been a marshy place supporting a growth of tules in the midst of which brackish water stood at the surface of the ground. Some reports say that an artesian well once existed at the place, but others contradict this statement. Water is kept at Flowing Well by the railroad company in a cistern and can be obtained if it is necessary to visit the place.

From the canal crossing there is a good view of the old beach of Lake Cahuilla. The most striking feature is a long bluff probably 40 feet or more in height, several
miles of which is visible from the road (Pl. XI, A). The road becomes increasingly sandy toward this old beach (4.5, 68.4). For a distance of about 500 feet the sand is very bad, and automobiles often have great difficulty in ascending the grade. It may be necessary to deflate the tires at this place. In case of getting stuck on the hill the best course is to back down, take a good start, and try again. There is usually no difficulty in the descent.

Old beach to Amos.—For several miles from the crossing of the beach the road leads southeastward approximately parallel to the railroad but a distance of a mile or two from it. The long detour is made on account of impassable sand near Mammoth Wash, at the north end of the Sand Hills. In this portion of the road there are innumerable gullies from a foot in depth and width to several feet in depth and a few hundred feet in width. All these gullies take a southwesterly course across the road, coming out of the Chocolate Mountains, which parallel the road at a distance of 5 or 6 miles on the northeast. These washes make it necessary to travel slowly in places.

At several of these washes tracks and trails turn toward the mountains to the left. Some of these are known to lead to Salvation Spring, in a pass in the Chocolate Range, but the main or best trail is not known to the writer. For the traveler to Yuma they are of no importance. The improvement of one of these trails as a short cut between the Imperial and Palo Verde valleys has been advocated sometimes but without success, the road from Glamis to Blythe being preferred because it is so much better.

A rather plain crossroad that leads southwestward (14.4, 58.5) was formerly used as a route to Imperial Valley. It crosses the railroad and goes down Mammoth Wash, a long wash bedded with deep sand, finally reaching the Imperial Valley and leading straight west into Brawley. Its course is shown on the map. It was scarcely ever traveled by automobiles in 1918 and was generally regarded as impassable.

Amos to Glamis.—From Amos to Glamis, a distance of about 16 miles, the road continues on the south side of the railroad. The roadbed is on an alluvial slope of gravel and sand washed down from the Chocolate Mountains. The land is remarkably well wooded for desert, being covered with ironwood trees and some creosote bush. The ironwood attains a height of 10 or 20 feet and grows at distances of 25 to 100 feet apart. As elsewhere in the desert, there is a great deal of dead wood, many trees having died and the process of decay being slow. This wooded aspect is noticeable nearly all the way from Niland to Yuma. Because of the supply of natural firewood for cooking the road is desirable for wagon travel and for campers.

A conspicuous feature of the desert between Amos and Glamis and even farther on the road to Yuma is the great row of sand dunes known as the Sand Hills (Pl. X), which rise as a long yellow or white ridge not far to the southwest and run nearly parallel with the railroad at a distance of 2 to 5 miles. They have the appearance of a low yellow mountain range.

Besides the Sand Hills the only other prominent feature of the landscape is the Chocolate Mountains, which parallel the road at a distance of 5 or 6 miles on the north. These mountains form a dark-brown mass consisting largely of granite, rhyolite, and basalt. They rise rather abruptly from the desert floor in a long straight scarp many miles in length. Farther west, just north of Niland, this scarp is broken by a great embayment where the lower desert level extends into the mountain front. The general trend of the range is southeastward, nearly in line with that of the Little San Bernardino Range, northeast of Coachella Valley. The Chocolate Mountains thus form the northeast wall of the great depression called the Salton Basin.
Glamis (32.9, 40.0) is the chief railroad station accessible from the country on the northeast and is the terminal point of a road from Palo Verde Valley to the Southern Pacific Railroad. It contains several houses, occupied by railroad laborers, and a combined store, at which gasoline and other supplies are obtainable, post office, and hotel. Water may be had from the railroad cistern. Usually a charge of 5 cents a head is made for watering stock.

**Glamis to Ogilby.**—From Glamis the road leads northeastward away from the railroad for a short distance, then turns southeastward and parallels it for several miles, this detour, like that near Niland, being necessary to avoid sand on the south side of the track. At 0.2 mile from Glamis (33.1, 39.8) a branch road leads northeastward to Palo Verde and Blythe. Farther on the road again crosses to the south side of the railroad (38.9, 34.0) and continues beside the track all the way to Ogilby and beyond. It is a hard dirt road, somewhat rough from dissection by little washes and dry runs but otherwise excellent. The country, like that from Amos to Glamis, is a broad plain covered with ironwood trees and bounded on one side by mountains and on the other by the Sand Hills.

Ogilby (52.1, 20.8) is a railroad station very similar to Glamis. Water and gasoline are obtainable, the usual charge of 5 cents a head being made for watering stock. Ogilby has had some importance at various times because it is the most convenient railroad station for mines in the Cargo Muchacho Mountains, 4 or 5 miles to the northeast, that have produced large amounts of gold. Branch roads lead north from Ogilby to these mines, which were deserted in 1918. Another branch road crosses the railroad and goes nearly east, affording a good but little used short cut to the northern road to Yuma described under “Branch roads into Yuma,” below. The main route continues southeastward along the railroad.

**Cargo Muchacho Mountains and Pilot Knob.**—The Chocolate Range breaks up into groups of scattered volcanic hills and low mountains northeast of Glamis and Ogilby. A prominent feature of the landscape near Ogilby is a nearly round group of mountains about 5 miles to the northeast, rising to two conical peaks over 2,000 feet high. This is the Cargo Muchacho Range, in which gold has been found, as stated above. It is composed of granite or granitic gneiss, much veined by dikes and stringers of quartz. The mountains are completely surrounded by alluvial waste, and their relations to adjacent mountain masses are unknown, although it is probable that they are older than the granites of the Peninsular Mountains and possibly are closely related to the bedrock of certain Arizona areas.

South of the road appears a single small dark mountain less than 1,000 feet in height but because of its isolation very prominent and visible for a great distance. This is Pilot Knob. It is very near the west bank of Colorado River. It consists of granite intruded by more recent volcanic rock and probably partly overlain by lava flows. A brief description of it is given by Blake.

At 2 miles from Ogilby and only a short distance north of the railroad is a group of low black hills isolated from the adjacent mountains. They are composed of a dark vesicular basalt, and the stone has been used for riprap and ballast on the railroad. The hills where visited appeared to be entirely volcanic, and the relation of the lava to the granitic rocks farther north is not known.

**Branch roads into Yuma.**—Southeast of Ogilby the road forks (58.8, 14.1), and one branch crosses the railroad and leads north a few miles, then turns southeastward and descends a deep ravine cut in the bluffs of Colorado River (see p. 34) onto the lowland called Yuma Valley, which it crosses in its route to Yuma. This route is 4 miles longer than the other, which continues eastward on the south side of the

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1 Lindgren, Waldemar, Problems of American geology, p. 244, Yale University Press, 1913
210 SALTON: SEA REGION, CALIFORNIA.

railroad, but it was somewhat better and more traveled in 1918. The southern road leads across some deeply dissected land just north of Pilot Knob and at places is very sandy. Its course for the last 6 miles into Yuma is across the Yuma Valley along the levee near the river. A description of these two roads is given in connection with the road from El Centro to Yuma (p. 216).

Yuma.—Yuma (72.9, 0.0) is just across Colorado River in Arizona and is reached by a bridge, on which no tolls are charged. It is a town of 4,237 people (1920) and an important agricultural center, owing to the recent reclamation of extensive tracts of land in its vicinity, as well as being the most important railroad town in this part of the Southwest east of the Pacific coast cities. All kinds of supplies and services are provided for the traveler. A well-traveled road leads from Yuma to Phoenix, a distance of about 196 miles.

BRAWLEY TO EL CENTRO.

[For log see pp. 142-143.]

The road from Brawley to El Centro, a distance of approximately 15 miles, passes through the very heart of Imperial Valley. It is one of the most traveled roads in the valley and is usually in excellent condition. Only small portions of it in the towns of Brawley, Imperial, and El Centro were paved in 1918, although it is probable that a hard-surfaced road will connect these thriving towns at no distant date. The dirt road was maintained in good condition by the prevalent system of wetting and rolling one half while the other was in use. It is a matter of quite as much importance to "irrigate" the roads in this region as it is to provide water for the crops; otherwise the fine silty soil works up into an unbearable dust, and the road gradually wears full of ruts. There is little to be said in description of this route, and even the road log will probably be not much needed, as the way is profusely marked by signposts.

SAN DIEGO TO JACUMBA.

For nearly 90 miles from San Diego the road to Imperial Valley by way of Jacumba follows the pleasant valleys and picturesque canyons across the Peninsular Range, whose west side forms the steep Pacific slope and whose east flank constitutes the still steeper declivity that fronts the Salton Basin. The highway was formerly much used, not only by tourists but also by motor trucks, but the completion of the San Diego & Arizona Railway has lessened somewhat its importance as a transportation route. The road is in part a graded dirt road, in part rock-cut mountain road, and in part paved, and is kept in good condition. The last 30 miles, from the foot of the mountains to El Centro, is the longest stretch of boulevard the traveler will find in this region. It is evident that this route presents none of the features of danger or uncertainty that have caused the desert watering-place work to be undertaken but is a popular scenic highway as well as a valuable artery of commerce for southern California.

The route from San Diego to Jacumba, about 76 miles, lies mainly on the Pacific slope and crosses well-settled country where agriculture and grazing are the principal industries and where water is relatively plentiful. For fruit raising or extensive agriculture irrigation is required, but only beyond Jacumba does the change from a well-watered country to a desert become marked. For this reason only a short description of this route will be given, the tourist being referred to the Automobile Club of Southern California, the Goodrich Touring Bureau, and the standard guides for information about roads and places. No United States Geological Survey signs will be seen, this route being adequately marked by other agencies and not falling properly under the province of a desert survey.
In the following notes the distances are taken from the maps of the Automobile Club of Southern California. Leaving San Diego at the Grant Hotel (0, 76), the road leads east over a rolling country dotted with vegetable gardens and fruit orchards, passing a pretty little village called Lemon Grove (0, 67). Lemon and orange groves are numerous by the roadside beyond this place where the road passes up the valley of Sweetwater River. Beyond Jamul (22, 54) there are steep grades, and low granite mountains are seen through the landscape green with many pastures and fields of barley. The road begins to traverse successive valleys and canyons separated by sharp divides and passes Dulzura (30, 46). Crossing from Dulzura Creek to the valley of Cottonwood River and thence passing up Potrero Creek it reaches the steepest grades of the ascent at a divide and enters the valley of Campo Creek, reaching Campo (54, 22). At several places along the way can be seen a large aqueduct that carries water to the city of San Diego from several streams and reservoirs in the surrounding mountains.

A few houses, a store or two, and possibly a few Indians from the neighboring reservation are about all that is to be seen at Campo. The San Diego & Arizona Railway was completed as far as this point from San Diego eastward in 1917 and was being pushed from both west and east across the summit of the mountain. This line has since been completed and now forms part of a transcontinental route with through service between San Diego, Chicago, and New Orleans. Two miles east of Campo (56, 20) a good road enters from the north. This leads to San Diego by way of Descanso or to Los Angeles by various inland routes. From this point all travel to Imperial Valley goes along the same road.

The country here is mountainous, lying mostly above 3,000 feet in elevation. The mountain masses consist of pink or gray granite. At some places they rise in sharp peaks and at others they are dissected into deep canyons, but much of the area presents rather steep, rounded slopes covered with a residual soil and a thick growth of liveoak, manzanita, and other mountain brush. There is little large timber except along watercourses. Small valleys with fields and pastures are common, but the land is for the most part a mountain wilderness used only for cattle range.

The divide between the Pacific slope and Salton Basin is reached 10 miles west of Jacumba, at an elevation slightly above 4,000 feet. Drainage from this point goes eastward into the desert, but no sharp change in vegetation is apparent. Descending into the valley of a little creek, the last perennial stream that is crossed, the road reaches the little village of Boulevard (69.5, 6.5). Out of this valley the road climbs a steep grade before descending the slope that leads into Jacumba Valley. Just west of Jacumba Creek (75.5, 0.5) is the crossing of the San Diego & Arizona Railway. The post office is near this crossing, but the springs and main settlement are half a mile away.

Jacumba is a town and summer resort that has long been a prominent watering place on account of its large springs of good water. In 1918 it contained two or three stores, as many hotels, a post office, and a lunch counter, as well as a camping ground for visitors, who frequent the place chiefly in summer. The mountain surroundings are attractive, although rather barren, but there are large groves of trees at the springs which rise at Jacumba.

The accompanying sketch map (Fig. 13) shows the geography of the springs and some of the important topographic features. It is not complete as to culture or accurately drawn to scale. The springs originate in the valley of a shallow mountain canyon that enters Jacumba Valley from the west. There is one large spring which yields cold water and feeds a stream that in November, 1917, flowed at least 1 second-foot of water. Near this is a small spring, or group of springs, very close together, which yields water with a sulphurous odor and a temperature of about 90°. The flow is only a few gallons a minute. These springs are regarded as medicinal, and the water is used in baths. The odor escapes rapidly and is not noticeable after the spring waters mingle with those of the larger stream.
The canyon or arroyo in which the springs are found has a sandy and gravelly valley 200 or 300 feet wide occupied by a gravelly streamway in which water flows on the surface at some places and sinks at others. At some points above the springs its flow is approximately as much as that from the large spring. A hill of granite and metamorphic schistose rocks in the middle of the little valley divides it in two ways at the springs. The wider and deeper valley is on the north and is occupied by a dry gravelly channel. But an alluvium-filled depression, evidently once a stream channel, lies south of this hill and more directly in the general axis of the valley. In this channel is the large cold spring, where water bubbles up with considerable force in a marshy area of several hundred square feet and gives rise to the stream below. Above the spring is a cliff of alluvial material about 10 feet high. The cliff is evidently retreating and is apparently caused, not by overflow of surface water, but by the carrying away of the soft soil by the rising waters below, with resultant gradual caving of the face of the little declivity. The surface drainage ap-

![Figure 13. Sketch map of Jacumba Springs, Calif.](image)

pears to follow the longer stream course northward. There is apparently little reason to doubt that the large spring originates from the rise of underflow waters of the arroyo above and is really only a slightly unusual example of flow in an intermittent stream. Analysis of water from this spring (see analysis No. 27, p. 282) indicates a water of good quality for drinking, with a slightly higher amount of sodium and potassium than of calcium and magnesium, almost identical in quality with surface waters of some streams of San Diego County.

The warm springs are more difficult of explanation. They rise through residual granitic soil on a slope apparently a little higher than the cold spring and have no evident connection with drainage. The rocks of the region are chiefly pegmatite granite, in low hills, but the railroad cut north of Jacumba shows that this rock is intimately mixed with masses of schist and slate, the whole more or less set on edge, with a strike slightly west or north. The schist and slate were observed also in the isolated granitic hill, but they are less prominent topographically than the granite. There are also volcanic flows a mile or so away capping some hills, but they apparently have nothing to do with the springs. The region is one where faulting is suspected, and it is possible that the warm spring waters issue along deep fractures. Waring states

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that earthquakes in 1892 and 1900 slightly altered the position of the outlet of the warm springs. He also says that the warm water is soft and excellent for laundry use, being evidently not greatly different from the cold water.

Jacumba Valley is a large plain several miles long and a mile or more wide lying mostly in Mexico. Jacumba itself is on the edge of the valley and a little over half a mile from the Mexican boundary. The valley drains northward and narrows to a canyon called Carrizo Gorge. From the point where this canyon reaches the desert the stream becomes interrupted and rises to the surface only rarely for short distances in its long and crooked course to the Salton Sea.

JACUMBA TO EL CENTRO.

[For log see pp. 143-144.]

Jacumba to Mountain Springs.—The present road from Jacumba to El Centro follows rather closely the line of an old stage road between Fort Yuma and San Diego which was used before the development of the irrigation projects of the present day and indeed long before the building of the transcontinental railways. At many points the road has been straightened, its grades reduced, and other changes effected, but the watering places at Mountain Springs and Coyote Wells are the same except that the place which now bears the latter name is a little west of the original water hole where the traveler once dug into the desert sand to obtain a drink of bitter ooze.

Leaving Jacumba at the springs, the road is nearly level for more than a mile across the grassy bottom of Jacumba Valley. High mountains wall the valley on the east, west, and north. Their topography is distinctly different from that noted in the irregular jagged granite peaks and rolling uplands farther west. Broad barren mountains with seemingly flat tops and steep smooth sides are conspicuous. Their color, too, is different, being a reddish brown. These mountains are capped by flows of lava, poured out on the rather even surface, which produce their tablelike appearance. They are seen only near the border of Jacumba Valley.

After ascending a moderate grade out of Jacumba Valley, the road threads a few miles of little narrow valleys, in one of which a cabin stands on the south side of the road (5.7, 39.9), and a distinct road leads north. About a quarter of a mile away on this road under a clump of willows is a little pool of good water known as Smuggler Spring, the name suggesting outlaw deeds along the border. The water seeps from residual granite sand and feeds a stream that flows for a short distance. It is used chiefly by prospectors. A mile beyond Smuggler Spring the mountains break off in an abrupt slope toward the northeast, and at one place in the bend above Mountain Springs the Salton Basin desert, many miles away and some thousands of feet below, is visible for an instant. The road at this point (6.7, 38.9) drops down what is perhaps the steepest grade encountered, hugging the mountain wall on one side as it curves back around the heads of canyons and overlooking a precipitous slope of several hundred feet on the other. After many windings it emerges on a little flat between the encircling ridges and reaches Mountain Springs (8.7, 36.9).

Mountain Springs are very near the San Diego-Imperial County line, probably in sec. 24, T. 17 S., R. 8 E. There is a store at the place where small quantities of automobile supplies and groceries are obtainable, and a water trough and faucet are provided for public convenience. The spring from which the water issues is a seep in residual granitic soil but has been developed and covered up by a spring house. About 1,000 feet south of the store the owner has developed a new spring by trenching a hillside bed of residual soil where there were a few rushes and a little palm tree indicating a seep of water. Still farther south is said to be another. The total flow is to be used in irrigating a garden spot near the store. None of the springs yield more than a few gallons a minute, but the water is apparently of good quality, as is to be expected in areas of granitic rocks. These springs are good examples of a
type common in rugged mountain areas of igneous rock. The rain falling on the
hillsides penetrates the thin coating of soil and the fractures and joints of the rocks
and drains downward along the lines of the ravines. At places residual soil seals
the openings of fractures more or less effectively, and a body of water gradually
collects in the soil and beneath it and forms a moist spot, which may be indicated
by vegetation. Inasmuch as the soil containing these seeps is more commonly
residual than detrital, it seems that the spring may have had much to do with the
disintegration of the rock mass into soil and its retention on the hillside. The supply
of water derived from such sources is usually small but generally capable of some
development by trenching or tunneling to provide more outlet area for seepage.
The water is generally of satisfactory quality for domestic use or irrigation.

In the higher parts of the mountains near Mountain Springs there are numerous
small seeps and hillside marshes at which water could be developed as at Mountain
Springs. Mr. Allan, a railway engineer who has made topographic surveys in the
vicinity, states that water occurs in nearly all the mountain canyons above an alti­
tude of 1,500 feet. Perennial streams do not exist anywhere east of Jacumba, however.

Mountain Springs to Coyote Wells.—Near Mountain Springs the vegetation under­
goes a marked change, the transition being swift from the juniper, liveoak, and
manzanita of the mountains to the cactus, ironwood, and creosote of the desert.
This change becomes complete at the border of the plain.

Much of the road in the 6 miles below Mountain Springs is hewn in rock along the
mountain side and has a nearly uniform grade, which appears very steep on the
ascent and warrants careful driving in either direction. The rock walls are bare,
smooth granite, which has been utilized at many places by certain concerns for
advertising signs. (See Pl. XVI, B). How different this road was in the recent
past is aptly illustrated by a quotation of the description given by the Mexican
Boundary Commission.10

Just before reaching Mountain Spring Canyon a stretch of very heavy sand is
encountered, which continues to the mouth of the canyon. The road through the
canyon is rough beyond description and although but 3 miles in length caused much
more damage to vehicles than did any other road on the entire survey.

A large concrete bridge over a canyon (14.0, 31.6) marks the beginning of a paved
road that continues into El Centro. After skirting the mountain wall for about a
mile below the bridge the road turns northeastward across the flat desert and is well
within the limits of the Salton Basin. Farther on the road passes under the San
Diego & Arizona Railway (16.0, 29.6). Somewhere near this point a trail leads west­
toward the gorge and to a spring called Dos Cabezas (see p. 272), but little is known
of it, and so many roads made in the construction of the railway lead in various
directions that the turn can not be identified.

Coyote Wells (20.0, 25.6) has a combined store and post office, a garage where
gasoline and oil are obtainable, and a railway station. There are also a few ranch
houses in the vicinity. Water is obtainable from a well at the store. It is not of
good quality but is drinkable. (See analysis No. 14, p. 282.) The water supply of
this region is discussed on pages 90-91. A mile and a half east of Coyote Wells and
200 feet north of the road the traveler may see, if he looks closely, an old well, which
marks the water hole of early days. Orcutt 11 in 1890 described this as being a place
in the wash and marked by two scrubby mesquite trees where coyotes obtained water
by digging in the sand; hence the name. The water was said to be brackish and to
have a foul odor. In November, 1917, water in the well stood 16 feet below the
surface but was full of filth, as no covering was provided.

10 Report of the Boundary Commission upon the survey and re-marking of the boundary between the
DETAILED DESCRIPTIONS.

Coyote Wells to Dixieland.—From Coyote Wells the road lies near the railway all the way into El Centro. It ascends a short grade (21.7, 23.9), passing out of the Coyote Wash onto some low hills that show folded strata of arkose sand and conglomerate. From the tops of these hills the land both north and south appears rough and broken. In this area about the year 1900 and at numerous times since interest has been great in the possibility of discovering oil or gas. In 1901 about 450,000 acres of land was located for petroleum, and numerous drills were busy in this part of the desert. Although no results have ever been very favorable, scores of wells have been drilled, many to a depth of several hundred feet. Most of these wells reached salt water at considerable depth, and a few were reported to have struck small quantities of gas and asphalt, but no oil in any appreciable quantity was found. It is generally thought that although there may be remote possibilities of the existence at depth of more promising formations, the geologic indications are rather unfavorable for the occurrence of petroleum.

A conspicuous mountain rises north of Coyote Wells as an isolated mass of moderate elevation said to be 2,800 feet above sea level. This is Carrizo Mountain, also called Coyote Mountain. It is made up largely of metamorphic sedimentary rocks with some intruded igneous masses in the center flanked by fossiliferous strata of Tertiary age. It contains large quantities of blue-gray marble that has been quarried to some extent. A trail leads north to a quarry in this marble (22.9, 22.7). The writer has also seen excellent specimens of graphita from this mountain.

Turning due east (26.1, 19.5), the road crosses a nearly level plain which is as arid and forsaken as any other portion of the United States. Seemingly infinite in width, almost unbroken by a landmark, supporting only the most meager growth of creosote bush, this lonely space may well have been dreaded by the traveler who 50 years ago tried to follow its uncharted trails to the land of golden dreams. As an automobile rolls smoothly along, covering more miles in an hour than could then be covered in several days, the perils of a time so recent seem unreal and exaggerated.

A Geological Survey sign at a branch road (28.8, 16.8) points north to Carrizo, Vallecito, and Julian. This branch is the best route to Carrizo or Vallecito from Imperial Valley, but most travelers to Julian take the longer but better-traveled mountain roads. A bank of deep sand just east of this signpost marks the old beach of Lake Cahuilla (p. 32) and is one of the features that add difficulty to all dirt roads that cross this beach in entering the Salton Basin. For this reason the road here leading to Carrizo is preferable to another that leaves the highway 2 miles farther east (30.8, 14.8) and goes northward to a junction with this road. At the same point, 2 miles east of the Geological Survey sign, a road also goes south, and its appearance might lead one to think it a well-traveled highway, as it is covered here with asphalt. It is a portion of a former highway to San Diego which reached Coyote Wells by a route lying a few miles south of the present road. By a trail leading south from this old road it is possible to reach a little used watering place called Yuha Well. (See p. 161.)

Dixieland (32.1, 13.5) marks the border between the unreclaimed desert and the irrigated territory of Imperial Valley. The Highline canal is crossed just east of Dixieland, and beyond it most of the available land is cultivated. West of Dixieland extensions are being planned that will probably encroach farther on the desert in the near future. The village consists of a few stores, a school, some houses, and a gasoline station.

Dixieland to El Centro.—After traversing 2 or 3 miles of cultivated land the traveler notices a seeming reversion to the desert. Great gullies dissect the plain in weird forms, cutting deep into the soft soil, which is a reddish silt perfectly stratified in horizontal layers—the product of long alluviation by the silt-bearing waters of the Colorado. These gullies have vertical walls with flat tablelike areas between and suggest some strange freak of erosion in an arid land where there is no rain to tear down
the sides or dissect the tops of the divides between arroyos. In the deeper washes are pools of clear water, probably supplied by the waste ditches of the irrigation system. The dissection continues in increasing prominence until the road reaches the principal gorge of all at New River (36.6, 19.0). Here a fairly large stream of water flows in a channel several hundred feet wide with walls 50 to 100 feet high and nearly as steep as those that have been passed. Most of this dissection is attributable to the floods of 1905 and later during the early stages of irrigation. A great sheet of water had spread over the land southward and over portions of the banks of New River, which was not nearly so deep then as now. Gradually the flood ate the streamway deeper, making the great channel that is now occupied by a diminutive stream. The tributary waters from the sides added their share of damage to the adjacent country, and so about 7,000 acres of once level plain in a very fertile valley was rendered worthless.

The channel of New River has long been one of the spillways for surplus waters of the Colorado’s summer floods, which have been known to fill the bottom of the Salton Basin several times since 1850, although the source of the mysterious waters that formed the lake was for a time unsuspected. The pools of water left in the channels of New and Alamo rivers were the only known watering places on the old trail from Fort Yuma to San Diego across this portion of the desert.

The crossing of the river was made by a jog southward descending the steep bank to a wooden bridge at a level not far above the water in the stream. The new bridge that was under construction in 1917 will straighten and improve the road.

Seeley (37.2, 8.4) is a little village not far from the east bank of New River. It lies mostly north of the road and a few blocks away, so that travelers rarely stop. In winter great quantities of baled cotton are seen stacked by the railway. East of Seeley is several miles of the most fertile and best improved land in the valley. Rich green alfalfa, said to yield seven cuttings a year, barley fields affording pasture for cattle, green groves of trees, and dense crops of milo maize all offer a striking contrast to the sandy and impoverished plain so lately passed.

El Centro (45.6, 0.0) is the county seat of Imperial County and a town of 5,464 inhabitants (1920). All sorts of supplies and accommodations are available. It affords a very agreeable stopping place after the long journey through territory so sparsely settled.

**Choice of routes.**—From Imperial Valley to Yuma, Ariz., there are two routes either of which was so bad in 1918 as to afford chiefly a choice between disadvantages so far as comfort and security were concerned. Nevertheless they offer incomparable opportunities for an acquaintance with the heart of the desert idealized by Harold Bell Wright in his tale of the reclaimed West, “The winning of Barbara Worth.” One who travels the Holtville or Sand Hills route is especially impressed with the size and loneliness of that parched and sunburned land that pleads in vain for the moisture which was denied by its Creator and which man has not yet succeeded in providing—indeed, can scarcely hope ever adequately to supply.

Leaving El Centro one road goes north 35 miles to Niland, traversing the length of Imperial Valley, and then turns southeastward, following approximately the course of the Southern Pacific Railroad into Yuma, 72 miles farther. With the exception of about 1 mile of heavy sand crossing the old beach east of Niland (pp. 207–208) this route is for the most part easily passable. However, it is cut up badly for many miles by little cross washes that come out of the Chocolate Mountains, a few miles to the northeast. For this reason and also because it is 40 miles longer, many travelers brave the perils of the Sand Hills on the other road. Both routes are fairly well supplied with water, but neither one affords many supply or service
stations. There are a few places on the Niland road where gasoline and oil are obtainable as well as water. From Alamo School to Yuma on the Holtville route, a distance of nearly 50 miles, the only persons likely to be met are those who live at the old county well and care for the planked road across the Sand Hills, usually a few men with teams. Both routes are used by automobiles, but the Niland road seems to be preferred by persons with teams on account of the more frequent supply stations, more plentiful fuel for camp fires, and absence of sand. The traveler should make inquiry at El Centro as to the relative practicability of the roads, for sand storms occasionally block the Holtville road temporarily. Stories told by chance travelers should be accepted with reservation, however, for everyone's opinion is influenced by his individual luck in getting through.

El Centro to Holtville.—The part of the road between El Centro and Holtville passes entirely through cultivated land in the heart of Imperial Valley and has no unpleasant features except possibly the dust, which often becomes bad on much traveled roads if they are not well cared for. Broad fields of the staple crops of Imperial Valley spread out on either side of the road, clumps of trees mark the dwelling houses, and herds of cattle roam the pastures. The district is one of especial productiveness and beauty. For several miles the road parallels the Holton interurban railway, over which motor cars run frequently on regular schedule. Leaving the track not far west of Holtville, the road goes north a short distance and turns east across Alamo River (9.7, 57.4), which together with New River, farther west, carried the waters of the Colorado into the Salton Sea during the memorable floods of 1905 and later. (See pp. 11–12.) This wide chasm, nearly 100 feet deep, was lowered 30 feet by the flood waters.

Holtville (10.6, 56.4) is a thriving town of the eastern part of the valley. Its population was 1,347 in 1920. Business houses fill most of three sides of the square, and the residence section is scattered over nearly 2 square miles. Supplies and services of all kinds are obtainable. Holtville is noted as having the only artesian water—in fact, the only well water of any kind—in the settled portion of Imperial Valley. Ground-water conditions in the region are described on pages 78–84.

Holtville to Alamo School.—After leaving Holtville the road runs southeastward, keeping at a distance of about half a mile from the channel of the Alamo, along which the ground is very broken. Practically all the land under the Highline canal has been in cultivation for several years. Auto Club and Goodrich signs mark a turn due east (15.5, 51.6). The road south to Calexico is said to be in a good condition, which is true at least as far as the Verde School, about 3 miles away. Further than this the writer has no information concerning it, but it undoubtedly traverses well-settled country.

Alamo School is the last public watering place in Imperial Valley on the Sand Hills road to Yuma. Although there are wells on the desert east of this point, it is wise to take water here if not already fully supplied. There is a schoolhouse on one corner of the crossroads at Alamo and a store on another. Water comes from a flowing well on the school lot and is led into a sheet-iron tank beside the rock from which it is drawn for filling wagons. There is also a faucet in the ground beside the tank to accommodate travelers. The well was drilled in 1912, is 4 inches in diameter, and is reported to be 877 feet deep. The discharge appeared to be about 5 gallons a minute, but the casing is greatly reduced and the water conducted 150 feet or more along the ground. The water is warm, about 90°, and has a slight color when it is drawn but is not unpleasant to the taste. The analysis (No. 60, p. 283) shows a rather high mineral content with a large percentage of sodium carbonate (black alkali), and it is probable that the water would be poor for irrigation. It is used chiefly by the school and the public for drinking.

Alamo School to new county well.—A little less than 2 miles east of Alamo the road crosses the East Highline canal, which is the line "that just divides the desert
from the sown." A large white board here contains a red-letter warning to east-bound travelers about taking ample supplies. It should not be read with disdain. Just east of the canal the road crosses the old beach (see p. 32), which contains deep sand, but east of the first quarter of a mile the road is a little better.

For about 12 miles from the East Highline canal to the new county well the road bears about 30° south of east. For a short distance from the canal the country is covered with little hillocks of sand built up around scattered clumps of mesquite, but these give place to a nearly flat plain where only a scattering growth of rather stunted creosote bush is visible. The surface of the ground appears deceptively hard and gravelly, being covered with little grains the size of a pea or smaller. This is merely a coating, however, of particles too large for the wind to carry away. Beneath is fine sand and silt, to which the deep holes made by unfortunate motorists in "digging out" along the road bear mute testimony. It may be necessary along this part of the road to deflate automobile tires to about half the normal pressure. (See p. 121.)

The new county well is in a very flat barren and sandy plain, in sec. 1, T. 17 S., R. 18 E. It is equipped with a small windmill, and there is a tank supplying water for stock. The well was drilled by J. D. McNeil, of Holtville, for Imperial County in 1917. It is 4 inches in diameter and 140 feet deep, and the water level is 80 feet below the surface. The driller reports having made a test well 880 feet deep 20 feet farther east in a trial for flowing water. The hole penetrated sand and gravel all the way, but the water level was the same as that in the well at present used. The water is of fair quality for drinking (see analysis No. 35, p. 283), its rather high mineral content being scarcely noticeable to the taste. The well is believed to tap a ground-water body maintained by seepage from Colorado River and continuous with that farther west in the artesian area around Holtville. (See p. 79.)

New county well to old county well.—The road at the new county well is only about a mile north of the international boundary, which it parallels for 10 miles east. The traveler is apt to be perplexed by the maze of crisscross trails along this part of the road. Nearly every car makes at places a new track, and the whole road has to be broken afresh after every sand storm. Usually the stranger will do well to pick out the plainest track and remain in it. Fortunately all the tracks come together at the county wells. From the new county well to the old county well the road becomes more and more sandy, crossing in places some small dunes. A few of these crossings are planked by boards laid lengthwise in parallel tracks. In case of getting stuck on one of these hills the best plan usually is to back up on level ground, take a good start, and try again, more than once if necessary. The traveler attempting this route for the first time may profit by reading the suggestions on pages 119-123.

The old county well (40.6, 26.5), so called to distinguish it from the new well farther west, is at the west edge of the Sand Hills. It was put down by Imperial County and is equipped with a windmill and a reservoir for public supply. There is a house at the place which is usually occupied by a number of men employed in maintaining the planked portion of the Sand Hills road. The well was drilled about 1910 or 1912. Its diameter is 10 inches, but the casing is so crooked and obstructed that its depth could not be measured. The best reported information is that the well is 120 feet deep and contains about 10 feet of water, making the water level 110 feet below the surface. Like the new county well, it is thought to tap an extensive body of ground water maintained by seepage from the Colorado. The quality is fair, as indicated by analysis No. 36 (p. 283).

Planked road across Sand Hills.—The road across the Sand Hills east of the old county well is surfaced with planks and constitutes one of the novelties of highway engineering in this region. The planks are 2 inches thick and 10 feet long and are laid transverse to the roadway. They are built into sections 12 or 15 feet in length and the sections are laid end to end, forming a continuous roadway. As the width
DETAILED DESCRIPTIONS.

of the road (10 feet) is not sufficient to allow vehicles to pass, turnouts are provided about every quarter of a mile.

The planked road is very troublesome to maintain because the wind is continually shifting the sand back and forth. In spite of windbreaks and barricades the road is frequently covered at places with several feet of sand. Occasionally sections are undermined so that they drop and fail to match properly. Several men and teams are required to keep the road in good condition. The cost of construction and maintenance has been so heavy that there is some talk of discontinuing the road, but its value as part of a short route from Yuma to San Diego will probably cause it to be maintained and improved.

The Sand Hills themselves (Pl. X) are a very picturesque feature of this route. They form a belt about 50 miles long and 5 to 7 miles wide of huge dunes of yellow shifting sand, and when the wind is not blowing the sand about disagreeably, which is a rather rare occurrence, they are decidedly attractive. The origin of this belt of dunes is discussed on pages 27-29.

The road in crossing the Sand Hills takes advantage of a low sag known as Telegraph Pass. At present a large electric transmission line also crosses the Sand Hills at the same place, but it diverges from the road at either side of the hills. The fact that the Sand Hills continue undiminished in size into Mexican territory has affected the engineering and financial phases of the development of Imperial Valley. But for them a canal from Colorado River to Imperial Valley entirely on United States soil would be possible. As it is, a closed conduit would be necessary for 10 or 12 miles, and its cost is practically prohibitive.

Sand Hills to Yuma Valley.—At the end of the planked road (47.2, 19.9) there is a three-way fork marked by a Geological Survey sign. The left-hand fork goes north to Ogilby, a station on the Southern Pacific Railroad, 4 miles away. It is known to be somewhat sandy but is probably passable. The right-hand fork follows a power line that crosses the Sand Hills along the same route as the highway but here bends to the east. This road is used only by linemen. Straight ahead on the middle course is the road to Yuma.

At the Southern Pacific Railroad (50.2, 16.9) the road joins the Niland route mentioned above, and thence it runs southeast along the railroad over a hard table-land. Farther on there is a road fork (53.0, 14.1) at which a choice of routes is offered. Most travelers recently have chosen the left-hand road, crossing the railroad here and approaching Yuma from the mesa on the north. This is a good road with the exception of about 1½ miles where it follows down a sandy wash from the river terrace into Yuma Valley.

The right-hand road, continuing along the railroad, crosses this bluff at a place where it is very badly dissected and sandy. Like the other road it is easier descending than coming out of the valley. Both roads lead across the Yuma Indian Reservation in the last 5 or 6 miles, but the right-hand fork passes very near the river at a bend west of Yuma and follows for a number of miles the levee protecting the reservation from overflow.

Yuma Indian Reservation.—The Yuma Indian Reservation includes most of the flood plain on the California side of Colorado River for 4 or 5 miles north of Yuma. Water for irrigation is diverted at the celebrated Laguna dam, at Potholes, about 10 miles above Yuma. The project is one of the first undertaken by the United States Reclamation Service in California, the weir having been completed in 1909 and water turned into the canals in the next year. The land of the reservation is allotted to individual Indians and cultivated by them. The average Yuma Indian is a large swarthy individual with more than the ordinary inclination to work, to judge by appearances. Families are scattered in rude little houses over the farms. They cultivate the land and raise some stock. Many Indians are seen working the roads, cutting brush, and tilling the soil. The report of the Commissioner of Indian Affairs
for the year ending June 30, 1917, shows that a total of 8,350 acres of land belonged to the Indians, of which 1,318 acres was under cultivation. Undoubtedly, more has been added since that date. The Indian population in 1917 was 833, of whom 259 were listed as adults, and of these 184 were engaged in agriculture. The value of agricultural products for the year was $66,500 and the income from labor $50,000, a total annual income of about $140 per capita. On the hill that stands out prominently on the north bank of the river at Yuma is the Fort Yuma Indian School, which had an average attendance of 177. Although these Indians retain numerous characteristics of their ancestors, they are fast adopting the customs of civilization. Nevertheless, their picturesque appearance adds a touch of interest even to the many-hued population of Yuma.

Yuma.—An interesting engineering feature of the Yuma irrigation project is the siphon under Colorado River at Yuma. A large district on the Arizona side is irrigated by water led down on the California side through the big canal (64.3, 2.8). This was necessary because of the difficulty of crossing Gila River, which empties into the Colorado just above Yuma on the Arizona side. The water is led under the Colorado in an inverted siphon 1,000 feet long and 14 feet in diameter, passing 50 feet below the river bed. The inlet end of this interesting structure may be seen by walking across the railroad bridge from the station at Yuma.

Supplies and services of all kinds are obtainable at Yuma, which was for many years an outpost on the southwestern border. It is the principal railroad town for many miles in either direction. Its population was 2,914 in 1910 but has increased rapidly with irrigation development and in 1920 was 4,237. The people are a strange admixture of Americans, Mexicans, Negroes, and Indians, with a considerable sprinkling of Orientals.

From Yuma the road to Phoenix leads east up Gila River valley. The distance is very nearly 200 miles. Local inquiries should be made as to the route, which is also described by Ross.12

WARNER TO BRAWLEY.12a

[For log see pp. 147-154.]

The road from Warner east to Imperial Valley by way of Borego and San Felipe is very little used as a through route. In the mountains east of Warner there is a rough and very steep descent through Grapevine Canyon. Farther on there are many miles of desert which is at places very sandy, and through the worst portion of the desert there is a stretch of 25 or 30 miles without water. Moreover, the road is so little traveled that at times it may be difficult to follow by persons unacquainted with the country. It is therefore impracticable as a freight road for teams, and even automobiles pass over it only occasionally. The distance between Warner and Brawley by this road is approximately 60 miles less than that through Julian and Jacumba, over the mountains, and even to El Centro there is an advantage of 30 miles in favor of this route. By traveling the old county road, which makes a cut-off south of Borego Valley, a further saving of about 10 miles is effected. A contemplated shortening of the road between Borego and Warner by constructing a new road through Montezuma Valley would make the road by way of Borego considerably shorter than at present.

There are practically no settlements on the route, and for that reason little effort has been made to provide better roads. Considerable interest was being taken in the Borego Valley lands in 1918 by settlers who were developing artesian water, and in

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12a According to information received in March, 1921, extensive improvements were being made in this road and numerous wells were to be drilled along it.
case this becomes an important oasis better roads will doubtless result. There were several families living in the Borego Valley in 1918 but no stores or supply stations anywhere between Warner and Imperial Valley. The road is therefore of local importance to persons entering a large territory in the Borego and San Felipe regions but is not recommended as a through route.

Warner.—Warner is one of the oldest settlements in the interior of southern California, having been occupied in 1845 by Jonathan Trumbull Warner, better known as Juan José Warner, who at that time obtained a grant of 26,000 acres of land in the present Warner Valley and made it his residence until 1857. During this time the Warner ranch was the first objective, west of Yuma, of several trails crossing the Colorado Desert. The ranch has remained in individual ownership and been an important settlement ever since. At present it is used chiefly as range, 8,000 head of cattle being reported as kept ordinarily. At Warner there are noted hot springs that attract health seekers, whose patronage supports a store, hotel, and other appurtenances of a small resort.

The village at Warner Springs is at the southwest base of some mountains about 6,000 feet high and itself lies at an elevation of 3,165 feet. To the southwest is a broad valley about 6 miles in diameter, shut in by mountains and draining out through a deep canyon of San Luis Rey River. Numerous canyons in the mountains to the northeast have a perennial flow of water, which becomes intermittent or disappears in the valley. In the valley, however, are numerous springs and marshes at which the water rises to the surface, often under slight artesian pressure, and the land is generally grassy and affords good pasture.

The Warner hot spring bursts up near the post office in the bed of a small canyon in granite. It rises at a rather constricted portion of the ravine, but this fact apparently has only an incidental bearing on its origin. Several pits have been dug out in the stream bed and walled with concrete. The spring yields a flow of 100 gallons or more a minute. The water has a temperature of about 140° F. It is strongly sulphured and gives off a pronounced odor of hydrogen sulphide. Otherwise the analysis (No. 50, p. 283) indicates that it is not especially highly mineralized. The hydrogen sulphide had disappeared before analysis. The water after it cools slightly is satisfactory for drinking, bathing, and irrigation.

The origin of the spring has been associated by all geologists who have examined it, so far as known, with a fault line that passes through this part of Warner Valley and continues down Grapevine Canyon. The water undoubtedly rises from a great depth; and although it may possibly originate as meteoric water first entering the granitic rocks at a much higher altitude, it is not improbable that it escapes from some highly heated mass of igneous rock deep within the earth's crust.

Road through Warner ranch.—Two or three roads lead from Warner southeastward across the Warner ranch, of which a new one, described in the road log, is probably most used. This climbs several steep grades and crosses a number of ravines, some containing running water. At a Geological Survey sign at a fork (5.9, 84.9) the road branches, the right-hand road leading to San Felipe Valley and ranch and several places farther south and east. Turning east (left) the Brawley road passes up a pretty forested valley and goes through a wooden gate (8.2, 82.6) at the ranch boundary, the gate being kept closed to confine the herds on the ranch. The road as a whole is not much traveled but is very good.

Grapevine Canyon.—East of the Warner ranch the road continues to ascend gentle grades. A branch road (8.4, 82.4), usually posted with wooden signs, leads to the left to Montezuma, a small settlement in a high upland valley not far away. This road was considerably traveled in 1918 and looked better than the Borego-Brawley road, which turns to the right. About 2 miles farther on (10.2, 80.6) the road reaches

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the summit of the divide between the Pacific slope and the slope to the Salton Basin, at an altitude of 4,000 feet. Within a distance of slightly more than 2 miles from this point there is a drop of 800 feet in altitude, and the grades are very steep, at places almost the limit possible for ascent by a Ford car, although the trip in that direction was made without mishap. The road is cut in the hillside at many places and is very narrow, crooked, and in poor condition, being washed out or strewn with boulders at many places unless recently repaired. Care should be used in driving, particularly in the rather uncommon event of parties meeting on the road. Nevertheless, it is safe enough for travel.

The canyon is narrow and rocky at most places but widens into a small valley about 1½ miles below the summit, and on the left two trails turn aside to a cabin which is visible about half a mile off the road. There are corrals around the cabin, which stands in a little ciénaga in granite hills. Water rises in a marsh of small extent, and ditches have been dug to develop it. No one was living at the cabin at the time it was visited, and it is not necessary to turn aside for water, which can easily be had at Grapevine Spring.

_Grapevine Spring._—Grapevine Spring, in sec. 36, T. 11 S., R. 4 E., rises in a local ciénaga where hard rock cuts across the bottom of Grapevine Canyon. The water flows over two waterfalls about 15 or 20 feet high and passes out through a gorge a few feet wide into a more open valley below. The stream is perennial for a distance of several hundred feet but gradually sinks into the canyon gravel. The spring receives its name from an abundance of grapevines which cover the rock walls of the gorge below the waterfalls. Figure 14 shows the geography of the vicinity. No signpost marks the location of the spring, and a traveler from the west may not notice it until he is in the valley below, as the road makes a circular detour of about half a mile to avoid the gorge occupied by the streamway and comes out on the little valley below, where there is a cabin and a garden of about an acre in extent. The house was vacant in January, 1918, but had recently been occupied. North of it toward the spring there is a hillside tunnel and dump representing an abandoned prospect, and the wreckage of an old stone mill used in working gold ore is still standing. The place is easily identified.
There is a rather open flat above the waterfalls where the water rises in a marshy area 20 or 30 feet across in which there is grass and a clump of willow trees. After flowing a few feet it plunges over the first fall. The second fall is probably 50 yards away. The borders of the stream and the hillsides adjacent are covered with grass, mesquite, willows, and other water-loving plants. It is remarkable that this is the highest altitude (3,500 feet) at which mesquite was observed in the course of this investigation and much higher than its usual zone of occurrence. The water is excellent in quality, and the flow amounts to perhaps 20 or 30 gallons a minute. There is also water in the adjacent mine tunnel, from which a pipe line conducts it to the little garden patch.

The rocks of the canyon are granitic gneiss and siliceous schist. The topography suggests the presence of a fault line passing in a nearly east-west direction about half a mile south of the spring and indicates that the area to the north has been lifted several hundred feet. The spring has evidently cut its course back as a waterfall to its present position, and the water appears to rise out of the soil and gravel above the impervious rim of hard rock at the edge of the fall.

Below Grapevine Spring the canyon gradually widens into a valley ranging from 200 or 300 feet to a mile or more in width bordered by steep mountains, which rise 1,000 to 2,000 feet above it. The road picks its way through this valley, at places using the sandy channel of the wash that occupies its lowest part but usually staying to one side on harder ground.

**Stuart Spring.**—Stuart Spring, also called Sumac Spring, is about 2 miles east of Grapevine Spring, in sec. 6, T. 12 S., R. 5 E. It is an excellent and very convenient watering place, and as its location is easily overlooked a United States Geological Survey sign (13.9, 76.9) was placed by the roadside near it. The road passes about 150 feet south of the spring, which issues from a hillside on the north wall of Grapevine Canyon. There is a wooden trough for cattle at the spring, and a pipe 15 feet long conveys water from a seep above into the trough. The water is of good quality, and the flow is a few gallons a minute. The spring is very peculiarly situated. It occupies a marshy area several feet across on a very steep hillside of granitic and metamorphic rocks. The water issues 20 or 30 feet above the bed of the wash below, and the surrounding area is covered with mesquite and brush. The spring is probably associated with the fault that passes eastward down Grapevine Canyon. The water issues from fractures in the rocks.

**Angelina Spring.**—East of Stuart Spring the road was badly cut up by gullies and washes when it was traveled by the writer but was easily passable as far as Yaqui Well. About 2 miles east of Stuart Spring, or 5 miles west of Yaqui Well, in Grapevine Canyon, there is reported to be a seep of water in the canyon gravel. At times the water flows at the surface, and at other times it must be obtained by digging. This seep is called Angelina Spring. It is a few hundred feet from the road and was not noticed in traversing the canyon. Stuart Spring is a much more valuable watering place for travelers.

**Yaqui Well to The Narrows.**—Yaqui Well (21.4, 69.4), sometimes called Indian Well, is in Grapevine Canyon, about 21 miles from Warner. Its location is marked by a Geological Survey sign, as it is an important though not especially desirable water hole. It is the last water obtainable on the eastward trip before reaching Borrego Valley, or if the short cut on the county road is taken it is the last water for 25 or 30 miles, until San Felipe or Harper Well is reached. The well is really only a little open hole dug in clayey gravel at the foot of a low rocky spur. The pool of water is only a foot or two in diameter and in 1918 was walled up with boulders and covered with a large stone slab. The supply of water is small, apparently only a very slow seep out of clay and granitic rocks. Its quality is poor, and it appears stale. Nevertheless it is drinkable and according to report has been the salvation of a number of famished travelers. There was also a small pool of dirty
seepage on the opposite (south) side of the road in 1918. A corral and the ruins of a
board shed were noted at the place but were not conspicuous.
A mile below Yaqui Well (22.4, 63.4) the road crosses from the north to the south
side of the wash, which below this crossing is a conspicuous wide sand bed formed
by occasional floods of great volume. This crossing is at times very soft and difficult
to pass, though when compacted by recent rains it may cause no trouble at all.
Below this point the road traverses a sandy terrace above the level of the wash.
This terrace may at times be difficult of passage in places. To the south of the
crossing is a considerable opening behind which mountains rise and in which an
extensive alluvial fill is deposited.
Farther on (26.0, 64.8) the mountains approach each other closely. The road
descends into the bed of the wash, which is very sandy. Finally the valley is con­
stricted to a mere gorge (27.0, 63.8) about 300 feet wide, with walls 200 or 300 feet
high, through which a big sand wash issues onto the broad desert. This gorge is
known as The Narrows.
Relation of San Felipe Creek to Grapevine Canyon.—Just west of Yaqui Well
(21.4, 69.4) there is an enlargement of the valley occupied by the road, and it is
apparent that some canyons to the southwest are tributary at this point. It would
hardly be suspected, however, that behind the mountains, 4 miles away, is San Felipe
Valley, from which a flow of water amounting probably to 2 or 3 second-feet is dis­
charged through a narrow gorge and sinks into the valley occupied by the road. The
lower part of Grapevine Canyon, as it is commonly known, is really occupied by
San Felipe Creek, which drains out through The Narrows to the desert and continues
as a wide sand wash to the Salton Sea.
The Narrows as a dam site.—It has been suggested by local residents that
The Narrows might be a valuable location for a dam to store the flood waters
that sometimes spill through this gap onto the desert. It would undoubtedly be an
easy matter to construct a dam across the gorge, and the plan might possibly be
worthy of investigation. However, there are numerous disadvantages. The supply
of water is very erratic and uncertain. No good agricultural land is found within
several miles of this place. Topographic maps are not available; but the slope of the
wash just above The Narrows is probably less than 100 feet to the mile, so that a lake
of considerable length but rather narrow could be impounded by a dam across the
outlet. Excavation of 50 feet or more might be necessary in the bed of The Narrows
to insure a good foundation. There is also a possibility that the surrounding rocks
might leak, as they are extremely sheared and fractured. In conjunction with other
development in the region the project might possibly prove feasible.
Vegetation from Warner to The Narrows.—From Warner to The Narrows there is a
very marked change in vegetation from the flora of a moderately well-watered moun­
tain area to that of an exceedingly arid desert. On the mountains around Warner
are forests, at many places of pine trees; in the valleys are large oaks; on the open
spaces is grass. East of the divide the trees are dwarfed to shrubs and bushes, and
the mountain sides are covered with thickets of small brush. Below Grapevine
Spring mesquite and creosote appear. Between Yaqui Well and The Narrows oca­
tilla, ironwood, and creosote are the principal shrubs. East of The Narrows the
plants are typical of the Salton Basin, and the surrounding mountain sides are sur­
faces of barren rock.
Choice of roads at The Narrows.—A Geological Survey sign at the north wall of the
exit from The Narrows (27.0, 63.8) points out the two possible roads from this place.
It may be hard for the traveler to see even one road, much less two. The Borego
road, however hugs the left (north) wall of the canyon for a short distance and then
bends north, up a hill and away from the wash of San Felipe Creek. Often no trace
of the other road can be seen, but by going east, down the bed of the big sand wash,
it can later be picked up and followed eastward where it leaves the wash and goes
toward Imperial Valley by the most direct route. There had been much difficulty in traveling this road in 1917 because of sand and washouts along the way, and some serious accidents had occurred. The writer had no opportunity to travel it, but on the advice of reliable persons the note "Impassable in 1918" was placed on the signpost. Parties are known to have traveled it since that date, however, and reported no serious difficulty. The road is 10 miles shorter than that through Borego Valley, which also is in many places anything but good.

The Narrows to Borego Valley.—The road through Borego Valley turning northeast at The Narrows climbs a steep sandy hill onto a long ridge covered by arkosic sand that appears to rest on bedrock at no great depth. Continuing north it descends a slope about 4 miles in length, over alluvial gravel and sand, which is difficult to travel in the opposite direction. To the north from the long slope there is an excellent view of Borego Valley, which has an apparently smooth surface that slopes toward the south. The two slopes meet near a cabin (32.1, 58.7), on the east side of the road, which was unoccupied in 1917. The road from this point continues slightly west of north toward ranch houses in Borego Valley and is very good. In Borego Valley the road passes east of a house (33.6, 57.2) which was occupied in 1918. In the yard of this house is a flowing well, the casing of which projects above the ground and from which water can be had at a faucet. At 0.3 mile from this point there is a Geological Survey sign (33.9, 56.9). The Brawley road turns east, the other road continuing north to ranches 1 or 2 miles away at which settlers lived in 1918.

Borego Valley includes 40 or 50 square miles of nearly level land and some adjacent alluvial slopes. Because it is inaccessible and far from any supply points it has not been thickly settled, although it has good prospects for a supply of ground water. Several settlers lived at scattered ranches in the valley in 1918, but only the house mentioned (33.6, 57.2) is passed on the Brawley road. There are no stores in the valley. Water of good quality is obtainable at the ranches. The ground-water conditions in this valley are discussed on pages 96-98.

Borego Spring (36.8, 54.0) is in sec. 17 or 18, T. 11 S., R. 7 E., at the east end of Borego Valley. The spring is at the base of some low gravel-covered hills, probably of Tertiary sediment, on the north side of an arroyo leading eastward from the valley. The valley of this arroyo is about a quarter of a mile wide, and the spring is on the north side of it, whereas the drainage channel is near the south side, so that the water issues from comparatively smooth ground somewhat higher than that adjacent on the south. The location of the spring is identifiable by a Geological Survey signpost on the clay point 100 feet to the north and by a house (unoccupied in 1918) on the bank of the arroyo a quarter of a mile to the south. Near the house there are also other springs, and between the two points is an area of grass, mesquite, arrow weed, and other shallow-water vegetation indicating a large area of ground-water discharge. Several springs near the old house consist of trenches or holes dug in the moist earth and supplied with a slow seepage of water. They were originally more used than the spring now utilized by travelers, but the water of this spring is considered better. The spring is a seep of water in clayey soil and is surrounded by a patch of green trees and fenced in to protect it from cattle. A barrel is sunk in the moist spot and carefully covered. It contains clear water, which flows through a pipe to a cattle trough. The flow is small, probably not above 1 or 2 gallons a minute, but supplies a large herd of range cattle. The water is satisfactory to the taste and is considered good by local inhabitants. Analysis (No. 6, p. 282) shows a rather high mineral content, however, with especially high sulphates. The water could probably be used for irrigation.

The source of the water is doubtless the underflow of ground water from Borego Valley eastward. A considerable volume of water is dissipated in the springs and

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vegetated area of the vicinity. There is apparently a slight artesian pressure which forces the water to rise at the spring.

*Borego Spring to San Felipe and Harper Well.*—From Borego Spring the road goes east over fairly level sandy land. The water that rises near Borego sinks quickly into the sandy stream bed or evaporates, and only a very sparse growth of desert plants is seen. The road crosses a low terrace lying north of the course of the wash below Borego Spring and bordered on the north and south by miles of badlands. At 3 miles east of the spring the road descends into the bed of a wide wash formed by the junction of the Borego Valley Wash with San Felipe Creek, which comes in at this point from The Narrows. This junction of the road and the wash is a place easily overlooked in going west and has been indicated by a Geological Survey sign which assures the traveler from the east that he is on the right trail and only 3 miles from water.

The dry wash turns southeastward and spreads out over a great territory east of Borego Mountain, a low mass of granite that rises to two summits several hundred feet above the surrounding desert, in which it seems lost and out of place. This mountain serves a useful purpose, however, as a landmark for travelers from the east. Those going by Borego must pass east and north of it; those using the short cut go south of it.

The road consists of a great many scattered tracks and spreads out over a large area in the wash east of Borego Mountain. One very dimly defined and extremely difficult trail turns to the left and passes down the main bed of San Felipe Wash, past Barrel Spring. Travelers are urged to avoid this trail if possible, but as they may take it inadvertently a log is given which will probably help in finding the right road again farther on. The traveler should follow the right-hand tracks or at least take a course near the east side of Borego Mountain. The several trails finally converge into a better one near the southeast end of the mountain. It will be impossible to stay much nearer than half a mile to the mountain at its south end because of sand dunes which accumulate here at the foot of the mountain.

Near the southeast point of Borego Mountain there is a small "dry lake" or playa (46.0, 44.8) in which the scattering trails become plain and from which the road leads southeastward over low gravelly hills. At places the sand is bad, but generally the road is passable. Many washes are crossed, but there are good stretches of road between. Gradually the gravel hills, which at places are 50 to 100 feet high, disappear, and the surface becomes very flat. The soil is loose sand or silt and makes a good road when not traveled enough to cut it into ruts. The vegetation gradually changes from ocatilla and creosote to mesquite.

The Barrel Springs branch of the trail east of Borego Mountain returns to the main road at a point marked by a little wooden sign (53.8, 37.0). A mile from this point (54.7, 36.1) the Borego Valley road meets the short cut from The Narrows, sometimes known as the county road. At this fork the inscription "Impassable in 1918" appears on the Geological Survey sign pointing west along the county road.

Half a mile east of the road junction at the Geological Survey sign there is a road fork that affords for a few miles a choice of two parallel routes, between which there is not much difference in character or length. The north branch is on the line of the county road, which was graded a few years ago by Imperial County as far west as the San Diego County line to encourage the use of this as a cross-country thoroughfare. As no work was done on the west end by San Diego County the road was not greatly bettered as a whole.

The south road passes San Felipe, a deserted town site (58.7, 32.4), where there are an abandoned garage, two or three vacant houses, and a well, near the garage. Seven or eight years ago a settlement was started here, on the assumption that irrigation was practicable by pumping water from wells. Several wells have been drilled in the neighborhood. The well beside the garage was equipped with a valve-bottom
bucket in February, 1918, and yielded water of rather poor quality. The well is about 12 inches in diameter, and the water level was 27.5 feet below the ground. It constitutes a possible watering place, and the water is used for drinking by persons who chance to stay here for any length of time. But better water is obtainable about 4 miles east, at Harper Well.

East of San Felipe on the road to Harper Well are three drilled wells at intervals of 1 mile, whose casings protrude above the ground. Water is less than 20 feet deep in all of them. About a mile west of San Felipe is another old drill hole at which there is some abandoned machinery and an empty concrete reservoir. The water stands at about 25 feet. The occurrence of ground water in this region is treated on pages 91–93.

One mile east of San Felipe (59.3, 31.5, by the north road) the branch roads unite. Farther on a branch road (61.5, 29.3), little used, goes south to several deserted homes. Just east of a sharp turn in the road (62.2, 28.6) is a Geological Survey sign, and about 100 feet north of the sign is Harper Well.

Harper Well, sometimes also known as Mesquite Well from the heavy mesquite timber near it, is in sec. 26, T. 12 S., R. 10 E. It is said to be 320 feet deep and has a 6-inch casing. It was originally drilled by a man named Harper in prospecting for oil, but only a weak flow of water was obtained. The casing protrudes about 6 inches above the ground, and water is led out of it in a 1-inch pipe to a reservoir of concrete, which has been fenced in by the county to protect the place from range cattle. The water flows first into a small covered reservoir where drinking water is obtainable, then into a larger open reservoir that supplies stock water. The overflow escapes into an adjacent arroyo and is used by cattle. The flow is very small, not more than about 2 gallons a minute. The water of Harper Well (see analysis No. 23, p. 282) is slightly salt to the taste but is much the best water obtainable for several miles in any direction and locally is considered desirable for drinking.

**Harper Well to Brawley.**—East of Harper Well the road is very good and passes nothing of importance until it reaches Kane Spring (66.5, 24.3). The water of Kane Spring (see analysis No. 28, p. 282) is poor but drinkable and abundant. East of the spring there are 7 miles of concrete road, and beyond that the Imperial Valley dirt roads are generally excellent. A more extended description is given in connection with the route from Coachella to Brawley (pp. 202–206).

**JULIAN TO EL CENTRO.**

[For log see pp. 154–159.]

Tourists passing eastward through Julian usually go south on the mountain roads through Buckman Springs, reaching the San Diego highway near Campo and going east through Jacumba to El Centro. Local travel, however, is considerable over a road connecting Julian, Mason Valley, Vallecito, Carrizo, and El Centro, and persons interested in this road have often tried to get it adopted as a route for through travel, the distance between Julian and El Centro being 25 to 30 miles shorter than that of the roads to the south. The road in 1918 was impracticable for extensive travel, especially by automobile, on account of steep hills east of Banner and east of Mason Valley that were so bad as to be considered by many utterly impassable, even though local residents succeeded in getting over them. There is also some very bad sand in the valley of Carrizo Creek. Watering places are sufficiently numerous along most of the way, although stretches between them are intensely arid. No supplies are obtainable between Julian and Dixieland, a distance of about 62 miles, although in 1918 ranches were occupied at nearly all the watering places. The road can not become an important highway without extensive improvement. Because it was entirely lacking in reliable signposts, it has been adequately posted by the Geological Survey. Most of the road is on the general route of one of the earliest roads in the country, which crossed the Colorado Desert from Yuma and proceeded to the Warner...
ranch, utilizing one of the best passes known across the mountains south of San Gorgonio Pass. It was used by the Butterfield stage, established in 1858, and some of the old stage stations are still to be seen on the road.

Julian to Banner.—Julian lies at an elevation of 4,219 feet, on the divide between the Pacific slope and the desert. It is a pretty little mountain town with several stores, two or three garages, and as many hotels. Its population is probably less than 500. Julian originated as a mining town, gold having been discovered there about 1870, and has since had a varied history, the mines at times producing large amounts of gold but now being almost entirely idle. The permanent prosperity of Julian is based on the growing of fruit, chiefly apples, and stock raising. Although rather high in altitude the country is not greatly dissected, and the topography in the neighborhood is that of a granite country with low rounded hills. Good water is obtained from springs and wells in the valleys, and grassy meadows are common. The rougher mountains are forested at places with small brush and live oak, at places with good-sized pines.

Persons leaving Julian for points on this road should take supplies for their entire journey, except water, which can be had at numerous places on the road. East of Julian the road crosses a rolling country for about a mile. Then the gentle slopes become steep and rugged as the road descends toward the level of the desert on the east. It is here that the Banner grade begins. In 3 miles the road, which is cut along the south wall of Banner Canyon, has a difference of 1,200 feet in altitude. It is too narrow at most places for vehicles to pass, though usually a space wide enough is found every 300 to 500 feet. There are also innumerable turns—about 125 sharp curves were counted from top to bottom—so that only a small portion of the road is visible at one time. The roadbed has been made by cutting and filling. On the south the mountains rise steeply, whereas on the north the road overlooks a steep declivity extending down to the bottom of the canyon. All the mountain sides are densely covered with a growth of live oak, manzanita, and scruffy underbrush in a tangle that is positively impenetrable where passages have not been cut through.

Several abandoned mines are seen near the road, and many large white veins of quartz cut the schistose rocks of the mountain mass. Excellent exposures of the rocks occur at many places in the cuts of the upper roadside. At most of these exposures the rocks are schist and slate apparently altered from very sandy sedimentary rocks. Cleavage is remarkably developed, and the cleavage planes dip at steep angles, usually northeast. The schists are cut here and there by quartz or granite intrusions, and masses of a coarse pegmatite granite containing garnets, black tourmaline, and mica are exposed at places.

At the bottom of the hill (4.4, 70.6) the road crosses a little stream of clear water that flows north, the road also turning north to Banner (4.8, 70.2), in sec. 5, T. 13 S., R. 4 E. Banner, like Julian, owes its first settlement to mining activities, but, unlike Julian, it is almost wholly dependent on them for support. Accordingly, in 1918 its population consisted of only one family, which occupied a little ranch and maintained a sort of hotel for transients. There were two or three other families and a few prospectors living in the mountains not far away. The place has a school building which is said to have accommodated 40 children a few years ago but was closed in 1918. Gasoline and oil are sometimes kept by the hotel people for the accommodation of motorists. Good water is plentiful either at the house or in the creeks near by.

Choice of roads at Banner.—Two roads are used between Banner and Mason Valley. One of these goes through the San Felipe ranch, which is on the headwaters of San Felipe Creek. It is easily passable except for a short stretch through a canyon near Mason Valley, which is sandy and rocky. The other road makes a short cut over the mountains and descends Rodriguez Canyon into Mason Valley, lessening the distance by 7 miles. In climbing the mountain divide there are some very steep grades which may not be passable. In 1917 the hills on the short road were impassable for auto-
mobiles going east but easy enough for the return trip. On the other hand, the canyon on the San Felipe route was so sandy as to be impassable going west but easy of descent going east. Accordingly persons going to Mason Valley and back made a circuit, going from Banner by way of San Felipe and returning through Rodriguez Canyon. Early in 1918 the short road through Rodriguez Canyon was improved so that it was pronounced passable in either direction; under those conditions it is the more desirable road.

San Felipe Valley branch.—The two roads mentioned fork just east of Banner (5.0, 70.0), and the road through San Felipe Valley goes northeast (left) down a narrow canyon along Banner Creek. The canyon here is 200 or 300 feet wide, has rocky walls of gneiss and schist that rise steeply to mountain peaks several hundred feet high, and is occupied by Banner Creek, which runs perennially as a turbulent stream of clear good water that measured about 1 second-foot in February, 1918. The canyon is forested with tall sycamores, liveoaks, and cottonwoods, the last large trees along the road. It opens into San Felipe Valley about a mile from Banner, and the creek water sinks quickly, leaving a dry gravelly stream bed.

The road goes through a gate (6.0) at the boundary of the San Felipe ranch and passes east over level land at the south side of the valley. A branch road (6.5) turns to the left and goes north to the ranch house, about 2 miles away. It also continues north to Warner. Two miles from this point the road passes over a low granite ridge that projects northward into the valley, dividing it into two parts. The ridge rises about 200 feet above the valley and extends from the southern mountains northward for about 2 miles, leaving a low pass to the north between it and mountains that inclose San Felipe Valley on that side. The road descends a steep but passable canyon east of this rocky spur and reaches the level valley again to the southeast. The road traverses its length and is very good.

A branch road (10.1) that comes from the northwest is a short cut through from Warner to Mason Valley. Beyond this the road passes through another gate (10.7) out of the San Felipe ranch. That part of the valley between the granite ridge and this gate is mostly covered with mesquite trees, which at places reach a height of 15 or 20 feet. There is also excellent grass. Parallel to the road and only a little distance north of it is a perennial stream of water considerably larger than Banner Creek, which flows through the valley and passes out through a gorge about 1 mile north of the gate at the exit of the ranch. In portions of the valley near the entrance to this gorge water often stands on the ground, and there is a mud flat covering probably a quarter section of land. The ground water of San Felipe Valley is treated on pages 91–93.

The San Felipe ranch is a large block of land under individual ownership which includes nearly all the desirable part of San Felipe Valley. Its history dates back to some early concession by the Mexican Government. Its owners maintain a large ranch house and buildings near the center of their holdings and engage in stock raising. A little farming is done by irrigating from a small earthen reservoir in the north end of the valley and by water from wells near the ranch house, but no important effort at development in this direction has been made.

The Windmill to Blair Valley.—Half a mile beyond the gate of the San Felipe ranch in sec. 34, T. 12 S., R. 5 E., is a well generally known only as The Windmill. The well is equipped with a windmill that delivers water to a large elevated tank, from which it runs into a trough for stock and which is provided with a faucet for drinking water. The well is a dug well 18 feet deep and 4 feet square, and the water level measured 10 feet below the surface. It penetrates sand and gravel of the valley fill and taps an extensive body of ground water under the valley floor. The quality of water is very poor, as indicated by the analysis (No. 53, p. 283), and its taste is distinctly alkaline. The alkali sulphates and chlorides are both high, as well as organic matter. The mineral concentration is probably due to the proximity of
the well to the playa in which ground water rises to flow out of the valley through a
narrow rock gorge called San Felipe Canyon. In general, the water of San Felipe
Valley is of good quality.

A mile southeast along the road is the Bushore homestead (12.1), where a well
that was just being dug in January, 1918, had reached water of reported good quality
at 60 feet. This is probably now a watering place. The road continues southeast­
ward over a plain, at some places grassy, at others covered with creosote bush and
cacti. There is a small playa, or "dry lake," in the southeast end of the valley.
At the exit from San Felipe Valley the road climbs a low granite ridge (16.1) about
100 feet high, which connects the high mountains that shut in the valley on either
side, and passes over into another little level plain known as Blair Valley, a little
basin 1 to 2 miles in diameter shut in all around by low mountains. At the entrance
to this basin, in its north end, is a small playa which is crossed by the road. The
course of the road is southwestward near the border of the valley over an excellent
roadbed of granitic sand. Blair Valley contains no water, so far as known, either in
springs or in wells, and the indications are not particularly favorable for finding any.
It is covered with various kinds of desert brush, none of which indicate water, and
it evidently receives little rain. Hemmed in by mountains on every side and with
no sign of either permanent or transient occupation except the dim road, it seems one
of the world's far-away places.

Box Canyon.—A portion of the southwest end of Blair Valley drains southwest­
ward through the mountains by a small wash (18.6) that plunges suddenly down a
steep descent into a narrow canyon, whose bottom is in many places scarcely wide
enough to afford comfortable passage for a vehicle and whose sides rise precipitously
from 50 to 200 feet and then gradually ascend to the height of small mountains.
The road picks its way over rocks, between boulders, and through deep sand that is too
much for most automobiles to pass in the reverse direction. The rocky canyon walls
are of gneiss with a banding twisted and contorted into almost every conceivable
shape. Veins of diorite or quartz are common but not of great size. Locally the
gorge is known as Box Canyon, although this is a term frequently applied in the
region to any deep canyon with nearly vertical walls.

Box Canyon opens into Mason Valley (20.0), and the road descends a rather steep
alluvial slope to the point where it is joined by the Rodriguez Canyon branch, at a
fork marked by a Geological Survey signpost (20.8, 51.2).

Rodriguez Canyon branch.—Little need be said of the short cut to Mason Valley
branching off to the right (5.0, 70.0) near Banner. It climbs some very steep hills
in the first 2 miles and in February, 1918, had lately been rebuilt in portions, so as
to reduce grades, leaving parts of the old road abandoned. Between 7 and 8 miles
from Julian the road traverses the north side of the mountain crest, affording to the
north an excellent view of San Felipe Valley. A mining cabin (7.2) on the north
side of the road was occupied in 1918 by a prospector, and opposite it, on the south,
was an excellent spring of water. Passing over the summit of the divide (8.3, 66.7),
the road descends a long gentle grade on a rather open upland, which finally narrows
to a steep-sided rocky canyon. Here at many places the road has been cut in the
canyon sides. The mountain rocks are banded gneiss and sandy schist with some
diorite and granite. There is no water in the canyon. The canyon opens into Mason
Valley (13.0, 62.0) and reaches the San Felipe road marked by a Geological Survey
signpost (13.8, 61.2).

Mason Valley.—Mason Valley is a depression about 5 miles in length and 2 to 3
miles in maximum width, almost completely inclosed by ranges that rise above it,
' on the south, to an altitude of 6,000 feet above sea level, whereas the altitude of the
valley is probably only about 2,000 feet. On the east a long ridge of granite directly
transverse to the valley incloses it completely except for a narrow canyon through
which the drainage of Mason Valley escapes into Vallecito Valley.
DETAILED DESCRIPTIONS.

The summits of the high mountains to the south are clad with pine forests, but Mason Valley supports a more desert-like flora of creosote bush, mesquite, and grass. The soil in the center of the valley is suitable for agriculture if supplied with water. The land has been taken up by settlers, several of whom were proving up on their claims and lived in the valley in 1918. They were clearing portions of the land and hoped to irrigate with well water. The valley receives its name from one of its first settlers, who for several years maintained a ranch here. The water supply of Mason Valley is discussed on pages 93-94.

From the Geological Survey sign at the upper end of the valley the road leads almost through the middle of the valley, passing a ranch house (14.1, 60.9), at which in 1918 water could be obtained, and continuing past other ranches not far away, at which wells were being completed. It ascends the low granite ridge (17.0, 58.0) separating Mason Valley from Vallecito Valley, which lies at a lower altitude than Mason Valley. Consequently, the slope leading up to the summit from Mason Valley is neither as long nor as steep as the descent into Vallecito Valley. The ascent of this slope in going west is very difficult. It would be possible at considerable expense to construct a road through the canyon at the lower end of Mason Valley and around this spur, but the present need for such an undertaking is hardly sufficient to justify it.

Campbell ranch.—The Campbell ranch is in the west end of Vallecito Valley, in sec. 7, T. 14 S., R. 6 E. It is about a mile southwest of the direct road through Vallecito and Mason valleys, and two branch roads, noted on the log, turn aside to it. The owners have a dam across a canyon between Mason and Vallecito valleys and divert water through a pipe line for the irrigation of a small area. Water for domestic use is obtained at a spring west of the ranch house. The spring has been developed by digging an open trench in residual granitic soil at a point on the side of the granite ridge that separates Mason and Vallecito valleys. The water flows in a 2-inch pipe line to the house. Its quality is apparently satisfactory. The only adequate explanation for a seep of water on the side of so narrow and barren a ridge is that the supply is probably ground water percolating through fractures from Mason Valley, which lies at a higher altitude on the west. The place is seldom frequented by chance travelers, because good water is obtainable not far away in either direction along the road.

Vallecito Valley.—The road in Vallecito Valley is fairly good, and the road log needs little amplification. One or two bad dry washes are crossed. Vallecito Valley is a mountain-walled depression very much like Mason Valley but larger and less perfectly shut in on the east, where it is connected with the border valley of Carrizo Creek by a waste-filled valley 1 or 2 miles wide lying between a mountain point jutting out from the Laguna Mountains, on the south, and a short, steep alluvial fan, built out from the north. The Laguna Mountains on the south and the Vallecito Mountains on the north rise high above Vallecito Valley.

Vallecito is a noted watering place at the east end of Vallecito Valley, in sec. 10, T. 14 S., R. 6 E. Its location can be identified by a large swamp, a ruined stage station, a water trough, and a Geological Survey sign. Innumerable springs exude from the swampy soil over an area of many acres, perhaps a square mile, and give birth to considerable streams of water that soon disappear eastward. The spring that feeds the trough is rather high on the north side of the valley. The water is high in mineral matter, especially sulphates, but is a fair drinking water and locally is considered good. (See analysis No. 49, p. 283.) The source of the water is in the high mountains, especially south of Vallecito Valley, and the water rises under artesian pressure at a constriction in the east end of the valley. The water supply of the valley is described on pages 94-95.

The road east of Vallecito follows a very sandy wash which at many places is difficult to travel. Gradually the road swerves southeastward and then bends due
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south (25.0, 50.0) around a small round mountain and climbs upon a low firm gravel terrace on the south side of the wash. A little farther on the road turns east (25.2, 49.8), but a branch road continuing south goes to the Agua Caliente Springs, which can be distinguished by a large patch of mesquite and other vegetation in a sort of amphitheater in the mountains about three-quarters of a mile to the south. The main road turns east and passes a watering trough (25.3, 49.7) beside which is a Geological Survey signpost giving directions on the main road and pointing south to Agua Caliente Springs.

Agua Caliente Springs.—Agua Caliente Springs are at the northeast corner of the Laguna Mountains, probably in secs. 18 and 19, T. 14 S., R. 7 E. The springs are about three-quarters of a mile off the main road but are easily reached by a branch road. A pipe line leads from one spring to a trough by the roadside but was out of repair and carried no water in 1918. Most of the springs are under private ownership and are fenced in, but the traveler may water there by duly respecting property rights. There is a cabin on the hillside near one spring, and a pipe conveys water almost to the door.

The accompanying sketch map (Fig. 15) shows the general geography of the locality. There are at least six of the large springs, all of which flow out of residual or detrital granitic soil at the base of granite mountains. Some of them originate near the mouths of small canyons or ravines, but none of these dry runs are large or afford more than a few hundred feet of drainage length. Other springs show no relation to drainage. Springs Nos. 2 and 3, near the house, have been dug out and developed slightly by trenching. The rest exhibit mere seepage surfaces; and around Nos. 4, 5, and 6 are extensive hillside marshes of soft ground covered with grass and rushes. None of the springs has a flow of more than a few gallons a minute, but No. 5 could be developed to yield considerably more. The water forms small streams, which disappear rather quickly in the gravelly soil. A considerable supply of shallow ground water is given to the little central valley below the springs, however, as is attested by a very rank growth of mesquite and grass over an area of

![Sketch map of Agua Caliente Springs, San Diego County, Calif.](image-url)

**Figure 15.** Sketch map of Agua Caliente Springs, San Diego County, Calif.
perhaps 40 acres. The quality of the water is apparently good, but some of the springs have a noticeably sulphurous odor, and No. 3 yields water having a temperature of about 90°.

The mountain rocks are granite but are very white and evidently greatly altered, probably by hydrothermal processes. Large areas of rock are greatly kaolinized. A small projection of rock from the center of the valley below the house is about 25 feet high and is soft white material, originally granite but now so soft that it crumbles in the hands. Farther back on the mountain slopes the rocks are greatly brecciated but more solid and in places slickensided. It is believed that the Agua Caliente Springs issue along a prominent fault zone at the east face of the Laguna Mountains and that their activity has had much to do with the alteration of the adjacent rocks. There is a marked similarity between such alteration here and at the mouth of Canebrake Canyon, a few miles to the southeast.

Agua Caliente to Carrizo Creek.—East of Agua Caliente there is a long valley that extends southeastward to Carrizo Creek and is occupied by a wide sand wash that represents the continuation of the Vallecito drainage. On the west side, near the base of the Laguna Mountains, the land is gravelly outwash and is covered by a growth of creosote, cactus, Spanish yucca, and ocotilla. To the east, at the base of the Vallecito Mountains, is a belt of folded alluvial strata carved into badlands. The lower part of Vallecito Creek passes through the badlands into Carrizo Creek.

At places southeast of Agua Caliente the road follows a wash and is rather sandy; at other places it takes a course by the side of the wash on firmer ground. At 3 miles down (28.3, 46.7) there is a separation of roads, one set of dim trails continuing southeastward down the wide sandy wash, passing near Palm Spring (see p. 276), and rejoining the other near Carrizo. The branch trail is rather bad and so dim as to be difficult to follow, though the traveler can hardly go astray by following the dry wash. The main road climbs out of the wash and passes southeastward near the foot of the Laguna Mountains over a gravelly plain. The traveler should follow this road if he can find it at the point where it leaves Vallecito Creek. Along this road a branch road turns west (30.9, 44.1) and leads past a deserted cabin to Canebrake Canyon.

The Canebrakes.—The Canebrakes is the local name for a small mountain stream on the east slope of the Laguna Mountains. The stream flows through the north end of T. 15 S., R. 7 E., and disappears at the desert border, probably in sec. 3. At that place it is about 1½ miles off the Julian-El Centro road. On the fairly level land between the canyon and the road is a homesteader's cabin, unoccupied in 1917, and evidence of an attempt to clear and cultivate a small plot of land. The remains of a stone-lined aqueduct are seen along the canyon for a considerable distance, and apparently the water of the creek was diverted for irrigation some years ago. On large boulders along the canyon are painted signs, some of which point westward to "Mason ranch." A wagon trail in nearly impassable condition leads up the canyon an unknown distance.

The flow of water in this canyon is variable, being greatest where it passes over rock bottom and probably less than 1 second-foot everywhere. Dense tangles of grass, arrow weed, mesquite, and cane grow along the narrow canyon bottom, and from the abundance of the cane it takes its name. Range cattle in considerable number are pastured on the grass here and farther up the stream, which probably drains a more open country at high altitudes in the Laguna Mountains.

The mountain walls at the entrance to Canebrake Canyon consist of sheared granite, very much whitened, kaolinized, and altered, and suggest the presence of a fault line along the mountain front. Half a mile upstream the rocks become much more dense and unweathered.

Descending over an excellent roadbed for about 3 miles from the branch road to Canebrake Canyon the road enters a wide flat covered with mesquite and at places
with grass and turns nearly straight east, continuing in that general direction to Carrizo. Near this point (34.2, 40.8) the surrounding county is made up of clay hills formed of Tertiary sandstone and clay, deeply and weirdly eroded into badlands, such as are found at many places about the Salton Basin. The road from this turn follows the main valley of Carrizo Creek, which flows northward from Jacumba Springs and here turns east.

Mountain Palm Spring.—Upon entering Carrizo Valley by the road just described (34.0, 41.0) the traveler can see in a large canyon 2 or 3 miles to the southwest a conspicuous bunch of green palm trees, which are at a place called Mountain Palm Spring. This may be reached or very nearly reached by wagon or automobile from the main road, but no well-defined trails were noted leading that way. The spring was not visited, but there is said to be a supply of good water there.

For the total length of its course down Carrizo Creek, a distance of about 12 miles, the road threads a valley half a mile to 1 mile wide cut through the badland hills (Pls. VII and VIII) and bounded by walls 50 feet or more in height. Locally the stream has cut a channel about 10 feet deep below the general level of the flood plain, which appears as a bare sand wash flanked by low terraces. The road at some places occupies the wash and at other places is on the terraces, which are commonly on the north side. Some of it is sandy, and there is a stretch of particularly bad road about 1 mile west of Carrizo (38-39, 36-37), where it may be necessary to deflate the tires of the automobile.

A Geological Survey sign (37.7, 37.3) on the north side of the road where vehicle tracks lead up Vallecito Wash by way of Palm Spring advises travelers to continue west on the better road.

Carrizo.—Carrizo (39.2, 35.8) is also known as Carrizo Station, from the stop on the old overland stage route from Yuma to Los Angeles. Carrizo Creek has for a long time flowed for a short distance at this place, but formerly the water rose at a point nearly 1 mile below the present watering place, and that was the location of the original station. In recent years the flow of water in the creek shows a tendency to rise farther and farther upstream, although it still flows past the original station, below which it soon sinks. The stream has a variable flow amounting to 1 or 2 second-feet. Its water is drinkable but salty, and there is a marked alkali deposit along its course. The present stream rises through sand and gravel and flows in a very recently cut gully about 10 feet deep for a distance of 1 mile. Carrizo Creek for several miles flows in a valley half a mile to 1 mile wide cut in badland exposures of soft Tertiary sediments whose bluffs rise 50 to 100 feet above the lower plain. A ridge, apparently of clayey material, at Carrizo cuts the lower valley transversely from the north and is crosscut by the stream at a narrow passage. This ridge isolates a level area of about a square mile lying west of it in which ground water is evidently shallow, as indicated by a good growth of grass. It appears that the ridge probably consists of impervious material which has caused the creek to rise to the surface. Gradually retreat of this flow of water upstream has caused the cutting away of a new channel lower than the surrounding valley.

The most convenient watering place for travelers is now a well near a house close to the upper limit of stream flow. The well and house are on opposite sides of the road, and a Geological Survey sign is erected at the place. The house was occupied in 1918. The well is on the brink of the recently cut arroyo beside the flowing stream and is equipped with a hand pump. It has the peculiar distinction of being both a flowing and a pumping well. A horizontal pipe has been inserted in the casing a few feet below the surface and conducts a small stream of water into the creek through the side of the bank. The flow is 1 or 2 gallons a minute. The well was drilled in 1914 by the Imperial Investment Co., an organization planning to develop water for irrigation. It is reported as 360 feet deep, is 12 inches in diameter, and at present has a water level 6 feet below the surface of the ground, the elevation of its side out-
DETAILED DESCRIPTIONS.

Carrizo to El Centro.—For 6 miles below Carrizo the road follows the creek eastward either over sandy mesquite-covered hummocks or down the sandy, flat bed of the wash that represents Carrizo Creek, between high yellow hills of soft and tilted sedimentary rocks (Pls. VII and VIII). Near the creek there is a considerable growth of mesquite, but the hills are utterly barren of vegetation. Finally the channel of Carrizo Creek turns sharply northeastward and the road ascends a steep sandy slope and turns southeastward, toward Imperial Valley. Beyond this the road crosses a rolling country of clay hills capped with gravel and at many places strewn with fossil shells, particularly of small sizes visible only on close inspection. Great quantities of boulders and pebbles of a blue marble derived from Carrizo Mountain are present at places. Gradually the hills grow less conspicuous, and the country becomes a smooth and barren desert plain.

At a point where the road forks (50.0, 25.0) there is a Geological Survey signpost. The left-hand branch goes nearly due east into Imperial, and the right-hand branch goes southeastward to a junction with the San Diego-El Centro highway. The road to Imperial is described below.

The El Centro road leads over a comparatively level plain, broken only by a few sandy mounds for several miles. It forks again (57.2, 17.8), but both branches go in a general southeasterly direction. The right-hand road is the better and goes nearly south, joining the boulevard that leads into El Centro from San Diego (58.2, 16.8) at a point marked by a Geological Survey signpost. The other road joins the highway about 2 miles farther east but before reaching it crosses some deep sand at the line of the old beach of the ancient Lake Cahuilla. Because of the sand this road is not recommended.

An excellent concrete road leads the rest of the way into El Centro. Imperial Valley is reached at Dixieland (61.5, 13.5), a little town at which supplies can be purchased. Farther on the road passes Seeley (66.6, 8.4), an important town. This road is more fully described in connection with the Jacumba-El Centro route (pp. 213-216).

CARRIZO TO IMPERIAL.

[For log see pp. 199-201.]

The road between Carrizo and Imperial as a whole is an excellent desert road except for a mile of bad sand where it crosses the old beach line. It is, however, generally passable for automobiles. Persons going east who do not care to reach El Centro will find it 2½ miles nearer from the road fork east of Carrizo into Imperial than into El Centro, but they will of course miss the advantage of the San Diego-El Centro boulevard for the last part of the journey.

From the road fork at the Geological Survey signpost (10.8, 22.5), 50 miles from Julian, the road to Imperial leads east over a very flat expanse of extremely barren desert. The broad plain is wind swept, so that all the fine sand is carried away and a residuum of pebbles about the size of peas remains to cover the ground. The road is excellent.

The old beach (19.0-20.0, 13.3-14.3) is very sandy, and automobiles may have trouble and need to have tires deflated to cross it. The sand appears to have been shifted greatly by the wind and has collected in mounds about clumps of mesquite over a large area.

East of the old beach is some very level land with the characteristic silty soil of Imperial Valley. In 1918 this was being made ready for irrigation. Houses were visible at several places off the road. Goodrich signs appear at many places on this road and all the way into Imperial.
The road crosses the West Main canal of the Imperial Valley system (23.8, 9.5) and beyond passes through country that is at most places settled and developed. There is some waste land along New River (26.8, 6.5), most of which was ruined by the floods of 1905-1907. East of this stream, however, there is some highly developed and very valuable agricultural land. Numerous branch roads turn off into the surrounding country, but the road is adequately signposted by private organizations. It is a dirt road of the usual Imperial Valley type and is excellent.

MECCA TO EHBENEBEBG.

[For log see pp. 161-166.]

The road from Mecca to Ehrenberg forms the last division, in California, of the shortest of the possible routes from Los Angeles to Phoenix, the distance being approximately 67 miles less than that by the shortest of the routes through the Imperial Valley. It should be remembered in traveling this road that the ferry is the only means of crossing the Colorado at Ehrenberg and that it is not operated during the high stage of the river in summer, a period of about three months, usually lasting from May 15 until the early part of August. In case the ferry is not available it is necessary to go from Blythe either to Yuma or to Parker, the distance being thus considerably increased.

This road is the main road between Coachella Valley and Palo Verde Valley and affords the only good way of reaching Chuckwalla Valley and adjacent mountain regions from either the west or the east.

Various disadvantages offset to some extent the directness of this road as a through route. It passes for long distances through deep sand, where progress is slow and accidents are possible, and it traverses one of the longest stretches of uninhabited and arid country found on the main routes of travel. There is no permanent habitation between Mecca and Patterson Well, a distance of 86 miles, and no supply station between Mecca and Blythe, a distance of 94.5 miles. There is one stretch of 40 miles without water, and sometimes pumps at the wells relied upon are out of order. Hence there is a stretch of 75 miles—between Shaver Well and the Patterson ranch—without reliable water supply. Grass and feed for stock are not obtainable between Mecca and Blythe, but firewood for campers is plentiful nearly everywhere. As a whole, the road is not much used for freightting, either by wagon or truck, but is considerably traveled by tourists and by light vehicles. Anyone traveling the road should take sufficient food and water to furnish subsistence while walking for help in case of accident, as serious misfortunes have occurred frequently on this road from lack of such forethought.

Signposts of the Automobile Club of Southern California are numerous, and several have been erected by the United States Geological Survey on the road, so that there is not much chance of getting off the main road.

Mecca to Shaver Canyon.—From the public water fountain (0.0, 94.5) just opposite the station at Mecca the road goes straight east for about 4 miles. This portion was at one time oiled, but most of the beneficial effects have been obliterated by wear and the drifting of sand. It is, however, usually passable without difficulty. Mecca is 155 feet below sea level, but the land rises imperceptibly toward the east, gradually taking on a visible slope near the borders of Coachella Valley. Some cultivated land irrigated from artesian wells is passed in the first mile, but beyond this stretch the desert is unbroken. A branch road turning south, marked by a Geological Survey sign (0.9, 93.6), serves several ranches along the railroad to the southeast and leads to Dos Palmas, from which poor roads lead to Chuckwalla Well (p. 249), Niland (p. 251) and other places. Half a mile south on this road is a dark grove, the Government experimental date farm at Mecca. (See pp. 200-201.)

The road passes under a large transmission line (3.9, 90.6) which distributes power to points in Coachella Valley and Imperial Valley. The power is generated in Bishop
Creek, in Owens Valley, about 300 miles to the northwest, and this extension reaching across the border into Mexico constitutes a part of what is probably one of the longest transmission systems in the world. There is a road along the power line used mainly by company employees but occasionally by the public also as a route to Dos Palmas. (See p. 246.) The company discourages its use as a public road as much as possible, and it is neither good nor much traveled.

From the power line the road ascends 2 miles of rather steep gravelly slopes at the base of the Mecca Hills, which limit Coachella Valley on the northeast. From this portion of the road there is an extensive view of the Salton Basin. To the south in the bottom of this basin is the Salton Sea, a placid lake 25 or 30 miles in length, and over it on a clear day may be seen the peak of Signal Mountain, beyond the Mexican boundary, rising like a smoky cloud, 70 miles away. The smooth floor of the valley is interrupted suddenly by the Mecca Hills (see p. 55), and at this point (6.0, 88.5) the road enters Shaver Canyon, which it follows for the next 7 miles.

The road through Shaver Canyon usually consists only of two wheel tracks winding about in the gravelly bottom of the canyon. The canyon is about 200 feet wide, with vertical walls 50 to 100 feet high (Pl. IX, A; Pl. XVII, A and B) carved in intricately folded and distorted strata of clay, sandstone, and conglomerate. The ascent is continuous and rather steep, and the road at places is sandy, but there is seldom any difficulty in traveling by automobile.

The Mecca Hills along Shaver Canyon are composed of very soft sedimentary rocks and have been eroded at most places into badlands. (See p. 26.) They are almost utterly devoid of vegetation and present steep bare surfaces. The hills have a prevailing yellow color, but this is varied in some places by streaks of red and white due to the varying composition of the sedimentary beds.

Shaver Well, in T. 6 S., R. 10 E., probably in sec. 26 (12.1, 82.4), is in the upper end of Shaver Canyon half a mile from the point where the road makes its exit from the canyon to an upland plain. It is a very important watering place on the Mecca-Blythe and Mecca-Dale roads. The well is dug in gravel near the middle of the wash, which is perhaps 150 feet wide at this point. It is square, 4 by 4 feet, lined with 2-inch boards, nicely curbed with the same material, and is provided with an iron pump (Pl. XVIII, A). In October, 1917, the depth of the well below the surface was 23.4 feet and the depth to the water level in the well was 21 feet. The water tastes faintly salty but is good for drinking. (See analysis No. 46, p. 283.)

At Shaver Well a mass of schist cuts across the canyon and forms the walls and bedrock for a distance of about 500 feet. It is covered on the sides by strata of conglomerate and gravel, which were evidently deposited upon the surface of the schist. The schist is a hard rock and presumably forms a bedrock floor at no great depth below the superficial gravel in the canyon. As it is impervious it acts as a submerged dam to drainage coming down the channel, causing it to rise and approach the surface. (See structure section, Fig. 4.) The effectiveness of this barrier is evident not only from the shallow depth of the well but also from the character of vegetation throughout the extent of outcrop of the schist. Palo verde trees, which make a rank growth near the well, become very uncommon not far below, and mesquite, generally regarded as the best indicator of water on the desert (see p. 114), which also thrives near the well, becomes more stunted a short distance below and disappears completely at the point where the schist drops beneath the beds of conglomerate and sandstone.

The ultimate amount of water that could be developed here is probably not large, because the drainage basin above is small and the rainfall very meager, but a satis-
factory continuous supply for domestic use or mining operations could probably be obtained by deepening the well or making a number of wells in the canyon.

Shaver Well affords the last convenient water for 40 miles, possibly for 75 miles, for travelers going east, who should therefore not fail to take a sufficient quantity to last until more can be obtained.

Shaver Well to the Hayfields.—On the flat just above Shaver Well a branch road (12.6, 81.9) leaves the main road and goes northeast to Cottonwood Spring and Dale (p. 264). It is marked by an Auto Club sign.

From the road fork the main highway runs slightly north of east, ascending a long slope in an intermontane valley 3 to 5 miles wide bounded on the north by the Cottonwood and Eagle mountains, on the south by the Orocopia Mountains, and on the west by the Mecca Hills, which its drainage crosses through Shaver Canyon. This is an ordinary desert valley filled with sand, gravel, and boulders washed out from the neighboring mountains. It probably occupies a structural trough between the Orocopia and Cottonwood mountains. The straight and rather high front of the Cottonwood and Eagle mountains is probably an eroded fault scarp, those ranges forming an uplifted block to the north of the fault. The valley probably occupies the site of an older similar valley in which were laid down sediments such as are now seen in the Mecca Hills, and these sediments are now at considerable depths in the bottom of this trough, concealed by recent débris. The valley is high and dry and forms an excellent roadbed. The vegetation consists chiefly of ocatilla (Pl. VI, B), creosote bush, and a few varieties of cactus. There are no indications of ground water in this valley, and it is probable that the small supply finds its way out through the gravel of Shaver Canyon.

To the north of the valley traversed by the road are the Cottonwood Mountains, which are practically continuous with the Eagle Mountains, farther east. These two ranges are made up chiefly of granite with small bodies of schist and gneiss and, in the Eagle Mountains, some dolomitic marble and large deposits of iron ore. Brief descriptions of the ranges have been given by Harder. 15 They rise abruptly to a height of a few hundred feet above the extensive alluvial fans that have been built up at their bases. They are deeply furrowed on the southern front, which is clearly seen from the road, but are not so much dissected farther in their interior. Some rather sharp and prominent peaks appear in the Cottonwood Range, but the Eagle Mountains show few prominent peaks in their interior and form a range of rather uniform height and moderately mountainous dissection. They rise to a maximum height of about 4,000 feet.

On the south, rising to one large black rounded summit that is conspicuous all the way from Mecca, are the Orocopia Mountains. These contain large amounts of extrusive trachyte and andesite, probably of Tertiary age, and also a great deal of schist and gneiss. On the west they are flanked by the Mecca Hills and on the east and south by sedimentary strata probably of the same age. Their northern front as seen from the road is very irregular and broken by great embayments in which large alluvial fans have been built up and above which at most places except the summit noted the rock masses do not rise to great height. This is part of the evidence from which the writer infers that they may be a fault block tilted down on the north at the base of the Cottonwood and Eagle mountains.

The road reaches a gentle divide and crosses to the north edge of the valley (30.0, 64.5), traversing hard sand near the base of Eagle Mountains. About a mile south of the road are two small playas, or "dry lakes," which occupy the bottom of a considerable shallow basin that is relatively high—probably 1,500 feet above sea level—and has no outlet. This locality is commonly called the Hayfields, because at exceptional times of heavy rains after water has flooded the playas and disappeared grass

DETAILED DESCRIPTIONS.

springs up on the usually barren flats and considerable crops of hay are harvested. At the Geological Survey sign (34.3, 60.2) a pipe line crosses the road and runs southwest into the eastern playa. It carries water from a small spring in the Eagle Mountains to a trough under a large palo verde tree about a mile from the road. The old road used before the present one was laid out crossed this pipe line half a mile southwest of the present crossing, and a faucet by the roadside was provided to furnish travelers with water. In 1918 water was still obtainable either at this faucet or at the cattle trough, but the supply was seldom used by travelers because of its distance from the road.

The spring that feeds the pipe line is in a mountain canyon and is inaccessible except on foot. Moreover, the water seeps from a body of sand collected in a little artificial reservoir and is generally not exposed at the surface. Analysis (see No. 24, p. 282) indicates a fair drinking water, slightly hard.

Several old roads and dim trails run south from the Hayfields to Mill Camp, a desert mining camp, and to the Chuckwalla Well road. (See p. 249.) They are probably passable but are little used and were not traversed.

Roads east of Hayfields.—East of the Hayfields the main road, which is still good passes into the west end of Chuckwalla Valley. There is a road fork here (38.9, 55.6) which offers a choice of routes for some distance. The left-hand branch is an old road that is still much used and passes Gruendike Well, where water is usually obtainable. The right-hand road is 1\(\frac{1}{2}\) miles shorter but does not pass the well. The two roads unite 13 miles away. Both are rather sandy and bad at places. A brief description of each is given.

From the fork the north (left) road passes northeast and then east. A branch road at the turn (41.3, 53.2) continues northeastward to Boulder Well and certain mining properties in the northeast end of the Eagle Mountains.

The Gruendike Well (49.8, 44.7) is in the NW. \(\frac{1}{4}\) sec. 15, T. 5 S., R. 16 E., and is about 200 feet north of the road at the Gruendike ranch, which in 1918 consisted of an unpainted, unoccupied frame house surrounded by an acre or two of fenced land partly planted to date palms and pepper trees that were badly in need of water. A windmill supplied water from a dug well to cattle ranging in the desert. Elevated on posts about 15 feet high beside the windmill was a large iron tank, and from it water was piped to a trough for stock and to a faucet on a pipe standing about 3 feet high just north of the house. Water was obtainable at the faucet for drinking provided there was any in the tank. It could also be had by bucket, but 80 feet of rope was necessary, and none was provided.

The well was curbed in good condition, and its shaft, 6 by 9 feet in size, was cribbed with boards. The depth of the well below the surface of the ground was 76.4 feet, and water was 2 feet deep. The water tastes of alkali but is drinkable. Analysis (No. 22, p. 282) shows a very high mineral content, particularly of sulphates. It is doubtful if this water would do for irrigation. No great supply would be available unless the well were deepened, as the windmill is said to pump it nearly dry when running freely.

On the south road (41.3, 51.9) a Geological Survey sign indicates a little-used branch road going south to Granite Mine Well, which is near the Granite mine, in the north edge of the Chuckwalla Mountains, and is 2.3 miles away. Water could be had there if needed. The road is rough but can be traversed by automobile nearly to the well, around which there are several buildings. The road to Blythe continues east and is rather rough, owing to the numerous gullies that cross it, and also sandy at places. Another Geological Survey sign is passed (48.9, 44.3) and points north on a dim trail to Gruendike Well. This trail is very good for a little distance but extremely bad beyond. Sometimes persons who unwittingly take the south road and
find it does not pass the well cut across here for water, but the road is not recom-
mended for automobilists.

Chuckwalla Valley.—In the next 25 miles the road leads through the heart of a
wide sandy, desolate desert known as Chuckwalla Valley. This includes two in-
closed basins centering around Palen Dry Lake, which is visible 5 or 6 miles
to the northeast from Gruendike Well, and Ford Dry Lake, 18 miles to the
southeast. Between these two depressions there is only a low alluvial divide, and
the difference in their altitude is not great. The two playas occupy the lowest parts
of the valley and are the ultimate destinations of the storm waters in their respective
drainage basins. For several miles from these playas the desert floor is flat and very
sandy, at places covered with sand dunes of considerable size. To the eye this
portion appears level, but in reality it slopes gradually upward from the playas, and
at the edges of the valley adjacent to the mountains there are steep alluvial fans.

Bordering the valley are several mountain ranges which almost inclose it. Be-
tween the ranges there are high alluvial passes lying 1,500 to 2,000 feet above sea
level. In the vicinity of Gruendike Well these ranges include the Eagle Mountains
on the west, previously described, the Coxcomb and Palen mountains on the north,
and the Chuckwalla and Little Chuckwalla mountains on the south.

The Coxcomb Mountains trend nearly due north, and their southern point lies
about 5 miles north of Gruendike Well. The range is very narrow, and its crest has
a saw-tooth appearance. Little is known of its geology, and no mines of importance
were reported there. Harder says that the range contains dark slate, shale, and
sandstone in its south end and lighter rock, possibly granite, in the north end. On
the west the Coxcomb and Eagle mountains are separated by a very narrow pass,
probably alluvial, through which portions of the basins north of the Eagle Mountains
are said to drain southward into Chuckwalla Valley. On the east a wide alluvial
divide between the Coxcomb and Granite mountains separates Chuckwalla Valley
from basins farther north. Directly between the Coxcomb and Palen mountains is
a broad embayment tributary to Chuckwalla Valley and reported to be covered at
places with large sand dunes.

The Palen Mountains form a bold dark rock mass which rises abruptly from the
desert and whose southern point is about 10 miles east of Gruendike Well. Immense
steep canyons furrow the sides of the mountains and have etched out in the summit
of the range gaps between which stand prominent peaks that are visible for many
miles. At the foot of these canyons big alluvial fans spread out on the valley floor;
to which they seem, from a distance, to be inclined at exceedingly steep angles.
At their summit the Palen Mountains rise to a height of 3,500 or 4,000 feet. To the
north they are lower and narrower and are directly connected with Granite Mountain.
The Palen Mountains are made up of igneous rocks, schist, and highly metamorphosed
sediments, including notable bodies of limestone and gypsum. Manganese and
other minerals occur in the mountains also, but inaccessibility and lack of water have
prevented exploitation.

South of Chuckwalla Valley are the Chuckwalla and Little Chuckwalla mountains.
The Chuckwalla Mountains lie only 2 or 3 miles south of the southern of the branch
roads described, from which they can be plainly seen. They are a massive range
resembling the Eagle Mountains and probably of about equal altitude but more
deeply and thoroughly dissected. A deep pass through them from east to west on
the line of Corn Spring, Aztec Well, and Mill Camp was once occupied by a road
much used in crossing the desert but now abandoned. So far as known these moun-
tains consist entirely of pink and gray granite or gneissic altered phases of these rocks,
A. SHAVER CANYON 3 MILES SOUTH OF SHAVER WELL.
Vertical strata of sandstone form the south (right) wall.

B. NORTH WALL OF SHAVER CANYON NEAR SHAVER WELL.
Most of the rock face is schist, but in the center is a remnant of stratified gravel.
A. SHAVER WELL.
Over the well is a palo verde tree.

B. CAMP NEAR FORD WELL.
The palo verde tree is unusually large, about 50 feet high.
A. COTTONWOOD SPRING, LOOKING WEST.

B. WEST OUTLET OF COTTONWOOD SPRING.

The pipe is discharging water from a small tunnel in granite.
although detailed study would probably show a greater complexity in their composition. There have been numerous mines, chiefly gold mines, in these mountains at different times. The Granite mine has recently been worked but was idle at the time it was visited. The ore occurs in shear zones in a gray granite and is associated with small amounts of copper, iron, and tungsten minerals. The Little Chuckwalla Mountains are a sharp, narrow range with many isolated peaks, lying east of the Chuckwalla Mountains. (See p. 250.)

The road through Chuckwalla Valley, especially between the Gruendike and Ford wells, is dreary and difficult to travel. It consists only of two wheel tracks across seemingly interminable miles of sand. At many places it is worn into sharp curves, alternately to left and right, caused by the careening of automobiles, and these give a very unpleasant side swing to a car. With a team the slower progress and hard walking are even more irksome on man and beast. The vegetation is chiefly a scattered growth of ironwood and a little creosote bush, commonly called greasewood.

About 5 miles southeast of the road junction east of Gruendike Well is a Geological Survey sign (58.0, 36.5) which directs the traveler southwestward to Corn Spring, a little oasis in a pass through the Chuckwalla Mountains. Another road, rather dim, crosses the main road farther on (61.1, 33.4). This goes west to Corn Spring and east to McCoy Spring. The eastern portion crosses deep sand that is probably impassable for automobiles.

North of this last road crossing and south of the jutting point of the Palen Mountains is a long belt of sand dunes, probably half a mile to a mile in width. These are continually shifting back and forth over the lowest part of the valley. Beneath them is a soft silt which has been considerably eroded where exposed. It contains much gypsum and indicates the possible presence of lake beds, which may be more extensive in the vicinity of Palen Dry Lake.

North of the sand dunes, in the high alluvial debris at the foot of the Palen Mountains, is a long bench, which was not visited or studied but is probably to be explained as due to a recent fault in the valley fill.

The road turns east beyond the dunes (66.2, 23.3), but a little loop somewhat better to travel continues 0.1 mile southeast and then swings back. From this loop a dim branch road leads southeastward and is said to go to the Wiley Well. It is probably very sandy and bad. A little distance farther on the main road branches, and a slight choice of routes is again possible. A Geological Survey sign is planted here (66.4, 28.1). The south (right) road is one recently surveyed on a straight line. It passes no water. The north road is a portion of the old road that is still much traveled because it passes two wells. The distances are equal.

The north road passes Hopkins Well (70.6, 23.9), which has also been called Teague Well and San Dimas Well. It was drilled in 1911 by J. W. Hopkins, of Blythe, who has furnished the information concerning it. The well is in the northeast corner of sec. 33, T. 6 S., R. 19 E., about 3½ miles west of the Ford Well. The depth of the well is 1,200 feet and the diameter is 12 inches down to 930 feet and 8 inches below. Water-bearing sands were found at various depths from 70 to 600 feet, but the water was of poor quality and was cased out, the only perforations in the casing being between the depths of 1,175 and 1,200 feet. The water near the bottom is said to be good, but at present the casing is badly corroded and partly open at the top, and the water is both dirty and salty. Mr. Hopkins thinks that shallow waters have got into the casing. The water level measured 70.8 feet below the surface in 1917. An iron pump was provided, but it was broken when the place was visited, and water could be raised only with difficulty and was hardly good enough for stock. Analysis (No. 25, p. 282) indicates a poor drinking water. It is probable that the pump has been repaired.
SALTON SEA REGION, CALIFORNIA.

Log of Hopkins Well.

<table>
<thead>
<tr>
<th>Thickness</th>
<th>Depth</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feet.</td>
<td>Feet.</td>
</tr>
<tr>
<td>Soil, probably fine sand and silt</td>
<td>60</td>
</tr>
<tr>
<td>Clay</td>
<td>60</td>
</tr>
<tr>
<td>Alternate sand and clay</td>
<td>40</td>
</tr>
<tr>
<td>Sand, sandrock, and gravel</td>
<td>100</td>
</tr>
<tr>
<td>Not given: presumably sand and gravel</td>
<td>500</td>
</tr>
<tr>
<td>Water-bearing gravel; good water</td>
<td>300</td>
</tr>
<tr>
<td>Bedrock, probably schist or granite</td>
<td>25</td>
</tr>
<tr>
<td></td>
<td>1,175</td>
</tr>
<tr>
<td></td>
<td>1,200</td>
</tr>
</tbody>
</table>

East of Hopkins Well the road crosses a playa, part of Ford Dry Lake, and is very smooth and good. At the east end of the playa is Ford Well (74.2, 20.3), in sec. 30, T. 6 S., R. 20 E. The well is equipped with a windmill and also with a small gasoline engine, and there is a cattle trough and corral near by. There is also a hut under a large palo verde tree at which an attendant often stays to look after the cattle ranging in the desert. (See Pl. XVIII, B.) The palo verde tree is perhaps 50 feet high and appears as a conspicuous dark object for several miles away, as most of the surrounding brush is creosote and other small desert bushes.

The well is drilled and is reported to be several hundred feet deep, but no accurate information about it was obtainable. The casing is about 10 inches in diameter, and the water level measured 89 feet below the surface with the windmill pumping slowly. The water (see analysis No. 20, p. 282) is salty and is not desirable for drinking or cooking, although it is used when necessary. Stock get accustomed to it without any noticeable harmful effects.

Many persons will be surprised to find cattle ranging in so desolate a place as most of the country crossed by the Mecca-Blythe road. Nevertheless, several hundred head are kept most of the year in Chuckwalla Valley and the Hayfields, farther west. They browse on the scanty bunch grass and the bushes of the desert. Their watering places are at the Hayfields trough and at the Gruendike and Ford wells. They range many miles away from these places and return only once in two or three days for water. Their appearance usually indicates that their life is a hard one.

Several plans have been proposed for reclaiming part of the land in Chuckwalla Valley by irrigation, either from Colorado River or by pumping from wells. These plans and the subject of ground water are treated on pages 101-106.

Ford Well to Patterson Well.—About 1 mile east of Ford Well the roads unite (75.2, 19.3). At the junction is a Geological Survey sign which was specially intended to reassure the traveler going west who finds himself suddenly confronted with two equally well-traveled roads leading apparently in different directions. A small ridge of sand dunes (76.2, 18.3) is crossed 1 mile east of the road junction. This is a considerable belt of shifting sand similar to the one farther west but less extensive. This is the last bad sand encountered on the road to Ehrenberg. The road continues east over a gravelly plain at the base of the McCoy Mountains, passing through their southern tip (84.6, 9.9). Prominent on the hillside just north of this pass is a copper prospect in white quartz. East of the mountains the road descends a gentle slope onto the broad terrace known as Palo Verde Mesa, on which the Patterson Well (86.6, 7.9) is situated.

The McCoy Mountains, also known sometimes as the Ironwood Mountains, are a narrow, sharp-crested range somewhat similar in appearance to the Coxcomb Mountains. Their maximum altitude is probably not over 2,500 feet, but the large and rather square peak that forms the southwest point of the range is one of the most prominent topographic features of the desert, being distinguishable for many miles. Like the Palen Mountains, the McCoy Mountains are deeply furrowed by many
canyons, but the deposits at their base are much less prominent than those of the Palen Mountains. The rocks of the McCoy Mountains, where examined, are mainly gneiss and schist, with large masses of diorite and porphyry. At places metamorphosed sediments and conglomerates were seen. The McCoy Mountains have been a center of mining activity at many times in the past. Copper was once the chief source of interest, but recently manganese has been found in their north end and has been developed extensively. (See also pp. 262-263.)

Patterson Well (86.6, 7.9), on the Patterson ranch, is a prominent watering place 8 miles west of Blythe. For travelers going west it furnishes the last really satisfactory drinking water for 75 miles, although there are a number of other wells along the way which are used. Analysis (No. 41, p. 283) indicates that it is rather highly mineralized, but its taste is satisfactory, and the water is prized locally for its good quality. It has given encouraging results in a small trial for irrigation. The land of the "mesa" on which it is located is very porous and well drained and may be expected to permit the use of a rather highly mineralized water.

There are a house and one or two small buildings at the place, which were occupied by the owner in 1918. Water is pumped by a gasoline engine to an elevated tank, and a faucet is provided at the roadside to accommodate travelers. The Patterson Well was dug in 1913 and is reported to be 156 feet deep, with the water level at 149 feet, which is representative of the general ground-water level on Palo Verde Mesa. (See p. 106.)

Patterson Well to Blythe.—The road from the Patterson ranch to Blythe is generally good but is sometimes badly worn into ruts in the soft silt of the Palo Verde Valley. It makes a little curve (90.0, 4.5), taking advantage of a small wash to descend from the large terrace, locally called Palo Verde Mesa, to the bottom lands of Colorado River, here known as Palo Verde Valley, which are being developed for agriculture. In the valley numerous farms and fields of cultivated crops are passed. Half a mile west of Blythe there is a crossroad marked by a Geological Survey sign. One road leads north to Rice (formerly Blythe Junction); another goes south to Yuma. The Blythe road continues eastward. The ground-water conditions of Palo Verde Mesa are described on page 106.

The boundary between Palo Verde Mesa and Palo Verde Valley is a long well-defined bluff which is crossed by the road 3½ miles east of Patterson Well. It is 50 to 100 feet high and is continuous along the Colorado at least from Parker to Yuma, and there is a similar bluff on the Arizona side. West of the main escarpment there are at places other small bluffs, indicating that the river has in past time wandered even farther west over the valley, but in the main the one bluff is the conspicuous feature separating valley from "mesa." A more extended description of these bluffs and terraces is given on pages 33-35.

The Palo Verde Valley occupies the lowland between the bluff just described and Colorado River. The maximum width of this lowland is 8 or 10 miles. On the north the Maria Mountains and on the south the Palo Verde Mountains approach the river and terminate this valley, its total length being a little more than 20 miles. The lowland constitutes the present flood plain of the Colorado and is practically level except that it is slightly higher at the river bank than at the foot of the bluff. For this reason much of it was subject to overflow before the building of protective levees.

The soil of the valley is a fine silt or sand and is wonderfully fertile. Where not reclaimed it supports a rank growth of vegetation, which feeds upon ground water, the water level varying from the surface to 20 feet in depth. At places the growth consists almost entirely of dense mesquite; at other places of saltbush and arrow weed; at still others there are dense thickets of willow. Wherever there is a little open space grass grows abundantly after rains or periods of inundation, and salt grass is found at many places.
Originally this lowland was considered swamp land and practically worthless, but its value for agriculture has been recognized in the present century. A capitalist named Blythe acquired large holdings in the valley many years ago, and it was to develop his estate that the irrigation system was begun. C. E. Tait, in charge of irrigation investigations in southern California, has written briefly as follows: 17

The irrigation system was begun for the Blythe ranch when it was in individual ownership. This property of 40,000 acres was later acquired by the Palo Verde Land & Water Co., which continued the construction of the canal system. The company proposes to extend the system for the reclamation of 60,000 acres of land in addition to the Blythe lands. The organization of the Palo Verde Mutual Co. was caused, and the existing ditches and water rights of the land and water company were exchanged for 60 per cent of the mutual company's stock. The mutual company must complete the irrigation system for the entire 100,000 acres. * * *

Water rights are based on riparian land as well as appropriation and use, inasmuch as the 40,000-acre tract has a 17-mile frontage on the river. Farms average about 80 acres.

The head gate of the Palo Verde canal was constructed in rock at Black Point. The river at the intake is unusually wide, and the fluctuation in the water level is about 7 feet. The canal is on a grade of 0.02 per cent and has a capacity of 35 second-feet. The canal first leads to Olive Lake, 5 acres in area, which is utilized for a settling basin. The system was capable of irrigating 20,000 acres in 1909. Extensions have been made since and will continue to be made as the lands are settled.

The land irrigated in 1912 amounted to 9,000 acres. Some levees have been built for flood protection, and recently there has been serious consideration of building many more.

The crops raised in the valley are chiefly alfalfa, cotton, milo maize, and other small grains. Yields are abundant, and in late years long-staple cotton has been especially profitable.

Blythe (91.5, 0.0) is the chief town of the Palo Verde Valley and the terminal point of the California Southern Railroad. It has a population of 1,622 (1920) and affords garage and hotel accommodations and an ample supply of provisions. The domestic water supply is derived from shallow wells, either bored or driven, none of which are much more than 100 feet in depth. The source of the water is seepage from Colorado River, and the quality as indicated by three analyses (Nos. 3-5, p. 282) is fair for domestic use and satisfactory for irrigation, for both of which it is used, although irrigation is done chiefly with water taken directly from the river. Ground-water conditions in Palo Verde Valley are described on pages 108-109.

Blythe to Ehrenberg.—The road from Blythe to Ehrenberg goes due east for about 2½ miles. Throughout this distance it is paralleled by irrigation ditches and passes cultivated fields. A few unimportant branch roads turn aside to neighboring farms. At the end of this stretch the road turns a little to the northeast and then to the southeast, crossing some low swampy land that is covered by a jungle of willows, arrow weed, mesquite, and cane. During the summer flood season this part of the road is either under water or very muddy, and travel is impracticable. Anyone leaving Blythe on this or any other road should take provisions enough to last for a journey of 50 or 100 miles, as Blythe is the only important town for many miles in any direction. The only dwelling at Ehrenberg is occupied by the ferryman. Water for domestic use is obtained from Colorado River and is not very satisfactory. No supplies are obtainable. On account of high water during the summer the ferry is out of operation for a period extending from about May 15 to early in August.

WATERING PLACES REACHED FROM MECCA-BLYTHE ROAD.

In addition to the notes given on pages 269-279, the following information was obtained about several of the watering places reached from the Mecca-Blythe road:

DETAILED DESCRIPTIONS.

Corn Spring, sometimes called Cohn Spring, 18 is in the Chuckwalla Mountains in unsurveyed land of T. 6 S., R. 16 E., probably in sec. 28. The spring has been a noted watering place for many years and was an oasis inhabited by Indians long before the appearance of white men. Innumerable carvings and hieroglyphics on the granite faces of the surrounding mountains bear witness to their presence and probably to their means of signposting watering places. At present there is a miner’s cabin under the inviting shade trees at the spring, and the place is a favorite resort of prospectors, who often camp there. The vicinity of Corn Spring is a ciénaga which constitutes an enlargement in an eastward-draining canyon. Encircling granite mountains rise 1,000 to 2,000 feet above, and the canyon outlet to the east occupies a narrow granite-walled gorge. There is a considerable area of alluvial soil and rocky outwash in the ciénaga, and perhaps 5 or 10 acres is covered with a rank growth of vegetation including mesquite and arrow weed. Near the spring there is a clump of about a dozen wild palms, some of which are 2 feet in diameter. The spring rises in the lower end of the alluvial area and apparently represents the discharge of ground water fed by the tributary canyons into this reservoir. It has been dug out in the form of a shallow well, which yields a small flow over its lower edge. The flow varies considerably with the seasons, indicating its close relation to rainfall on adjacent slopes. At the time when visited it was only a few gallons a minute, but it is said to reach several miner’s inches at times. The water is used for domestic purposes and has been successfully used in the irrigation of a garden. Its quality as indicated by analysis (No. 12, p. 282) is good for both domestic use and irrigation. Indeed, it is much above the average of desert water. It is characterized by a considerable lime content.

Aztec Well is near the center of the Chuckwalla Mountains, in a large pass leading from Mill Camp on the west to Corn Spring on the east. The well was dug by Frank Coffey, of Mecca, who reports that the quality of water is good.

Mill Camp is also known as the Red Cloud mine and has been a prominent mining camp at times but was not visited by the Survey party. It is not definitely known whether the water is obtained from springs or wells, but it probably comes from wells. The supply is reliable, and the quality is said to be fair.

Boulder Well is the chief watering place for miners working in the east end of the Eagle Mountains, and a camp at the well is often occupied. The well was dug about 1907. It was originally 80 feet deep, and the depth to water is reported as 60 feet. The water is said to be highly mineralized but usable. There is a windmill at the well, which may be out of repair. The writer has never visited the well, but the information concerning it is reliable.

MECCA TO BLYTHE BY WAY OF DOS PALMAS.

[For log see pp. 166-171.]

From Mecca two natural avenues determined by the topography lead east to Colorado River. One of these goes through Shaver Canyon and Chuckwalla Valley and is utilized by the main Mecca-Blythe highway. (See pp. 236-238.) The one here considered is, in general, parallel but at a distance of 15 to 20 miles farther south and passes through Dos Palmas, south of the Orocopia and Chuckwalla mountains and north of the Chocolate Range. The two routes are similar in character, but the southern one has been supplanted by the newer road farther north and is now seldom traveled, although it was the route of a stage line of importance in early days when the other route was unknown, and the remains of stage stations at Dos Palmas, Canyon Springs, Chuckwalla, and Mule Springs attest its former usefulness.

The main Mecca-Blythe highway is about 8 miles shorter than the road here described, but the Dos Palmas road is about 20 miles shorter to Palo Verde or points

18Orcutt, C. R., West Am. Scientist, October, 1888.
near by in the south end of Palo Verde Valley. Consequently should the south end of Palo Verde Valley become thickly settled, this road may again assume importance as a route between Coachella Valley and Colorado River.

At many places the road is at present nothing but a dim trail. It is used chiefly by prospectors and persons with local interests in the region traversed. It is bad in places, and, especially from Mecca to Dos Palmas, portions of it are nearly impassable because of sand. Its use by motorists can not be encouraged unless it is improved, although it is occasionally traveled by them. Anyone traveling this road should take ample supplies. Water is not plentiful nor of very good quality but is obtainable at several places.

Mecca to power line.—Leaving Mecca at the public water fountain, near the station (0.0, 102.6), the route goes east on the main Mecca-Blythe road to a corner marked by a Geological Survey sign (0.9, 101.7), where it turns south. Half a mile farther on it reaches the entrance to the Government experimental date farm (see p. 200) and turns east beside this inviting 40-acre garden of date palms. A quarter of a mile farther east the road leaves the date farm and goes southeastward across sandy territory to the Southern Pacific Railroad (2.9, 99.7), along the north side of which it runs for about 5 miles. At places it is very sandy, and traveling is difficult.

There are scattered ranches in this region. Coachella Valley artesian water is obtainable for irrigation, but only a little land has been reclaimed. Much of the soil is shifting sand, and the vegetation is a scattered growth of saltbush. There are areas of good soil, however, chiefly south of the railroad.

At 8.7 miles from Mecca the road branches, and the right-hand fork continues southeastward along the railroad to Mortmar, a station on the Southern Pacific Railroad about 1 mile away; the left-hand fork goes to Dos Palmas. There is a Geological Survey sign at the forks. In this district water stands near the surface locally, and mesquite and salt grass are abundant over a few acres.

The road passes beneath an electric transmission line (9.5, 93.1), which connects Imperial Valley with the Southern Sierras system. (See p. 236.) The transmission line is followed by a road used chiefly by the power company's employees but to some extent also by the public. Some persons report that a route following the power line southeastward about 3 miles from this point and then using the old Salton road, which goes northeastward to Dos Palmas, is better than that here described, although a little longer. The writer does not know about this matter. All the roads of this neighborhood are so bad that the traveler can hardly do worse by taking a different one.

Power line to Dos Palmas.—East of the power line the road ascends a steep and increasingly sandy slope. The sand is of all kinds—coarse, fine, gravelly, and stony—and terminates in a wide belt of deep beach sand at the foot of some clay hills, a southern extension of the Mecca Hills. It may be necessary to deflate tires at this point. The road then passes along some small arroyos in the clay hills for about a mile (12.5-13.5, 89.1-90.1) and descends over the old beach again. This old beach is the bugbear of this road, and if an automobile crosses it safely the rest of the trip may be considered rather tame. Heroic measures are often necessary to cross the sand, however, as deep holes dug by previous travelers and stretches of the road carefully filled with brush will testify. From the second crossing of the old beach there is a firm road into Dos Palmas (15.8, 86.8). (For a description of the old beach see pp. 32-33.)

Dos Palmas is a spring near the center of a very low area bordered on the west by the clay hills, which extend for a few miles south of the road, on the north by the precipitous towering slopes of the Orocopia Mountains, and on the east by a gradually rising plain that is interrupted by the Chocolate Mountains. On the south it opens into the depression occupied by the Salton Sea, although scattered low hills in that direction more or less completely isolate the basin and give it the appearance of a separate depression.
Dos Palmas was a watering place in early days on the old stage road to Palo Verde and Ehrenberg and was the site of a stage station whose ruins still stand near the spring. The name is Spanish but is locally corrupted to "Dos Palms." The spring is marked by an acre or two of rank vegetation including grass, tules, rushes, mesquite, some willows, and a clump of five palms in addition to the two isolated palms that gave the place its name. A very dilapidated unoccupied cabin is near the spring, and a few hundred feet north is the abandoned machinery of an old pumping plant. The water of Dos Palmas rises in a marshy pool within the cluster of vegetation and flows for a little distance in a recently dug ditch. Travelers can follow a footpath through the jungle of vegetation to an open spot where a bucket usually is found hanging on a post.

Ground-water conditions at this place are more fully discussed elsewhere (p. 86). Dos Palmas is the largest of a number of springs due to the escape of artesian water impounded in this part of the Salton Basin. The available supply is considerable, and artesian wells are obtainable in the vicinity. Spring water is of poor quality, however, and although drinkable it is not desirable when other water is available. The analysis (No. 17, p. 282) shows a high mineral content, of which common salt (sodium chloride) is a dominant feature. The water is probably unfit for irrigation in the surrounding territory. It issues from the ground at a temperature of about 80° F.

The Orocopia Mountains rise steep and black north of Dos Palmas, and the detritus of black schist strewn profusely over the plain at their base indicates that that rock is predominant in their make-up. They culminate in one dark rounded summit, probably 3,000 feet high, that is conspicuous throughout much of the Salton Basin.

Dos Palmas to Clemens Well.—East of Dos Palmas the road is good and ascends gradually a gently steepening slope toward a great pass that is visible eastward between the Orocopia and Chocolate mountains. Out of this pass a wide wash called Salt Creek extends westward to Dos Palmas and thence spreads out over the lowland, where it disappears. The detritus carried down this wash has almost obliterated the old beach where the road crosses it for the last time, so that no difficulty is encountered. Farther east the road becomes gravelly and washes become well defined.

A branch road leading southeast (right) to Frink Spring and Niland is marked with a county signpost (17.2, 85.4). The road was not traversed as far as Frink Spring but is reported as very sandy and bad. Southeastward from Frink Spring it is sandy but passable.

The road drops into the Salt Creek sand wash (23.2, 79.4), which has a smooth bed a quarter to half a mile wide and steep banks cut in folded alluvial conglomerate. These beds gradually increase in height from a few feet to more than 50 feet at places. The road consists of innumerable tracks, all going up the wash. It is a peculiar fact that the bed of a gravelly wash like this becomes packed and hard after a rain, making a road almost like pavement, over which an automobile spins beautifully unless it breaks through the surface crust or crushes the gravel surface, when trouble begins. Accordingly the best plan is to pick a course generally following previous travel but avoiding any specific track. On the south side of the wash is a Geological Survey sign (25.4, 77.2), and about 100 feet south of it is Clemens Well.

Clemens Well is probably in sec. 31, T. 7 S., R. 13 E. There is a small wood sign on a post beside the well with the name of the well painted on it. The well has been dug only a few years and has largely replaced Canyon Spring, which is a little farther on, as a watering place, because it is much more convenient to the road. The well is dug in gravel at the mouth of a little tributary arroyo that enters Salt Creek. The walls of the arroyo are about 50 feet high and are composed of yellowish ill-stratified conglomerate of granitic and volcanic rocks with layers of sand and clay. The depth of the well is 17 feet, and in January, 1918, the depth to water was 16 feet. There was a good board curbing and a rope and bucket at the
well. The water is of fair quality as judged by taste but is slightly discolored. It is much better than the Dos Palmas water, however. The well penetrates gravel and sand, outwash from the adjacent slopes, and the water is evidently a small seep held up by layers of clay. The supply is adequate for travelers but would probably be exhausted by continuous pumping.

Clemens Well to Canyon Spring station.—The scenery in the next few miles is desolate but exhibits a fascinating variety of form and color. The white or yellow floor of the sand wash is broken by occasional clumps of ironwood. On the sides are steep walls of soft strata carved into deep arroyos tributary to the main wash. Volcanic hills and mountains, which appear numerously below Clemens Well, project through the clay and gravel hills to the south. East of Clemens Well the north wall of the canyon consists largely of red, yellow, and white volcanic rock, which stands up in steep cliffs. The old stage station of Canyon Spring is a rock house still in fair condition which stands on the south side of the wash.

Canyon Spring is in a deep canyon tributary to the Salt Creek wash at a point just north of the old stage station and is probably in sec. 20, T. 7 S., R. 13 E. It is about 1 mile north of the road and preserves the name of the stage station. Near the old station there is also a county signpost which gives directions to the spring and other places. The spring is accessible by a wagon road, which is probably not passable for automobiles. It was not visited by the writer, but fairly reliable information concerning it is available.

The supply of water is a small seep in the sand of the canyon and is not of good quality. The place has rarely been visited since the completion of Clemens Well, which furnishes better water at a point nearer the main road. There is some interesting and complex geology in the region, and it is probable that the water is brought to the surface by a rock dam across the canyon. Loew 19 gives a section at the spring showing Tertiary sediments overlying granite, the two intruded by trachyte, and all overlain by more recent unconsolidated material. The Tertiary rocks are inclined at steep angles.

Canyon Spring station to Tabaseca fork.—From Canyon Spring station the road continues northeast and at places is rough and sandy. Finally the main road turns east (right) (31.0, 71.6), up a side wash by which it emerges from the main arroyo, but stray tracks indicate a trail leading on northeast to Mill Camp and other places. There is a county signpost which gives directions, and the road can be followed easily. Beyond this point it leads out in a broad desert valley covered with recent gravel and outwash and considerably dissected by arroyos so that it is rolling and uneven. Some of the gullies are sandy and treacherous, but most of them are easily crossed. The surrounding country is a monotonous expanse of gravelly soil which supports a sparse growth of creosote and other small shrubs, including a few cacti. The road bears southeast and then turns east at a point marked by a Geological Survey sign (34.9, 67.7), from which a dim and rough but passable branch road leads south to Tabaseca Tank, in sec. 31, T. 7 S., R. 14 E., 1 mile away.

Tabaseca Tank is a natural basin in the bed of an arroyo that issues from volcanic hills on the north slope of the Chocolate Mountains. Two very sharp prominent peaks of red rhyolite are conspicuous a little distance to the southeast, and the tank is almost at their base. The place is little known and seldom frequented, but the supply is said to be reliable at all seasons unless campers have drawn heavily upon it. There may be a little difficulty in locating the tank, but it can be found by search. The road ends in a level space just west of the arroyo in which the tank is situated.

A rather remarkable condition appears to account for the formation of the tank.20 The arroyo is 10 to 20 feet deep and rather narrow and trenches a fairly smooth sur-

face of red volcanic rock, through which it drains northward. Transverse to this arroyo and dipping about 30° S. there is a small slip, probably a thrust fault, the trace of which is well exposed in sides of the arroyo at the tank and consists of a seam of white gouge about 1 foot thick. (See Fig. 16.) Along this fault the rock mass to the south has been shoved forward, and the overhanging cliff so formed has been worn back a few feet by a waterfall, which has excavated the pool below now occupied by the tank. This pool is several feet deep, is about 20 feet in diameter, and is full of gravel and rocks. The gravel is generally saturated with water, which can be obtained by digging a foot or two. The water is preserved for a long time, as the cliff of the waterfall shades it, and the gravel prevents animals from drawing heavily upon it.

Tabaseca fork to Chuckwalla Well.—From the Tabaseca fork the road to Blythe continues eastward through similar country, ascending continuously a long upland valley lying between the Chuckwalla and Chocolate mountains. A crossroad (44.7, 57.9) is marked by a Geological Survey sign. The road going north leads to Gulliday Well, 3½ miles away, where a small supply of good water can be found. This road is very rough but can be traversed by an automobile. Southward the cross-road leads down Iris Pass, in the Chocolate Mountains, to Niland. (See p. 207.) The Blythe road continues east, becoming gradually smoother as it rises, and is good for several miles.

![Figure 16](image-url) - Sectional diagram showing origin and structure of Tabaseca Tank.

At 3 or 4 miles north of the road are the Chuckwalia Mountains. (See p. 240.) To the south (see p. 208) the Chocolate Mountains appear as a rather subdued range of dark-brown hills consisting largely of volcanic rocks. Two sharp twin peaks near Tabaseca Tank are conspicuous features, probably representing old volcanic necks.

At the summit (48.0, 54.6), which ends the long climb that has been uninterrupted from Dos Palmas, the road begins an even longer descent eastward. The first part is down a very troublesome sand wash, which is especially bad on the westward trip. Finally the road turns east out of this wash (56.0, 46.6) and then bends north to the county signpost (56.8, 45.8) near Chuckwalla Well and again turns east. Chuckwalla Well is in the NW ½ sec. 33, T. 8 S., R. 17 E. It is one of the oldest watering places south of the Chuckwalla Mountains, having been an important place on the Ehrenberg-Los Angeles stage road. The road does not pass directly by the well, but a county sign points toward it, and the débris left by campers indicates the spot, which is at a sharp bend in the road. The road at this bend is on the south side of a large wash that drains east, and the well is about 100 yards away on the north side of the wash, in the mouth of a small tributary. It is hidden in a tangle of brush but can be easily found by a little search.

The well is an open hole 4 feet in diameter and 7½ feet deep, neatly walled with round boulders. The depth to water on November 8, 1917, was 5 feet, and the water
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was clean and drinkable, although rather salty. (See analysis No. 11, p. 282.) The well is dug in gravel in the mouth of a small wash that comes from a range of much dissected hills that connects the Chuckwalla and Little Chuckwalla mountains. This hilly mass seems to be composed largely of conglomeratic sediments. The scrubby mesquite so much sought as an indicator of water grows abundantly about the place, and it is probable that the water is merely seepage contained in the gravels of the wash and held up by impervious clay beds.

It is reliably reported that water stands at or near the surface in the large wash half a mile west of Chuckwalla Well. The place is known as Chuckwalla Spring. Similar springs are said to exist on the north slope of the divide not far from Chuckwalla Well.

Chuckwalla Well to Wiley Well.—From Chuckwalla Well the route is eastward in the bed of a small sand wash that runs parallel to the south side of the Little Chuckwalla Mountains, which are only about 2 miles away. Farther east it passes for 4 or 5 miles through a group of low detached hills which are composed in some places of granite and in others of lava. Beyond this point the road turns northeast across a level gravel plain and except for a few sand washes is excellent.

A branch road (70.8, 31.8), though dim and little traveled, is important as leading to Salvation Spring and Niland (p. 253). It is an extremely bad road at places. Travelers going west should carefully avoid it. It is so dim that it can not be easily mistaken for the Chuckwalla road, although there is no signpost at the fork.

On the north side of the road (72.0, 30.6) is a tumble-down stone wall, the remains of the abandoned Mule Spring stage station. No spring ever existed here, but there was once a well in the wash north of the road. All traces of this well are gone, however, and no water is obtainable near the place.

The Little Chuckwalla Mountains are steep-sided mountains of considerable height with several prominent sharp peaks. They are separated into an eastern and western portion by a narrow pass. The outwash from these mountains indicates that they contain granite and metamorphic rocks, and some dark masses on their sides and rounded forms on their east end suggest the presence of volcanic material. The western portion, as indicated by wash at Chuckwalla Well, appears to be granite.

Between the Chuckwalla and Little Chuckwalla mountains is a rounded divide, much lower than either but higher than the adjacent valleys, which appears to be deeply dissected and to consist of rather soft material. At Chuckwalla Well the rock is a coarse conglomerate, rudely stratified and mingled with layers of finer materials. There is a suggestion in the surface features of dissected sedimentary beds older than the recent deposits.

South of the Little Chuckwalla Mountains and scattered over the Arroyo Seco valley are numerous low dark hills partially grouped in a cluster called the Black Hills. These hills are composed chiefly of dark-red or black vesicular lava, which at places rests on granite. The lava beds have been folded and disturbed considerably and dip beneath recent gravel at most places, exposing sharp scarps on the opposite sides. This makes it appear that a large area may be underlain by disturbed lava flows of about the same age as the extensive volcanic rocks in the Palo Verde and Chocolate mountains.

The Wiley Well (77.8, 24.8) is in T. 8 S., R. 20 E., probably in either sec. 9 or sec. 16. The well was dug by A. P. Wiley, of Palo Verde, in 1908 and has been a useful watering place since that time. It was neatly curbed and in good repair in February, 1918, when there was a bucket and some baling wire at the well but no rope. A county signpost stands on the road about 50 feet south of the well. The well is on the east bank of a large wash through which a considerable territory on the south slopes of the Little Chuckwalla Mountains drains northward into Ford Dry Lake. It is nearly midway between the Little Chuckwalla and Mule mountains and at the south side of the Chuckwalla Valley. The well is about 3 feet in diameter.
On November 7, 1917, its depth measured 45 feet, and the water was 37 feet below the surface of the ground. There is a heavy growth of palo verde and ironwood trees along the wash but no mesquite. The water reached is apparently underflow seeping down the drainage course. The soil is rather clayey, and Mr. Wiley reports layers of "cement" in the well, so that possibly the water is merely held up by an impervious layer and does not constitute a true water table. If such is the case further digging would allow the water to escape into porous rocks below. The water is suitable for drinking. (See analysis No. 52, p. 283.)

The water supply of this region is described in connection with the Arroyo Seco valley (p. 106). The area is not favorable for obtaining water except at a few localities in arroyos or in washes where seepage water runs over impervious rock barriers or clay beds. It is probable that water could be had at depths of 100 feet or less in the pass between the Little Chuckwalla Mountains and the Black Hills at well-chosen places where bedrock is nearest the surface. Probably water could be obtained in a well in the arroyo at Mule Spring stage station, as the two original mesquites that were selected as the indication for locating the former well still stand on the bank of the arroyo.

**Mule Mountains to Blythe.**—East of Wiley Well there is a low sandy belt for 2 miles, beyond which the road climbs a long ascent toward a pass through the Mule Mountains. East of the summit (81.0, 21.6) the road descends a very rocky, narrow ravine for about 1 mile. Thence, crossing a small plain encircled by scattered portions of the mountain range, it goes through another pass (83.8, 18.8), which is in an arroyo and very sandy, so that the traveler may have difficulty for half a mile in getting through.

The northern part of the Mule Mountains, north of the road, is a considerable granite mass with two or three prominent peaks. The range includes a group of scattered granite hills, which become smaller and finally disappear to the south and southwest. The mass is geologically old and is nearly buried on the south in great slopes of its own alluvial débris. At the summit of the western pass the road crosses a divide composed entirely of conglomeratic detritus that has been considerably trenched by recent erosion and probably has suffered a slight amount of deformation. So far as observed the rocks of the mountains are entirely granitic, chiefly granite or diorite. The eastern pass lies between low rounded hills composed of pink and gray biotite granite. Some prospecting has been done in these mountains, and gold ore is reported, but lack of water and transportation have prevented development.

East of the Mule Mountains the road crosses Palo Verde Mesa, a terrace between mountain and valley, and descends a bluff (86.6, 16.0). The surface of the terrace is composed of very loose sand nearly all the way, and the terrace bluff is very sandy but was surfaced with weeds and other material so as to be easily passable in 1918. Below the terrace (see p. 243) the road goes east through a mesquite thicket for a little distance and then reaches irrigated land in the Palo Verde Valley and joins the Glamis-Blythe road (88.8, 13.8) at a corner marked by a Geological Survey signpost.

About a quarter of a mile south of this corner is Rannells, a little town where supplies can be obtained. (See p. 254.) Northward the road passes through Palo Verde Valley into Blythe (102.6, 0.0) over a route described on page 253.

**Mecca to Niland.**

East of the Salton Sea a number of very bad roads go southeast to Dos Palmas, Frink Spring, Niland, and intermediate points along the Southern Pacific Railroad. The available information on these roads is given in the logs (pp. 166-172).

Frink Spring, directly east of the Salton Sea and about midway between Dos Palmas and Niland, in sec. 20, T. 9 S., R. 13 E., is easily recognized, as it is by the roadside and is surrounded by a thicket of marshy vegetation. There are several
other small springs along the road on either side, which all yield very salty unpalatable water. That of Frink Spring is so salty as to be hardly fit for human use (see analysis No. 21, p. 283), although it is occasionally used by both men and animals.

All the springs of the vicinity are aligned in a northwest-southeast direction along a wave-cut terrace at the foot of the old beach of Lake Cahuilla, which is half a mile to 1 mile farther east at most places. Along this terrace are numerous exposures of a granitic conglomerate containing boulders of granite, porphyritic rocks, and various other materials. This is exposed in an arroyo just west of Frink Spring but is covered on the west by strata of sandstone and clay dipping westward and by silty soil apparently of a later age. There is an acre or two of rushes and water plants around Frink Spring, and the soil is a soft black muck. The conglomerate occurs about its edges. To the east there is a drift of outwash from the old beach. Conditions seem to indicate that the conglomerate is a water-bearing stratum capped by impervious soil on the east and west and that water under artesian pressure escapes upward where the conglomerate is exposed. The conglomerate is tilted and broken at places, and seams of salts are deposited in cracks along its surface, indicating that the escape of water may also be aided by fissures. The waters are all highly mineralized and leave incrustations of travertine and alkali on plants, sticks, stones, and everything over which they flow. The source of the water is probably a combination of various inflow waters contributed to the Salton Basin. (See p. 83.) There is a considerable quantity available, and the spring flows 20 or 30 gallons a minute down a ditch in which the water bubbles up with considerable force.

NILAND TO GULLIDAY WELL.

A few comments may be added to the notes on the route from Niland to Gulliday Well given in the logs (pp. 172-173).

West of the southern part of Iris Pass the mountains are of granite, rugged in topography and several hundred feet high. Those on the east are similar in color and topography. The east side of the wide portion of the pass apparently contains alluvial strata of clay or sand dissected into subdued badlands. At the south entrance to the narrow canyon tilted beds of sandstone and conglomerate rest irregularly on a white igneous rock which appears to be almost wholly crystalline and which grades at other places into distinct effusive lavas, rhyolitic in appearance. Volcanic rocks cover extensive areas in this region and beneath a scoriaceous or noncrystalline outer surface exhibit a tendency toward complete crystallization, where exposed to much depth by erosion.

The white volcanic rock persists for half a mile and appears to floor the canyon at very slight depth beneath a covering of gravel. In places rocks project from the bottom of the wash, and it is difficult to pass. The canyon then broadens for a distance and its walls are formed of red and yellow clay and sand, much of which is very fine grained. These beds are at places horizontal but more commonly tilted, folded, and sharply faulted. No fossils were observed, but the beds resemble closely the Tertiary sedimentary series found at many places about the Salton Sea.

Near its upper end the canyon is crossed by a vertical bed of dark rhyolitic breccia about 100 feet thick. This hard rock has resisted erosion well, and the canyon is not more than 10 feet wide. South of the dark volcanic rock is a bed of white, soft tuff about equal in thickness to the rhyolite and probably in vertical position. On each side of the volcanic rocks are beds of conglomerate that apparently lie nearly horizontal and contain boulders of rhyolite and other volcanic rocks. The lava and tuff are probably interbedded with the sedimentary beds and have reached their abnormal position by folding.

Mesquite was observed at several places in the canyon, both in the sedimentary beds and where the bedrock crops out in the bottom of the canyon. It is believed
that water could easily be obtained at slight depth at such places from underflow in
the canyon gravel. Probably a number of favorable places for wells yielding small
quantities of water could be found by looking carefully in the surrounding canyons.
One or two water holes are vaguely reported to exist in the region, but only deer and
coyotes seem to know their location.

Gulliday Well is in the unsurveyed T. 7 S., R. 16 E., probably in sec. 19. The
well is dug in the east side of a gully and is merely a round hole 4 feet in diameter
and 6 feet deep. On January 16, 1918, it contained 3 feet of water. The upper part
of the well is in gravel, and the lower part in granite. It is apparently fed by a
slight seepage down the gully. Some rank bunch grass around the well is the only
vegetation that might indicate water. The well has been used chiefly as a watering
place for prospectors, and the quantity of the water is not sufficient for heavy or
long-continued use. The water is of good quality.

BLYTHE TO GLAMIS.

[For log see pp. 174-175.]

From Blythe an important road goes south and slightly west, by a nearly direct
route, to Glamis, the nearest station on the Southern Pacific Railroad. It is used by
persons going from Blythe either to Imperial Valley or to Yuma and is the only im-
portant road connecting these places. A little-traveled, little-known, and at present
very bad road passes to the west through the Chocolate Mountains at Salvation Spring
and affords a considerably shorter way of reaching Imperial Valley, and for this reason
it is sometimes advocated for travel in that direction. But without substantial
improvement it is out of consideration for any but local residents. A short cut
described in conjunction with this route branches off before reaching Glamis and
makes possible a saving of 15 miles in distance to Yuma, but it has not been much
used, possibly because it is not very well known. It is poorly supplied with water
but is an excellent road that may often be used to advantage.

The Blythe-Glamis road is, as a whole, one of the best desert roads in the Salton
Sea region. Portions of it in Palo Verde Valley which are rather heavily traveled
and poorly cared for are sometimes very disagreeable because of dust and deep ruts.
Water is not plentiful but is obtainable frequently enough to make the road safe, the
longest stretch between watering places being about 21 miles.

Blythe to Runnells.—Palo Verde Valley is a large area of flood plain along Colorado
River centering around Blythe and Palo Verde, which is being developed agricul-
turally by irrigation from the river and which is more fully described on pages 243-244.
The roads in this valley have been signposted very satisfactorily by the Automobile
Club of Southern California.

For 6 miles between Blythe and the Neighbor School the land is under irrigation
and the road is fairly good, although in 1918 roads in general were rather ill kept
throughout the valley. This condition is incident to settlement of a new country
and will undoubtedly improve rapidly. A mile beyond Neighbor School (7.0, 51.5)
the road turns southwest across unreclaimed desert land near the west edge of the
valley. This land is mostly covered with a heavy growth of mesquite 8 to 10 feet
high. The road is not confined to straight lines, and no work had ever been done
on it prior to 1918 except the construction of a few fills across some deep lagoons that
usually stand full of water. Consequently every traveler who finds the beaten paths
too uncomfortable makes a new track alongside the old road, and a network of trails
sometimes several hundred feet wide results, all the tracks weaving around confusedly
but eventually reaching the right destination. For this part of the road the log is
rather hard to give exactly, and the figures here used probably represent only an
approximation to distances as another traveler might measure them.
The intricate system of trails finally converges into one road (11.2, 47.3), which leads south on section lines through land that was just being prepared for irrigation in 1918. A few houses are scattered about at places on or near the road.

A branch road (13.8, 44.7) leads west and is marked by a Geological Survey sign-post. It is a poor and little-traveled road but important because it leads to many watering places farther west and finally connects with the Coachella Valley at Mecca.

The little village of Kannells (14.0, 44.5) consists of a combined store and post office, a hotel, and a dwelling or two. Supplies and provisions are obtainable in small quantities, and water can be had at a well slightly off the road to the east. Analysis (No. 43, p. 283) shows the water of Kannells Well to be slightly higher in mineral content than the well waters of Blythe that were analyzed, but it is fairly satisfactory for domestic use. The well is about 100 feet deep and is 2 inches in diameter. It is equipped with a windmill. There is said to be great variation in the quality of water from different strata in the same well in this locality, and it is not known definitely from what depth this well derives its water. The reason for variation is believed to be the mingling of desert-basin drainage with water that percolates from Colorado River. (See p. 109.)

Rannells to Palo Verde.—From Rannells to Palo Verde there has been little develop­ment, and the road wanders about through a mesquite forest which at places is varied by grassy land. There is also good grass at most places even in the mesquite thickets, and cattle range here in considerable numbers. There would appear to be no more effectual hiding places in the world than one of these thickets, and it is a mystery how the owners ever find or corral their stock.

Palo Verde (18.7, 39.8) is a long-established settlement in the south end of Palo Verde Valley. It consists of a store and post office, a school, and one or two other buildings. Small quantities of automobile supplies and provisions are available, and water can be had at a pump near the store. The domestic supply is obtained from shallow driven wells, and its quality is fair, as indicated by the analysis (No. 39, p. 283). A deep oxbow river channel full of clear but sluggish water fed by seep­age runs through Palo Verde and escapes to the river a few miles away. This water is also used locally for domestic purposes and is said to be used somewhat for irrigation, by pumping. (For analysis of this water see No. 40, p. 283.)

The analyses indicate that the ground water at Palo Verde is purer than the sur­face water. Both are rather high in mineral matter, but the chloride content is not large enough to make them unsatisfactory for drinking. They are said to give good results in irrigation but have been tried only on small areas.

Palo Verde to Palo Verde Mountains.—South of Palo Verde the road is very much like that farther north and the country is generally covered with mesquite. A branch road (21.8, 36.7) turns east (left) to Cibola Landing, a river crossing not far east. A boat was said to carry passengers and mail across the river at this point on certain days each week. Cibola is a settlement on the Arizona side of the river where some farming is done and bee raising is said to be an important industry.

Leaving the Palo Verde Valley (22.3, 36.2) the road ascends a little gully and reaches a terrace overlooking the valley. To the southwest the Palo Verde Moun­tains looms up conspicuously, particularly a tall red pinnacle known as Palo Verde Peak, on the top of which appears a little projection that looks like a stake driven into the top of the mountain. It is really a stone cairn 6 feet in height, marking a triangulation station established by the Coast and Geodetic Survey.

The road crosses a gravel-strewn plain at the base of the mountains for some dis­tance, then follows a gradually narrowing canyon southward to the top of the divide just west of the high peak mentioned above. Here (27.3, 30.7) the road passes across an almost imperceptible divide and threads an opposite canyon leading southward to the plains of the Arroyo Seco. The canyon road is narrow and at places crooked but very good. Careful driving is advisable, especially when meeting other vehicles.
The Palo Verde Mountains are a rather low range of northwesterly trend. So far as was noted they are entirely volcanic, consisting chiefly of rhyolite or andesite. This is a rather compact rock, at places slightly vesicular but generally compact and nearly white, locally almost crystalline. Structurally the mountains consist chiefly of thick flows of lava, and these at places are tilted so as to form sharp scarps, the surfaces sloping away at 20°-30°. In the west end, however, the range appears to consist of nearly horizontal flows which are typified by the Flat Top Mountains, two broad level summits in the western part of the range 6 or 7 miles from the road. Palo Verde Peak is probably a volcanic neck and may well be the remnant of the vent from which the surrounding lavas issued. In the northwest end of the range is another very prominent spirelike peak called Red Butte, which is doubtless also a volcanic core. Farther west the range gradually lowers to scattered lava hills and merges more or less with adjacent mountains to the west.

The volcanic rock, which appears to predominate in the mountain range, yields a wide range of colors on weathering. Purple and red are the prevailing colors; tints of brown and yellow are less prominent. Nowhere in all the ranges of the region were desert colors seen more beautifully developed, and the trip through these mountains is decidedly worth while for that alone.

The arroyos and canyons of the Palo Verde Mountains generally support only a scanty growth of vegetation. Ironwood and palo verde trees are the only species prominent along the road. Water is not known to occur in tanks, springs, or canyon gravel except at one small spring in the northwest end at Red Butte.

It is notable that in the canyons followed by the road there is evidence of recent increase in erosion. Beds of gravel containing rudely stratified pebbles of volcanic rock are seen, particularly along the southern slope of the pass, lining the walls and extending to heights of 30 to 50 feet on the sides of the canyon. Evidence of increased erosion indicated by the cutting below the tops of these deposits was seen at numbers of other places in various mountain ranges but is particularly well exhibited here. Its correlation with the formation of the Colorado River terraces (see pp. 36-40) seems justifiable because the canyons are near the Colorado. All drainage lines that lead to the Colorado Valley are intrenched in the terrace, and this intrenchment may have extended back even to the heads of tributary canyons.

At most places the Palo Verde Mountains appear to be surrounded by boulders and gravel, the product of erosion of the mountains. At the south end of the mountains is a small exposure of sedimentary rock of peculiar whiteness, well stratified. This is a water-laid sandstone mixed with much calcareous cement. It crops out at places in prominent gray or white patches but is generally covered by recent detritus. Some fossils were found in specimens of this rock. (See p. 46.)

Palo Verde Mountains to Smith Well.—South of the Palo Verde Mountains the road crosses a broad valley, which slopes east and is tributary to Arroyo Seco, a wide sand wash trenches to a depth of several feet below the surrounding level and timbered with ironwood and palo verde. In Arroyo Seco the road divides into two parallel roads (30.9, 27.6), either of which is satisfactory and which unite about 5 miles away. From the east road a branch road (34.9, 23.6) leads eastward to a group of manganese mines in a small outlying range of the Chocolate Mountains, which were being operated in 1918. Continuing south the divided roads reunite (36.2, 22.3) and a mile farther on reach Smith Well (37.3, 21.2).

Smith Well is a dug well about 35 feet deep. It is on the bank of an arroyo leading north at the west end of an isolated part of the Chocolate Mountains, in which the manganese mines previously mentioned occur. The well was equipped with a windlass in 1918 and supplied water of fair quality. (See analysis No. 47, p. 283.) Persons going to Yuma by the Tumco road (see p. 257) should not neglect to take water here, for there is no more available before reaching Yuma. At the well a mining camp was being established in 1918, and a mill was being erected on the side
of low volcanic hills just east of the road. The well shaft is 5 feet in diameter and measured 35.6 feet deep on December 6, 1917. Water was 32.8 feet below the surface. Rhyolite crops out not more than 200 feet northeast of the well and just across the road. The upper part of the well is in gravel, but the bottom is said to be in "porphyry," which is evidently the same as the rhyolite. The water is derived from underground drainage in the gravels over the surface of the igneous rocks beneath. The supply is evidently small, as it is said the well can be bailed dry. The mining company hoped to develop more mill water by other wells to be dug near by. In the wash ironwood, palo verde, and black willows are abundant, but there is no mesquite.

Mines near Smith Well.—Smith Well is at the west base of a small isolated mountain range that trends a little east of north. The rock mass is volcanic, composed of andesite or rhyolite, red or pinkish on the surface but rather whitish beneath and very similar in superficial appearance to that of the Palo Verde Mountains. The range has a subdued topography, its summits being less sharp and jagged than those of the Palo Verde Mountains.

The mining of manganese in the eastern part of this range assumed considerable importance in 1918, stimulated by the demands of war. Manganese occurs as an oxide, chiefly psilomelane, in fissure veins in the volcanic rocks and also in certain beds of conglomerate that are probably of Quaternary age. In spite of difficulties of transportation and water supply a production of more than 3,000 tons was made in 1917 and 1918. Production has ceased entirely since that time, as the demand for manganese has fallen off.

About 3 miles west of Smith Well is the old Paymaster mine, a lead-silver property that has been worked intermittently for many years. It was being operated in 1918. It is also reported that a low-grade gold ore exists in a ledge in the volcanic rock near the well, and it was intended to develop this ore in conjunction with ore from the Paymaster, all of which was to be treated in a mill at Smith Well.

Alternate roads across the Chocolate Mountains.—From Smith Well south the road had been rather badly worn in 1918 by heavy traffic of autotucks to the mines but was in general fairly good. It ascends a long slope beside a wash for a few miles and then divides (41.1, 17.4), one part leading southwest and the other south. The two branches meet again at the south edge of the Chocolate Mountains. The west road (right) leads over a rolling, hilly country and descends a narrow, rather sandy canyon for about 2 miles. It is easily passable going south but probably difficult going north because of sand in the canyon. The east road is shorter and better. The west road, however, is a more attractive scenic route. Striking exposures of slaty schist whose flat surfaces dip at angles of about 60° form the wall of the mountain pass at places. Slabs of this material shine almost like mirrors in the desert sun.

The Tumco short cut leading to Yuma branches from the east road at a fork (44.2, 14.3) marked by a Geological Survey sign. A description of the Tumco road follows that of the present route (pp. 257–258).

The Glamis road leads southwest (right) from the Tumco fork, gradually climbing to the summit of a high alluvial divide that affords a pass through the Chocolate Mountains. This pass is about 2 miles wide and is at an altitude of about 1,200 feet. West and east of it are low mountains similar to those farther north. This branch of the Glamis road joins the western one at the mouth of a canyon south of the Chocolate Mountains (49.3, 9.2) and takes a course nearly southwest to Glamis.

Two series of rocks were noted in the Chocolate Mountains near the passes occupied by the two roads. In the west pass are metamorphic rocks consisting of granite and

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schists, the schists with well-marked slaty cleavage. West and north of the west road nearly all the rocks as indicated by the topography and by their débris appear to be granitic, and they are probably some of the oldest of the kind in California. On both sides of the eastern pass, however, all the rocks are volcanic—andesite or basalt—and along the south front of the range, which rises rather steeply west of the junction of the two roads through the mountains, all appear to be volcanic. There is one especially prominent red peak that has all the earmarks of a volcanic neck, about a mile west of the road. The volcanic rocks are extruded over the granitic rocks and are generally supposed to be Tertiary in age by correlation with the nearest similar rocks of established identity.

The south front of the Chocolate Mountains is rather steep and straight and has been interpreted to be a fault scarp, but the relations of metamorphic and igneous rocks and of later sedimentary rocks along this line are so little known that speculation is hardly justifiable regarding it. There is a suggestion in the drainage and topography of a fault extending from Smith Well southward through the pass along the line of the Tumco road. This also is not very definitely understood.

It appears that bedrock is but thinly covered by recent wash at many places in the plain south of the Chocolate Mountains. For several miles along the road to Glamis south of the main range low hills and plane surfaces of granite are common, and hills consisting chiefly of a dark vesicular basalt occur at many points. It is likely that granite, in places overlain by lava, is present at shallow depths for several miles from the mountain front.

Chocolate Mountains to Glamis.—From the south side of the mountains to Glamis there is almost nothing of importance. A hard gravel-covered plain slopes uniformly southwest, broken here and there for a distance of 3 or 4 miles by low granite and basalt masses which rise usually less than 100 feet above it. Near Glamis the Sand Hills, beyond the Southern Pacific Railroad, begin to show conspicuously like a range of snowdrifts hidden away on the desert.

Glamis is a place maintained entirely by the Southern Pacific Railroad. In addition to the station there is a small store, and the same building accommodates a hotel and post office. There are several dwelling houses for railroad employees. Water is obtainable from a railroad cistern supplied by tank cars from Mecca, and usually drinking water can be had at the store, where gasoline and oil are kept for sale.

Persons proceeding to Imperial Valley should use the Yuma-Niland log (p. 141) from this point, and those going to Yuma the reverse log of the same route (p. 139).

BLYTHE TO YUMA BY WAY OF TUMCO.

[For log see pp. 177-179.]

Branching from the Blythe-Glamis road (44.2, 38.5), at a fork marked by a Geological Survey sign, the Tumco road leads south down a sandy wash for some distance on the west side of some low rounded mountains that extend back to one considerable summit about 6 miles east. The wash is rather thickly timbered with palo verde and ironwood trees. The heavy growth of timber suggests a considerable supply of water, at least intermittently. The volcanic rock of the neighboring mountains probably underlies this wash at shallow depth, and water might be obtainable at depths of 100 feet, more or less, in the local basins of the bedrock.

The sand in this wash is coarse and gravelly and not particularly bad. Beyond a point about 6 miles from the fork the wash gradually spreads out over the desert, almost disappearing, and the road no longer follows it. The surrounding country is a smooth gravel-covered plain and supports a scattered growth of ironwood trees. Gradually the road approaches the Cargo Muchacho Mountains, which rise steeply to two or three imposing peaks that are visible for a long distance.
A dim branch road (61.2, 21.5) leading north from the Yuma road is said to go to a place called Hoge Ferry, on the Colorado, north of Picacho. It was reported as a poor road, but nothing definite is known of it. A board sign designated the fork in 1918.

Near the base of the Cargo Muchacho Mountains the road crosses a wash (62.7, 20.0), up which a side road leads east to a town half a mile away. The town consists of empty houses and is the ghost of a mining camp said once to have had a population of 1,000. It has passed through many of the ups and downs of a mining camp. Originally it was known as Hedges, but during the present century it was renamed Tumco by the United Mining Co., which acquired possession of the mines. Water was not obtainable in 1918 but would be if mining activity should again attract people to the place.

The Cargo Muchacho Range consists of two adjoining rugged mountain masses that rise to heights of about 2,500 feet above sea level and are separated only by a deep canyon. The rock is granitic or schistose material cut in every conceivable fashion by pegmatitic dikes, which range from a few inches to several feet in width. These dikes appear to have assisted very greatly in resisting erosion and cause the mountains to have a bold relief.

Many of the pegmatite veins are mineralized, and mining has been done intermittently in the ranges since 1879.22 Originally ore was taken to Colorado River for milling. Later a pipe line was laid and water pumped 12 miles from the river to the mines. A production amounting to several million dollars has been made at the mines near Tumco, but they were abandoned in 1918. There are several properties here and elsewhere in the range, all of which are said to have some rather valuable ore and several of which have been developed to depths of 1,000 feet or more. At Tumco there is a large mill, now idle, tailings from which have been sluiced down the arroyo on the west in great quantity and now form a sedimentary deposit 5 to 10 feet deep which is crossed by the Yuma road.

A short distance south of Tumco several dim crossroads lead south to Ogilby, a station on the Southern Pacific Railroad about 4 miles away. They also go northeast into the mountains. The traveler will usually go right by following the plainest road to the southeast and can not run a serious danger of getting lost. The railroad is not far away on one side, and the mountains soon become impassable on the other.

Finally this road meets the Niland-Yuma road at a corner (71.7, 11.0) marked by a Geological Survey signpost. Thence it crosses several miles of the "mesa" and descends to the level of Yuma Valley, over which the road leads into Yuma. A fuller description of this portion of the road is given on page 219.

BLYTHE TO RICE (FORMERLY BLYTHE JUNCTION).

[For log see pp. 179-181.]

A rather bad but passable road connects Blythe, in the Palo Verde Valley, with Rice (formerly Blythe Junction), on the Phoenix branch of the Atchison, Topeka & Santa Fe Railway. The country between the two places is uninhabited except for settlements near Blythe and a few mining camps at distances of several miles from the road. There is a stretch of about half a mile that is particularly bad going north where the road ascends from the valley to the terrace, about 5 miles north of Blythe. The road also crosses several miles of very bad sand south of Rice, in the Blythe Junction Basin. The worst of this sand is crossed by a planked road, but 5 or 6 miles of sandy road is not planked. Gyp Well, on this road, affords a convenient watering place, but it is unreliable, owing to the fact that water is pumped there only as suits the convenience of a mining company, which in 1918 had practically suspended operations. Brown Well, 35 miles from Blythe, is a former watering place.

at which, according to information received in April, 1921, water can no longer be obtained. Travelers should therefore be prepared to carry water from Blythe to Rice (41 miles), unless assured by local informants that water can be obtained at Gyp Well. As a whole the road is traveled by automobiles only when necessary.

_Blythe to Maria Mountains._—From Blythe (0.0, 40.8) fairly good dirt roads lead through the irrigated land of Palo Verde Valley to the foot of the "mesa" or terrace which borders the valley. At the foot of the terrace bluff (6.1, 34.7) the road crosses the track of the California Southern Railroad. The terrace bluff is very sandy, and its ascent may be difficult. The road over the terrace above is very good for a long distance, the land being hard and gravelly and fairly smooth. A branch road enters from the left (13.4, 27.4) and may be used by persons going south as an alternate route into Blythe, but it is little traveled. It passes to the south called Graham Well (abandoned in 1918), where there was once a small settlement. The most conspicuous feature of the landscape in this region is the steep southwest front of the Maria Mountains, to which the road is nearly parallel.

A Geological Survey sign (20.0, 20.8) marks a branch road that turns west (left) to various mines and watering places in the McCoy and Palen mountains. At 0.1 mile west of the sign the branch road crosses Mineral Switch, a siding of the California Southern Railroad at which freight to and from the neighboring mining properties is handled. No one lived at the siding in 1918, but freighters and laborers were often working there and kept a small supply of water, which was hauled by rail from Blythe.

Another branch road (22.2, 18.6) turns west about 2 miles farther on, leading to the mines of the United Gypsum Co., which are about 2½ miles west, in the Little Maria Mountains. Beyond this point the main road ascends a slope toward a pass between the Maria and Little Maria mountains. The summit of the pass (23.2, 17.6) is a low rock ridge that connects these ranges and separates the slope south of them from the Blythe Junction Basin.

The Maria and Little Maria mountains are two very broken and irregular ranges that probably do not reach more than 2,000 to 2,500 feet above sea level. The rocks of the ranges are all igneous or metamorphic sedimentary rocks of undetermined age but generally presumed to be pre-Cambrian or possibly Paleozoic. They comprise limestone and gypsum interbedded with quartzite; also large masses of granitic gneiss and schist cut by stringers and veins of quartz, which are at places developed into pegmatites. Hornblende, epidote, and biotite were noted in specimens of the schist. The whole mass has been intricately folded and faulted, and the sedimentary rocks are so much metamorphosed that if any fossils ever existed in them none have yet been obtained. The middle part of the south side of the Maria Mountains is a remarkable scarp which rises very steeply from the alluvial debris at its foot to a height of probably 1,000 feet or more. About halfway up this steep face a great white band runs horizontally across it and is conspicuous for many miles. The band is marble, probably 200 feet thick, pure white beneath its slightly yellowish surface. It is badly sheared and broken and breaks up into splinterly fragments. This mountain front is apparently a large fault scarp. The marble bed dips steeply north, into the mountain side, and beneath it granite, schist, and a highly metamorphosed conglomerate containing pebbles of quartz and limestone were observed.

The gypsum beds of the Maria Mountains are among the notable bodies of this material in the world so far as size and purity are concerned. The gypsum occurs as very fine particles of selenite, more rarely as alabaster, in beds some of which are more than 100 feet thick, interbedded with limestone. The United Gypsum Co. had developed properties in the east end of the Little Maria Mountains to a considerable extent in 1916 but was forced to quit by labor shortage and other war conditions. Its property is only about 3 miles from Mineral Switch, on the California Southern

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[33] Surr, Gordon, Gypsum deposits in the Maria Mountains, Calif.: Min. World, April 15, 1911.
Railroad, so that it is favorably situated to become a producer again. The beds extend intermittently throughout the length of the Little Maria Mountains and reappear in the Palen Mountains, farther west.

Gold and copper occur at many places in the Maria ranges and have long been the objects of desultory prospecting. The ores occur in quartz veins and as mineralized zones in schist. Lack of water and inaccessibility are deterrents of development, however. Recently an important body of manganese ores has been developed near the south point of the Little Maria Mountains. It occurs in a brecciated zone in limestone at the surface of the ground.24

Aside from one or two canyon wells and a few natural tanks no water is found anywhere in the range. The United Gypsum Co. gets its water at Gyp Well, in the Blythe Junction Basin, and other mining properties depend on water hauled by the railroad to Mineral Switch.

From the pass in the Maria Mountains the road goes northwest, crossing the California Southern Railroad (23.2, 17.6) and descending onto the smooth floor of the Blythe Junction Basin, a very broad, flat plain that extends far to the north. Near the south edge of this basin is Gyp Well (26.3, 15.5). A Geological Survey sign marks the turnout to the well and directs also to Mohave Tank, a watering place in the Little Maria Mountains which is reached by a branch road from this point.

**Gyp Well to Brown Well.**—Gyp Well is in T. 3 S., R. 20 E., probably in sec. 13, and is about a quarter of a mile west of the main road. It was drilled in the summer of 1914 by the United Gypsum Co. in order to obtain water for its mining camp, 3 miles to the south, in the Little Maria Mountains. For this reason it was called the Gypsum Company Well and the name has since been contracted by local usage to Gyp Well. The company hauled water by tractor from the well to the camp and kept water in a tank at the well when the mines were being worked, but after the suspension of mining operations in 1917 the tank was often dry and the watering place was no longer reliable. Water was pumped by a large gasoline engine sheltered in a little house near the well; the engine was evidently the same that was used in drilling the well and was attached to a large walking beam. Over the well was a large wooden derrick that had been used in drilling, and near the place was a deserted cabin.

The well is drilled in valley fill and was reported by various persons as between 500 and 600 feet in depth. One person gave the depth as 585 feet and the depth to water as 125 feet but said that water at that depth was of poor quality and that good water was obtained deeper and was admitted into the casing. There seems to be some reason to doubt the assertion that water was obtained at 125 feet, as is shown in the discussion of ground water in the Blythe Junction Basin (pp. 99-101), particularly as the informant was not intimately acquainted with the details of drilling. The casing of the well was not plainly visible but appeared to be at least 12 inches in diameter. It is probable that the well is drilled entirely in valley fill, as there would have been no reason for penetrating bedrock. The Little Maria Mountains, however, are only a little more than a mile away, so that bedrock probably occurs at places in the vicinity at the depth of the well. No water could be obtained at the time of the writer's visit, but the quality is said to be good.

Northwest of Gyp Well the road continues good for some distance, crossing fairly smooth land on which is a considerable growth of ironwood and palo verde trees. Beside this part of the road there is a telephone line, part of a line connecting Blythe and Rice. Gradually the road becomes more and more sandy and finally branches (27.9, 11.9), one branch following the telephone line straight ahead, the other turning to the west (left) and by a circuitous route avoiding some very bad sand, though

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it, too, is very sandy, particularly where it crosses numerous dry washes. Mileage is measured on this branch road, which is slightly longer. The two roads reunite at Brown Well (34.4, 6.4).

Brown Well is in T. 2 S., R. 20 E., probably in sec. 16. It is 3 or 4 miles west of the lowest part of the Blythe Junction Basin and about 2 miles from the base of Arica Mountain, a lone low mass of granitic and metamorphic rocks that breaks the continuity between this basin and that of Danby Dry Lake, on the northwest. The well was dug by Floyd Brown, who now lives at Blythe, and it was a well-known watering place for many years, but information received in April, 1921, indicates that water is no longer obtainable here. Near the well is a house in which Mr. Brown formerly lived, but it was unoccupied in October, 1917. The well was equipped with a pump operated by a 6-horsepower gasoline engine and in addition had a tub attached to a cable and arranged for lifting water by horsepower. A tank near the well was usually kept full of water, which could be obtained at a faucet. The well is 5 by 5 feet in size and is cribbed with boards and well curbed. On October 30, 1917, its depth was measured as 304 feet and the depth to water as 297 feet. The water is of fair quality. (See analysis No. 8, p. 282.) The ground water of Blythe Junction Basin is discussed on pages 99-101.

Arica Mountain, northwest of Brown Well, is a low mass 3 or 4 miles in length and about half that in width, which rises perhaps 600 feet above the surrounding plain. In the center there is a low east-west saddle. Several gold mines and prospects have been developed there, but that of the Assets Realizing Mining Co. was the only one active in 1917. It employed about 20 men and operated a shaft 900 feet deep and another 400 feet deep, besides other workings. An expensive mill and power plant were nearly ready for operation, and water was pumped from a deep well by a pumping plant in the desert about 2 miles to the east. Porphyritic igneous rocks, much altered and at places chloritic and schistose, in contact with limestone were observed in the mountain.

Brown Well to Rice.—From Brown Well the road takes a straight course northeast into Rice (formerly Blythe Junction). Between the two places there is a belt of shifting sand which forms low dunes, and for 2 miles across this sand the road is planked. The sand in this region appears to drift from the northwest to the southeast. Along protected knobs of Arica Mountain, to the west, it is piled up like snowdrifts. A branch road (37.1, 3.7) goes west from the south end of the planked road to the mines in Arica Mountain.

Near Rice (40.6, 0.2) a road marked by a Geological Survey sign goes east. It is part of an important road from Los Angeles to Parker and goes west from Rice along the Santa Fe Railway.

In 1918 Blythe Junction (40.8, 0.0) consisted of two or three buildings, one of them a combined store and hotel. Gasoline and some provisions were obtainable. The place is chiefly important as a railway station, although the station building was recently burned. Water is supplied by the Santa Fe Railway from tank cars and can be obtained at the store. In 1919 the name of this place was changed to Rice.

Rice and the greater part of the road from Brown Well are north of the region shown on Plate III but are shown on a sketch map (Fig. 11, p. 180).

McCoy Spring, Adams Well, Chandler Well, and McCoy Tanks from Blythe and Rice.

[For log see pp. 182-183.]

From Mineral Switch, on the California Southern Railroad, 20 miles northwest of Blythe, a road leads west to the north end of the McCoy Mountains and thence south to McCoy Spring. Branch roads lead to several watering places and mining claims in the Maria, McCoy, and Palen mountains. The part of this road from Mineral
Switch to the McCoy Mountains is naturally good but in 1917-18 had been badly worn by heavy freighting from the manganese mines generally known as the Black Jack group. The other roads were dim and little traveled and generally poor, though passable. It was difficult to go much nearer than 1 mile to Adams Well by automobile, and impossible to cross the Palen Mountains to Packard Well in any vehicle. The roads are not through routes and are of only local importance. Moreover, they may have undergone changes since the field work for this guide was done.

Mineral Switch to McCoy Mountains.—From Mineral Switch (0.1) the road leads southwest through the point of the Little Maria Mountains (see p. 259), thence west and northwest to the north end of the McCoy Mountains, passing several branch roads as noted in the log. The region crossed is generally plain, covered with boulders and gravel from the adjacent mountains. It is dissected at places by dry washes. There is a considerable growth of ironwood trees along most of the road, but no vegetation indicating water.

At a three-way fork at the north end of the McCoy Mountains there is a Geological Survey sign; the road to McCoy Springs (middle) branches from that to Adams Well (right), and a third road (left) goes south to the Black Jack mining camp, which was active in 1918. The camp is easily visible on the mountain side and is about 1 mile south of the road fork. Water can be had there in emergency when the mines are working.

The road to McCoy Spring goes west over a hard gravelly surface, and its course gradually turns south. Several dim trails branch off at one place, and a Geological Survey sign giving distances and containing the admonition “Go south 8 miles” is placed at a doubtful point (12.5). The road beyond this point has been almost unused so long that it is badly washed out and obliterated at places. It threads the east side of a broad valley lying between the Palen and McCoy mountains and passes between the main sand wash that occupies the middle of the valley and the McCoy Mountains. It is crossed by innumerable gullies leading west from the mountains and is very rough. The surrounding valley is heavily timbered with ironwood and a few other desert trees and presents the appearance of a veritable wilderness. At former times the road has been an important one, but at present it is abandoned except by prospectors and transient desert travelers.

Finally (19.8) the intersection of two dim roads is reached. This was once an important point and is posted with several old signs that are either illegible or unreliable. A Geological Survey sign has been placed here to give the right direction to McCoy Spring, which is east. The faint road that leads south from this place disappears after a mile or so in a waste of washes and sand dunes and is impassable for automobiles, although wagons could go south to Ford Well, on the Mecca-Blythe road. The trail leading west was once a wagon road through Chuckwalla Valley and is also very sandy, although its exact character is unknown.

Turning east the road ascends a gentle alluvial slope beside a deep dry wash and ends in a little flat (22.1) that has evidently been used often as a camping place. McCoy Spring is in the wash about 50 yards east of this place, in or near sec. 17, T. 5 S., R. 20 E. It is near the middle of the McCoy Mountains at their western base and is one of the oldest known water holes in the east end of Riverside County. It is never dry, although the flow is very small, not more than a few barrels a day. When seen in November, 1917, there was a pool of water 3 or 4 feet in diameter and 18 inches deep in small depression in the bed of an arroyo. The place had much the appearance of a rock tank. The water was rather stale and full of green algae but drinkable. An analysis of the water is given on page 282 (No. 34). A clump of mesquite and some ironwood grow near the spring, and on the rocks in the vicinity are numerous Indian carvings and hieroglyphics. Conditions do not indicate any great supply of water, and probably but little more could be developed.
The McCoy Mountains are a steep and narrow range with sharp peaks and crest, cut by numerous steep, short canyons. The mountains are very dark in color, having an excellent coat of "desert varnish." So far as known, they are composed of either igneous or metamorphic sedimentary rocks, but no limestone or gypsum, such as occurs in the Maria and Palen mountains, has been reported in them. There are great masses of granitic rock, apparently a quartz porphyry or diorite and probably intrusive, at the north end and in the vicinity of McCoy Spring and McCoy Tanks. There is also some quartz-sericite schist. Near McCoy Spring there is a considerable amount of a very much metamorphosed arkose conglomerate containing rounded boulders of quartz and granite. Somewhat similar conglomerate was noted at the southeast point of the mountains associated with large masses of fissile greenish schist. Veins of quartz and other acidic rocks are found at places.

In the north end of the McCoy Mountains manganese has been found in fissure veins, some of which are several feet thick. The ore occurs as oxides, chiefly psilomelane, and is of excellent quality. Several claims were developed during the war in 1917-18, and several thousand tons of ore was produced from these deposits and the neighboring ones in the Maria Mountains. Adams Well.—Adams Well is near the border line between Tps. 2 and 3 S., R. 18 E., about a mile from the east side of these townships. No very accurate surveys are available, so that its sectional location is not known. The last mile of the road that leads to the well is impassable for automobiles. From Adams Well a road once ran west to Packard Well, about 3 miles away, but this was impassable for any kind of vehicle in 1917. Adams Well was dug recently, probably about 1915, to furnish water for prospectors in the Palen Mountains.

The well is in a dry wash draining southeast through the Palen Mountains at a point where the range is constricted to a narrow belt of rough hills. The well is dug in gravel at a place where the wash is about 200 feet wide and is walled by tilted strata of conglomerate, probably Tertiary or younger. The sides of the well are neatly walled with natural granite boulders about 1 foot in diameter, and the opening left is about 2 feet in diameter. The well measured 43 feet deep on November 2, 1917, and the depth to water was 20 feet. In the wash near by are several clumps of mesquite which were probably taken as indicating a favorable spot to dig for water. The well was covered with boards, and a 5-gallon can and baling wire were the only means of obtaining water. The water looked fairly clean but tasted poor. Analysis (No. 1, p. 282) indicates that it is a fairly good drinking water. It is evidently derived from the underflow in canyon gravels, and the supply available is probably not large.

Palen Mountains and Granite Mountain.—The Palen Mountains are much lower in the vicinity of Adams and Packard wells than they are farther south. They are connected by a rough belt of deeply eroded and slightly folded alluvial gravel with Granite Mountain, a huge round mass that towers high above the surrounding desert basins. Granite Mountain is said to be composed of a crystalline porphyritic biotite granite. Harder studied the geology of this particular portion of the Palen Mountains in detail because of the presence of important gypsum deposits. These he describes as occurring in a belt 3 miles long and half a mile to 1½ miles wide in a general east-west direction across the Palen Mountains south of Adams and Packard wells. The gypsum is associated with beds of limestone, quartzite, and chert, and the whole series is cut by dark igneous intrusive rocks and intricately folded and faulted. In general the gypsum and limestone beds strike somewhat south of west and dip at steep angles, usually north.

25Jones, E. L., Jr., op. cit.
The gypsum beds are white, the limestone a little more cream-colored. Both show up conspicuously wherever present. Many short tunnels and prospect pits have been dug on the hillsides in the gypsum beds and are visible for long distances.

There is an interesting question as to the age of the belt of alluvial sediments south of Granite Mountain. These beds are composed of poorly consolidated sand, gravel, and coarse conglomerate. They are so deeply eroded by many canyon streams that a topography approaching that of badlands is produced at places. Folding and slight faulting are apparent at many places in the mass. From their lithologic and structural resemblance to the Tertiary beds in other parts of this region these deposits are tentatively referred to that period, but it may be that they are Quaternary.

**Chandler Well.**—Chandler Well is in T. 3 S., R. 20 E., probably in sec. 29, and is easily reached by the branch road that turns north 9.2 miles west of mineral Switch. The distance is 44 miles, but automobiles probably can not travel the last quarter mile of the road, which follows the rocky and sandy bed of a canyon. From the well a burro trail leads north through a pass to Mohave Tank, about 1 mile away.

Chandler Well was dug some years ago to supply water for prospectors in the Little Maria Mountains, and it is used chiefly for that purpose at present. The well is in a canyon on the south side of the mountains. It was neatly curbed, provided with rope and bucket, and in good condition when visited in October, 1917. It is 4 by 4 feet and penetrates canyon gravel and boulders for about 4 feet, below which it passes through bedrock of sheared gneiss and schist which seems originally to have been a granite. The well measured 17 feet in depth and contained 2 feet of water. Near the well are two clumps of scrubby mesquite, which, as usual, has been used in choosing the place to dig for water. No sample of the water was taken, but its quality is good. It is evidently derived from the underflow in the canyon gravels and in the fractures in bedrock, and the supply is probably small.

**McCoy Tanks.**—The two McCoy Tanks are in a canyon at the east base of the McCoy Mountains, in T. 4 S., R. 20 E., probably in secs. 28 and 32, and are about half a mile apart. They are in the first large canyon south of the north end of the mountain range, at the north base of a conspicuous conical peak. The road leading to the tanks ends on the north bank of the dry wash in which the tanks are found, at a point about 100 yards above the larger tank and perhaps half a mile below the smaller one. The location of the larger tank when it was seen in November, 1917, was marked by a large pole tripod erected over the bed of the gully above the tank.

The lower and larger tank occupies a hole about 15 feet long, 8 feet wide, and 6 feet deep in the bed of the wash. The surrounding rock is a badly shattered porphyry, and the tank is said to leak and does not hold water for more than one or two months after being filled by a rain. The dry wash becomes a deep and rocky canyon near the smaller tank, which is in a little bowl in porphyry. It is water-tight and holds water for several months when not used dry. Its capacity, however, is only a few barrels. Both tanks are often dry in midsummer.

In the next large canyon south of McCoy Tanks at a rather high elevation in the mountains a good tank is reliably reported to exist. Nothing more is known of it.

**MECCA TO DALE.**

[For log see p. 184.]

The road from Mecca to Cottonwood Spring and Dale is the best way of access to a large region in the eastern Cottonwood Mountains and the Eagle Mountains. The first 12.6 miles is over the same route as the Mecca-Blythe road and is much traveled; but beyond this stretch the road is used only by local persons interested chiefly in mining and may therefore be little used for long intervals. As a whole it is a fair wagon road, and it is satisfactory for automobiles except for a short distance in
Cottonwood Canyon, which may be nearly impassable because of sand. A portion of the road near Dale was reported as badly washed out in 1918. Local inquiries should be made as to its exact condition. Supplies are not obtainable anywhere after leaving Mecca, and water is very scarce around Dale.

Mecca to Shaver Well.—The Mecca-Blythe road leads east through the Mecca Hills, some interesting geologic features of which are described elsewhere (pp. 26-27, 55-56). At Shaver Well (12.1) a supply of water should be taken, because it may be difficult to reach Cottonwood Spring.

Shaver Well to Cottonwood Spring.—Half a mile east of Shaver Well the road turns to the left (12.6), leaving the Blythe road, passes for some distance up a sand wash, and thence ascends a long gravel slope to the base of the Cottonwood Mountains. This slope is steep and rocky and is really a large alluvial fan built up at the mouth of Cottonwood Canyon. It is covered thinly with the hardier desert plants, such as cactus, creosote bush, and especially ocotilla. (See Pl. VI, B.)

At its entrance (20.5) Cottonwood Canyon is a sand wash several hundred feet wide, but it soon becomes a narrow canyon with granite walls 200 to 300 feet high. The sand is deep and soft, and its condition varies considerably with the amount of rain and travel. It is often nearly impassable for automobiles. Cottonwood Spring (23.5) is just off the road in a little tributary canyon (see Pl. XIX), is a noted watering place, and supplies the only easily accessible water in a radius of 10 or 20 miles. The spring is a little to the east of the main road, but its location is easily recognized by the large clump of tall cottonwoods. There is a prospector's cabin at the place and a pumping plant (abandoned in 1917), but no one has lived at the spring recently. There are really two springs a few feet apart, which issue from the base of a 20-foot cliff that cuts across the course of a small canyon in granite hills. The granite is sheared and at places slickensided, so that the cliff possibly represents a small fault. The springs have been developed by tunneling the granite for a few feet, and a joint of 1-inch pipe conducts a steady flow out of one tunnel. The total flow of the two springs is about 20 gallons a minute and sinks into the sand within 200 feet. The water evidently issues from fractures in the granite and is supplied by the rainfall tributary to the canyon above the spring. This canyon is shallow and rocky, is a mile or two in length, and contains local deposits of gravelly soil along its bed, on which mesquite bushes indicate a small supply of water. At one of these little soil-covered areas about half a mile from the springs is a small dug well, now nearly filled up, in which a growth of tules or cat-tails indicates the presence of water. These little local reservoirs along the canyon probably store up water during floods and slowly feed it down through the crevices of the granite to supply the springs below. The water is of excellent quality for a desert country. (See analysis No. 13, p. 282.) It would be good for irrigation and could possibly be used in boilers. Aside from local tanks and a few springs reported in isolated and inaccessible places by prospectors there is no other water in the region. The only hope of developing water is by searching the mountain canyons for favorable places to dig wells and obtain a small supply or by constructing catchment basins to conserve rain water.

Cottonwood and Eagle mountains.—Cottonwood Canyon is the dividing line between the Cottonwood Mountains, on the west, and the Eagle Mountains, on the east, and except for this canyon the two ranges are practically continuous. The rocks observed in the canyon are nearly all pink biotite granite, with some granitic variations. The geology, particularly of the Eagle Mountains, is best described by Harder.27 Topographically both ranges are of a rather subdued mountainous character. Although the dissection is deep, the divides and peaks are rounded and inconspicuous from a distance. The summit of the Eagle Mountains has an altitude of about 4,000 feet above sea level.

The south wall of both ranges is rather straight and abrupt, and the fact that the drainage of Cottonwood Canyon originates in a high plateau on the north side and passes through a deep canyon to the south suggests that the south boundary may be a fault line and that the drainage was established before the mountains were elevated. Rich 28 states that the west wall of the Eagle Mountains east of Pinto Basin and northeast of Cottonwood Spring is a fault line of this character; and undoubtedly faulting has produced much of the present mountain topography in this region, as elsewhere in southern California.

Cottonwood Spring to Dale.—Eight miles of the road from Cottonwood Spring to Dale was traveled by the writer, but of the rest only indefinite information from inhabitants of the region is available. The substance of that is contained in the road log and is as reliable as could be gathered.

North of Cottonwood Spring the road emerges from the mountains upon a plateau which for 2 or 3 miles still drains south to Cottonwood Canyon. Farther north there is a large upland of imperfect drainage which has a sandy granitic soil and is covered with a semimountainous vegetation including considerable bunch grass.

COTTONWOOD SPRING TO PINYON WELL.

[For log see pp. 185-186.]

The road connecting Cottonwood Spring with Pleasant Valley, from which access to Indio or Banning is possible by other connecting roads, is little traveled; but is naturally good and passable either by automobile or otherwise. The portion of the road from the Eldorado mine to the Cottonwood-Dale road had been almost obliterated in 1918, and only a faint line through the desert bushes marked the place where it once existed as a plain road. The road is scarcely ever used except by miners or local inhabitants, and only a brief description of some important features will be given.

Cottonwood Spring to Eldorado mine.—From Cottonwood Spring to the road fork (7.7) the route is the same as that of the Mecca-Dale road, and the roadbed is good. At this point, marked by an old but plain county signpost, the road turns westward (left). It passes through a large area of low granite hills, which project as isolated knobs from a plateau formed by their own waste materials. After crossing 3 or 4 miles of these hills the course is over a high plain at the west side of Pinto Basin, and finally the road turns west into a little canyon reaching the Eldorado mine (21.8). Branch roads (20.2 and 21.3) lead north to a place called White Tank and on to Twenty-nine Palms, in San Bernardino County. The roads are rarely used and very bad. (See p. 187.)

The Eldorado mine was one of the few gold mines in the desert that was being operated in 1918. It is in the north wall of a little canyon at the southeast corner of the Hexie Mountains, in the NE. 1/4 sec. 17, T. 3 S., R. 10 E. The shaft and workings extend to a depth of about 400 feet. The ore is found in veins in a mineralized zone in schistose rocks and at places is said to be high in gold. Wulfenite, vanadanite, and other minerals occur associated with the gold, and vanadium was being recovered at the time the mine was visited. The ore is treated on amalgam plates and cyanided. Water is obtained at Pinyon Well, nearly 9 miles away, and led by gravity to the mine in a pipe line. When the mine is being operated it is a reliable watering place. There is a large camp house in the canyon, as well as the ordinary mine buildings.

Eldorado mine to Pinyon Well.—West of the Eldorado mine the road crosses a divide and passes over into a sand wash, which drains eastward. As the road continues up this wash the mountains gradually recede and Pleasant Valley is entered. In the valley the road forks (26.3.) The shorter road to Pinyon Well is the one

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Pleasant Valley, which the road traverses, is a basin lying in the western part of T. 3 S., R. 9 E. It drains toward a small playa in the SE. ¼ sec. 8, which if filled with water to the depth of a few feet would overflow into the wash leading east along portions of the road through a canyon into the Pinto Basin. The playa and main drainage line are on the north side of the valley, at the base of the Hexie Mountains. On the south there is a long alluvial slope that seems to reach back nearly to the top of the Little San Bernardino Mountains. On the northwest there is another long ascending slope. The gentle southern slope, the abrupt rise of the Hexie Mountains, and the drainage of the valley along one side and out through a narrow canyon suggest the presence of a fault along the south front of the Hexie Mountains which has caused the formation of the valley. The water supply of Pleasant Valley is discussed on pages 98-99.

After crossing Pleasant Valley the road enters a canyon in the Little San Bernardino Mountains and ascends it to Pinyon Well (30.6). The canyon is rather sandy but passable by automobile. Its walls are dark granite or diorite with masses of a very black micaceous schist, the whole cut by prominent veins of quartz and light-colored acidic intrusive rocks. Along the road the pipe line, about 2 inches in diameter, that conducts water from Pinyon Well to the Eldorado mine is uncovered at many places.

Pinyon Well is in the NE. ¼ sec. 24, T. 3 S., R. 8 E. The well was the only water supply of many mines operated at different times in a region covering several miles. Mining was formerly carried on near the well, and the wreck of an old 2-stamp mill, two deserted cabins, and some abandoned shafts still mark the spot. The old camp is on the southeast side of the road in the opening of a small side canyon. The canyons are inclosed by rough mountains, which probably rise 1,000 to 2,000 feet higher than the well. The mountain slopes are at many places covered with manzanita, juniper, and pine, their vegetation resembling that of the Peninsular Mountains more than that of any other part of the Salton Sea region east of the Pacific divide. There are really two wells. One is in front of the cabins about 20 feet from the road and was covered in January, 1918, by a low curb about 1 foot high. A rope and bucket were provided for obtaining water. This well is 3 to 4 feet in size, and was walled with plank. It measured 27.7 feet in depth, and the water stood 20.7 feet below the curb. The well penetrates canyon gravel at first but probably ends in the bedrock, which is a much veined granodiorite in the canyon wall near by. The second well is 200 feet south of the other on the same side of the road. It is dug in the mountain side beside the canyon and starts directly in a dark veined granodiorite, considerably cracked and sheared. Its depth from the top of the curb, about 5 feet above the level of the wash, was 41 feet, and the depth to water 12 feet. It is walled with 2-inch plank.

The water is very good and is evidently fed by underflow along the canyon. Drainage from the summit of the Little San Bernardino Mountains, probably the highest mountains in the Riverside County desert, between 5,000 to 6,000 feet above the sea, seems to reach this and adjacent canyons in considerable quantity, although the supply of any one well may not be large.

PINYON WELL TO INDIOS.

[For logs see pp. 186-187.]

Pinyon Well to County Well.—From Pinyon Well the road ascends a narrow and sandy canyon through mountains of considerable height to a divide (1.7) on the crest of the Little San Bernardino Mountains. Peaks of the surrounding mountains
rise probably 1,000 feet or more above the road. There is a very steep descent down a rocky hill for about a quarter of a mile beyond the summit, and this is the farthest point reached by most automobiles that attempt to come from Indio. The road continues down another sandy canyon, whose walls are steeper and higher than those of the canyon east of the divide. There is a well in the middle of this canyon, and opposite it a Riverside County signpost. This well was dug several years ago on the wagon road northeast of Indio, then used considerably for freighting to mines in the Pinyon district. It is on the south side of the road, in a canyon several hundred feet deep walled by high mountains. In 1918 it was neatly curbed and fitted with an iron pump (which would not work) and also provided with rope and bucket. There is a horse trough beside the well. The water contained some boards and other trash. The well is dug in canyon gravel near two large willows. On the opposite side of the road is a large patch of mesquite. The canyon is separated into two almost equally large stream channels about 200 feet below the well by an isolated block of granite about 50 feet in diameter, which rises to a height of 20 or 30 feet. This doubtless has some effect in forcing water near the surface in the area above the well. The water is evidently canyon underflow.

Little San Bernardino Mountains.—There has been little uniformity in the name applied to the prominent range here called the Little San Bernardino Mountains, probably because it has been so imperfectly mapped and known. On most maps it is shown as a part of the San Bernardino Mountains or is called the Little San Bernardino Mountains. It is poorly separated on the east from a range generally known as the Cottonwood Mountains. The north end, southeast of Morongo Valley, is known locally as the Morongo Mountains, and the middle part, near Pinyon Well, is usually described in the mining literature of the region as the Pinyon Mountains district.

So far as could be observed in the vicinity of the Pinyon Well road, the main part of the mountains is composed of a great batholithic mass of granitic rocks, ranging from pink biotite granite to dark diorite. West of the divide there is little but pink and gray granite with rather coarse crystals. East of the divide there are larger masses of dark diorite and porphyritic rock and some large bodies of dark schist with a very abnormal proportion of black mica. All these rocks are cut by prominent veins of quartz and granite dikes, and some of these are said to contain good gold ore; but lack of water and roads has retarded development here, as everywhere else in the desert.

The only water supply to be had in the mountains is from wells in canyon gravel or hillside detritus, where a little of the run-off is conserved in loose soil or in water-bearing crevices in the granite.

County Well to Indio.—On emerging from the mountains the traveler finds himself high on the border of Coachella Valley. From 15 to 20 miles away, on the opposite side, rise the San Jacinto and Santa Rosa mountains. In the foreground, on the northeast side of Coachella Valley, is a low ridge of smaller mountains or hills nearly parallel to the base of the Little San Bernardino Mountains and about 2 to 3 miles away. These are the Indio Hills (p. 26). Between them and the Little San Bernardino Mountains a considerable valley extends southeastward, forming the continuation of the drainage of the canyon followed by the road. The road descends this valley, following the beds of its dry washes most of the way. It is rough and rocky and very poor at places but easily passable for one descending. The Indio Hills gradually diminish in height toward the southeast, and the road turns southwest (17.9), passing through a gap in the hills. The crossing of the hills is very sandy and soft. Beyond the gap the road leads across a mesquite-covered portion of Coachella Valley and soon reaches houses (19.9) and well-kept roads leading into Indio, where supplies of all kinds and hotel accommodations are available and good water is plentiful. Good roads lead from Indio to other places.
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WHITE TANK.

White Tank (see p. 187) is on unsurveyed land in T. 2. S., R. 10 E., and would probably fall in sec. 18. The tank is really a reservoir made by constructing a concrete dam across a gorge walled by granite. This dam is about 15 feet high, and water would cover an area of about an acre if the reservoir were filled to capacity. In January, 1918, the reservoir was completely dry, however, only a mass of wet mud indicating the recent presence of water. The tank is filled by rains and usually contains water most of the year but is sometimes dry. Cattle have open access to the pond, and the water is therefore somewhat foul but is used by prospectors.

NOTES ON OTHER WATERING PLACES.

Most of the watering places described in the following pages are not on any of the roads for which logs have been given but are in isolated places, many of them accessible only on horseback or on foot. Many of them were not visited during this investigation. The information concerning them is the most reliable that could be obtained from persons acquainted with their location.

Agua Dulce is an artesian spring of the Figtree John and Fish Spring variety and was once an important watering place but is now supplanted by the artesian wells of neighboring ranches. It is in sec. 19, T. 8 S., R. 9 E., in southern Coachella Valley.

Alamo Bonito, a group of artesian springs near the Coachella-Brawley road in southern Coachella Valley, in sec. 35, T. 7 S., R. 8 E., was once an important watering place but is now little used owing to the development of artesian wells on surrounding ranches. The springs are understood to be similar to Figtree John and Fish springs.

Alamorio is a village 4 miles east of Brawley in Imperial Valley. It contains a few buildings and one or two stores. The place is interesting because of a flowing well drilled in 1911 and owned in 1918 by Mrs. D. C. Huddleston. The well is one of the earliest flowing wells obtained in the Holtville area and is at present near the northern boundary of the area in which flows are known. The well is said to be slightly more than 500 feet deep and has a flow of 30 or 40 gallons a minute. Its diameter is 4 inches. Mrs. Huddleston reports that the well often varies in flow and throws up quantities of sand and trash at times. In the summer of 1917, she states, it "threw up sand, rocks, and sticks for 36 hours, and its flow increased temporarily to 360 gallons a minute." It has since settled to normal conditions again. Pieces of some material thrown up by the well were seen by the writer and consisted of flat limonite-stained concretions about half an inch in diameter. The water is used for domestic purposes and for stock, and a plunge was being constructed to utilize it in 1918. The water has a temperature of 80° to 90° as it emerges from the ground. The analysis (No. 54, p. 283) indicates a very high mineral content and shows that the water is bad for domestic use and probably unfit even for irrigation. Its taste is perceptibly salt but not so much as the analysis might indicate. It is characterized by an exceptionally high content of sodium chloride, or common salt.

At 30.6 miles from Mecca on the road to Blythe a distinct road leads to the left to a more or less permanently abandoned cattle camp 0.3 mile away. There are a small frame house, a corral, and a concrete reservoir at the place, but the reservoir was dry when visited in October, 1917. A pipe line comes to the reservoir from the northeast down a large alluvial fan. If it is followed it leads up a canyon from the south slope of the Eagle Mountains. In the canyon, 3 miles from the camp, is Anshute Well. It is accessible only on foot, although the first 2 miles might be traveled by wagon or on horseback. The route is one of particular interest and will be briefly described. About a mile from the camp the pipe line reaches the foothills of the Eagle Mountains and passes around a rocky point composed of granitic rocks, considerably metamorphosed and at places showing a gneissic banding. On the smooth surfaces
of these rocks are numerous queer figures, carvings, and hieroglyphics made by Indians. (See p. 124.) As the canyon narrows the trail is better defined by a more modern trail marker consisting of little rocks laid on larger rocks, in places a pile of two or three small stones on top of a conspicuous boulder. The canyon is very steep and narrow for the last mile and is filled with great granite blocks, many of them larger than a house. At some places it is necessary to climb the hillside around these blocks; at others it is possible to crawl beneath them. The pipe line has been carried over these obstructions with great difficulty and is exposed in some places and buried in others. In 1917 the line was broken about halfway from the camp to the well, and a very small stream of water trickled from it at the break.

The well is on the east canyon wall. It consists of a trench and a tributary tunnel. The trench is 25 feet long, 3 feet wide, and 8 feet deep and has been blasted parallel to the wash and in its east edge along the vertical face of the rock. From the trench a tunnel extends about 25 feet into the mountain side. The rock is a pink granite with many cracks and crevices and shows evidence of much shearing. Around the trench grows a patch of scrubby mesquite, which as in other places has been the indication sought in determining the place to dig for water, although it is probable that a seep may have existed here originally, as is indicated by the marked Indian trail.

Water is about a foot deep in the bottom of the trench and tunnel. The mouth of the tunnel is covered with a piece of canvas. The pipe line is buried and leads into the bottom of the pool, where its opening is covered with a screen. The line must have been badly clogged, however, for the water stood several inches above the outlet. The water in the pool was clean, although bees frequent the place and often drown in the water. Tadpoles were numerous and seemed to thrive.

It is probable that the maximum supply of water has been developed, though possibly other places along the canyon might yield as much more if opened in a similar way. The occurrence of water in cracks and crevices of granite is common and rather well known, but the supply is nearly always small. This place is so inaccessible that its importance can only be very slight and local.

Arrowweed Spring is shown on a General Land Office map of T. 11 S., R. 21 E. (surveyed in 1915), and is in the northeast corner of sec. 28. The topography indicates that it is in a deep gully draining across the "mesa." It is about 2 miles northeast from the supposed location of Tolbard Well, but that well may not be accurately shown on the map and may correspond with the spring. No other information is available.

Barrel Spring, in sec. 35 (?), T. 11 S., R. 8 E., is a little known watering place in the San Felipe embayment of the Salton Basin about 3 miles east of Borego Mountain. It is half a mile north of a dim road that follows the dry bed of San Felipe Creek for a portion of the distance between Borego Spring and Harper Well. The turnout to Barrel Spring is a very faint wagon trail, probably not passable for automobiles, at a point 11 miles from Borego Spring and is marked by a large white board sign bearing the inscription "Barrel Spring 1/2 M. north. Dig 20 feet west of cottonwood tree." The place is distinguishable by a large row of sand hills, covered with a dark growth of mesquite, in the west edge of which is the spring. It is on the north slope, and so is not visible until nearly reached. Near a little cottonwood 12 feet high (1918) is an open hole filled with a pool of water 5 or 6 feet in diameter, very yellowish and dirty looking. Beside the pool a barrel is sunk in the sand and was uncovered and filled with the same dirty water, which, however, tastes better than it looks. The water is used chiefly by persons driving teams to or from Borego Valley but seldom by anyone else. Mesquite-covered sand hills 20 or 30 feet high extend for half a mile or so eastward, and their presence indicates moisture in more than usual quantity in this exceedingly dry region. It seems likely that structural conditions in the thinly buried, folded Tertiary rocks below have created
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a slight upward pressure of the ground water here, and that the moistness and the resultant growth of vegetation have helped to fix the shifting sand rather firmly in place. Barrel Spring is merely a low place on the side of the sand hills where water is shallow. Possibly other water could be found in shallow wells in the sand. The locality is at a low altitude near the level of the San Felipe Creek bed, down which considerable ground water percolates eastward. Conditions here apparently are somewhat similar to those at Kane Spring (p. 31). The quality of any water obtained here would probably be very poor.

**Burnt Palms Spring** is a little known water hole in the Mecca Hills, east of Shaver Canyon, probably in sec. 10, T. 7 S., R. 10 E. It can be reached from the canyon by a burro trail that is passable only on foot or by a trail that enters the first large canyon in the Mecca Hills east of Shaver Canyon. The entrance to this canyon is about 2 miles southeast of that to Shaver Canyon. The spring is half a mile off the main canyon, up a tributary arroyo, and the turn is best identified by noting a prominent anticlinal fold in the rock strata at the junction of two large canyons about 1½ miles above the entrance to the hills. To the left (north) is Burnt Palms. To the east a plainer trail leads to Hidden Spring. The burro trail from Shaver Canyon is very difficult to find, but by searching a little way into the entrances of several side canyons entering Shaver Canyon on the east 3 miles south of Shaver Well the traveler can soon pick up the trail. It is a prominent path leading across some high clay hills. The spring is identified by two large palms, whose dead fringes have been burned, leaving the trunks black. There are two or three other palms farther south in the bed of the same deep wash. Salt grass and mesquite grow in patches. It is usually necessary to dig a foot or two into the moist soil to get water, which is salty and of poor quality. A permanently used well would probably supply better water. The water appears to be furnished by seepage held up above impervious clay strata in the bed of the wash. The geologic conditions are interesting and are indicated by the structure section shown in Figure 17. It is problematic whether the supply here is derived from local rainfall or from ground water falling east of the Mecca Hills and seeping through them to the Salton Basin. It is possible that by drilling wells in synclinal folds such as are shown here a small flow of water might be obtained.

**Calexico** is one of the large towns of Imperial Valley and with its Mexican extension known as Mexicali has a population of several thousand. The city water supply is purified Colorado River water and is available to travelers at nearly all public places.

The **Chocolate Mountains Water Holes** appear on the map of a General Land Office survey (1915) and are labeled "Water in holes." Two holes, evidently natural tanks, are shown on opposite sides of a small canyon draining north near the summit of the Chocolate Mountains. They are near the south quarter stake of sec. 10, T. 11 S., R. 17 E., and are probably the same as some natural tanks reported by

![Figure 17. Structure section from Burnt Palms S. 15° W. along wash.](image-url)
local inhabitants to occur in this part of the range several miles east of Salvation Spring.

Clark Well is at the north side of Clark Dry Lake, in a large inclosed basin at the south end of the Santa Rosa Mountains. It is accessible by poor and infrequently traveled trails from Borego Valley or from the summit of the Santa Rosa Mountains and can be reached by wagon probably only from Borego Spring or Valley. It was not visited during this investigation. Some reports stated that in 1918 the well was filled up and water was not obtainable but that ground water could be had at shallow depth by digging. The water is said to be good.

Coffey Spring is reported to be at the south base of the Chocolate Mountains, 6 miles northeast of Frink Spring, in an arroyo leading toward that spring. It is said that wagons can follow the arroyo to Coffey Spring. It is reported to furnish good water.

Dos Cabezas is a spring of good water reliably reported to exist at the north edge of the mountains about 12 miles west of Coyote Wells, from which it is accessible by a poor wagon road that leads up Carrizo Gorge to Jacumba Valley. The spring is somewhere in the southern part of T. 16 S., R. 8 E. It is said to have a rather large flow.

Durmid is a station on the Southern Pacific Railroad east of Salton Sea. It is supplied with water hauled from Mecca by the railroad company.

Eagle Tank is a natural rock basin about 20 feet in diameter and 10 to 15 feet deep in the bed of a gorge tributary to Placer Canyon, in the northwestern part of the Eagle Mountains. The gorge is the third large one entering Placer Canyon from the south below the old Placer Canyon reservoir, a distance of about half a mile, and the tank is several hundred yards from its mouth. It is at the base of a vertical cliff about 20 feet high in the gorge bottom. The tank is said to contain water all the year round, but during the dry season the water is stale and dirty, and even during the torrential rains it is filled with green algae and animal life, such as crustaceans, larvae, and tadpoles. When fresh the water is very good, and even during the dry season it is used by prospectors, for it is the only place within a radius of 15 or 20 miles where water can be procured, unless the pipe line from Cottonwood Spring to the Iron Chief mine is in order. Several other tanks in the Eagle Mountains hold water for several weeks or a month after the rains.

Edom is a station on the Southern Pacific Railroad about 12 miles northwest of Indio. It is accessible by poor wagon roads, and there is talk of building a good road from it into Indio. Some ranches are being developed in the vicinity, it is reported, and well waters are obtainable, but at what depth is not known. Like all the railroad stations in the desert it constitutes a possible watering place.

The Granite mine, in the north edge of the Chuckwalla Mountains, is reached by a branch road that turns south from the Mecca-Blythe highway at a point 41.3 miles from Mecca (p. 239), from which it is 21 miles to the Granite Mine Well. The mine consists of a number of tunnels and shafts high on the mountain side about half a mile southeast of the camp and well and is reached from them by burro trails. Near the well are two houses, one of which was occupied in 1917 by a miner, although he was not at home when the writer called. Many specimens of chrysocolla, magnetite, wulfenite, and other minerals were scattered about; but the mine is said to have been worked for gold. The well is on the east bank of a gully about 15 feet deep cut through granite at the base of the mountains. From it a pipe line leads east to a mill, but it was not in order when seen. Water had evidently been pumped by an engine but could be obtained only by rope and bucket, and these were not provided. The well measured 41 feet deep, and water was reached at 22.5 feet. It is said that tunnels were driven from the bottom of the well to develop more water by allowing greater infiltration, the water evidently being held in crevices in the granite. The well is 4 by 4 feet and was covered with boards and curbed with boards.
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to a depth of about 10 feet. Water drawn from the well appeared a little stale, as if from long standing, but looked clear and did not taste bad. It is probably good when regularly used. The supply is undoubtedly limited but sufficient for small mining requirements.

Granite Tanks are reported to be in the northeast corner of the Chuckwalla Mountains in a canyon near the mountain border and are said to be accessible by wagon. They are little used except by prospectors, the Granite mine and Corn Spring being more prominent watering places. The water supply is usually reliable but perhaps not always so.

Gray Well, now abandoned, formerly furnished water for Gray's mill, a gold mill in the desert about 5 miles south of Blythe Junction (Rice). The well is in T. 2 S., R. 20 E., probably in sec. 11. Water is reported to have been obtained at a depth of 137 feet. It was too salty for domestic use. The well is near the center of the Blythe Junction Basin, about 2½ miles northeast of Brown Well, and is of importance only for the information it affords about ground water in the basin. (See pp. 99-101.)

Hanna Well is at the north edge of Fish Mountain, in a canyon known as Fish Creek, through which runs a very poor wagon road connecting Carrizo and San Felipe valleys. It is easily accessible from the north, however. Conflicting reports state that water is unobtainable here and that there is plenty of good water. The well is in sec. 29, T. 13 S., R. 9 E., and has been used to supply prospecting and well-drilling parties.

Henson Well is in the NW. ¼ sec. 26, T. 3 S., R. 8 E., about three-quarters of a mile south of the road from Pinyon Well to Indio at a point 1.3 miles from Pinyon Well, and is accessible by a burro trail, possibly even by wagon. The well is in a little flat in a very narrow canyon and is high up near the summit of the Little San Bernardino Mountains. Near it are the ruins of an old arrastre and the remains of one or two small stone buildings. The spot is one of the most picturesque in the desert region, as the mountains are very rugged and rise about 1,000 feet above the well to a total height of nearly 6,000 feet, and their slopes are wooded with pine trees and a good growth of juniper and manzanita. The well is a dug hole about 4 feet square and reaches water at about 10 feet. It is curbed with boards and in January, 1918, was provided with a rope and bucket but needed cleaning. The water was siphoned to the Eldorado mine with that of Pinyon Well at that time. The supply is the small underflow in the canyon. The place is important only to miners.

Heyburn Well is indicated on a township plat of the General Land Office (1915 survey) as being near the south quarter stake of sec. 13, T. 11 S., R. 16 E. It is at the south base of the Chocolate Mountains, in the mouth of a large arroyo, and there is a cabin near it. A wagon trail leading to the Niland-Yuma road is shown on the plat. Nothing more is known of this well. The entrance to the canyon is a prominent reentrant in the Chocolate Range just east of Salvation Pass.

Hidden Spring is an excellent but very little known water hole in the eastern part of Mecca Hills, probably in sec. 11, T. 7 S., R. 10 E. It can be reached on foot by following the burro trail to Burnt Palms (see p. 271) and then going down the Burnt Palms Wash to its junction with a larger canyon from the east and following this canyon for a mile east. This was the route used by the writer. Automobile tracks leading up the canyon, however, indicate that it is accessible by vehicles from the southwest. This route probably runs about as follows, though little could be learned of it: From Mecca 4 miles east to the power line, thence 2 miles southeast along the power-line road, thence turning to the left, entering the first large canyon that comes out of the Mecca Hills east of Shaver Canyon, and following this canyon to the spring.

The location of the spring, as suggested by the name, is very obscure and can be recognized only by observing the canyon carefully. About 3 miles from the entrance

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to the hills the canyon becomes very deep and narrow. Its walls are of coarse gravel and conglomerate and more than 100 feet high. Then a peculiar yellow, purple, and red rock is observed on both sides of the canyon for a few hundred feet. This is a volcanic rock, probably trachyte or andesite, and cuts the canyon walls. On the north side of the canyon at this point is the entrance to Hidden Spring, which is about 100 yards away in a side canyon. The entrance to this canyon is almost completely obscured. The volcanic rock on the north side of the main canyon through which the tributary is cut is covered by a thick bed of a very coarse black conglomerate composed of fragments of schist. This conglomerate has broken off in huge boulders 20 to 40 feet in diameter and almost completely blocked the entrance. Nothing larger than a small burro could get through, for it is necessary to crawl 100 feet or more by a tortuous passage beneath these boulders. Beyond them, however, the canyon widens and the spring is easily seen.

Near the spring there are two separate clumps of wild palms of about 12 each. The dead fringes are reflected—and have escaped the burning that has defaced so many of the desert palms—so that they are especially attractive. Beneath the first clump is a shallow pool of clear water about 2 feet in diameter. It contained numerous "wiggletails" when visited but was otherwise of good quality. The water is apparently used chiefly by wild animals.

The source of the water is undoubtedly underflow in the canyon gravels brought to the surface by the impervious dam of volcanic rock at the canyon mouth. In the main wash a few hundred feet east, at the edge of the volcanic outcrop, is a thick clump of mesquite, and it is probable that water could be found at a depth of 20 or 30 feet there, for it is doubtless rises over the impervious barrier. There is, however, a covering of gravel in the wider bed of the main canyon.

The geology at the spring is very interesting and is indicated roughly by the structure section (Fig. 18). The sedimentary rocks of the Mecca Hills dip southwest down the canyon for a distance and then rise in an abrupt anticline at the junction of Burnt Palms Wash. (See also structure section at Burnt Palms, Fig. 17.) The exact nature of the exposure of volcanic rock is a little puzzling, and it was examined only very hastily in the gathering dusk. It appears, however, to be intrusive into the sediments. The capping of coarse schist conglomerate is apparently unconformable with slight discordance over the finer gravels beneath.

Hoover Well, at the east end of Carrizo Mountain and according to report about 1 mile west of a marble quarry, is "a reliable well at a little amphitheater in a narrow canyon." 28a

The Laguna is a small lake at a high altitude near the crest of the Peninsular Range in T. 15 S., R. 5 E. Little is known about it. Other small lakes are reported in the vicinity.

28a See Chase, J. S., California desert trails, p. 279, 1919.
DETAILED DESCRIPTIONS.

The following description of a nameless spring in the Laguna Mountains is taken from field notes accompanying withdrawal No. 331, public water reserve No. 14, California No. 2: The spring is in the NW ¼ NW ¼ sec. 24, T. 15 S., R. 6 E., near the head of a deep canyon of northeasterly trend (evidently Canebrake Canyon). Water seeps from the ground under a large granite boulder, flows for 100 feet, and sinks in sand. The flow is about 5 gallons a minute. The spring is 6 miles from a wagon road (probably the Julian-El Centro road) and 3 miles from water (Canebrake Canyon). The surrounding rocks are gray granite.

Lost Horse Well, also known as Lost Horse Spring, is in the NE ¼ sec. 21, T. 2 S., R. 8 E. It is reached by a branch road that turns south 2.8 miles east of Quail Spring at a fork marked by a Geological Survey sign, from which it is 5.5 miles. It is also accessible by a dim road leading south 1.1 miles southeast of the Geological Survey sign at the Keys ranch, from which it is about 3 miles. It is in the east edge of a high valley on the north edge of the Little San Bernardino Mountains and is at the foot of a long granite spur a few hundred feet high which forms the east wall of the valley. The position of the well is marked by two great patches of very white granite surrounded by much darker rock on the mountain side just east of the well. At the place is a good adobe house, several outbuildings housing various kinds of machinery, and two dilapidated windmills. The place was abandoned in December, 1917, but is used as a mining camp when the Lost Horse mine, about 4 miles to the southeast in the granite ridge, is being operated. The original spring consisted of an open hole dug into residual granitic soil along a small arroyo. Near the place is a bunch of mesquite, the indication of water. A well has been sunk near this spot on the south, and as a result the spring has gone dry. This well was 39 feet deep and the depth to water 27.5 feet on December 15, 1917. It has a board curb in bad condition, and the water appeared dirty and full of trash. The windmill was not in order, and no bucket or rope was provided. The water is good when the well is clean. North of this well is another on the opposite side of the little arroyo, also equipped with a windmill that was out of repair. This well was an open shaft 4 feet square in pink granite. The bottom was full of dirt but showed a little water. The first well is 4 by 6 feet and is dug in granite soil for 3 feet and solid rock below that depth. The total supply of water available is evidently small.

Magnesia Spring is a small spring of poor water in Magnesia Canyon, in sec. 14, T. 5 S., R. 5 E. It can be reached by wagon from the Banning-Brawley road but is almost never used as a watering place. It may be of some importance to prospectors.

Martinez, in sec 16, T. 7 S., R. 8 E., is a settlement in the western part of Coachella Valley, off the beaten track of travel. Little is known of it, but it is a possible watering place and is accessible by various rural roads.

A large tank is reported by several persons to exist near the center of the Maria Mountains in a big canyon draining west. It is said to be approachable within a short distance by wagon on the west and to be connected with Willow Spring, 3 miles to the east, by a burro trail. It holds water most of the year.

Mohave Tank is in T. 3 S., R. 20 E., probably in or near sec. 28. It is in a canyon in the north edge of the Little Maria Mountains and is accessible from the Blythe-Rice road. It can be reached by going southwest from Gyp Well on a plain road, turning to the right about half a mile from the well, and following a dim wagon trail southwestward toward a gap very plainly visible in the mountains. At about 3½ miles from Gyp Well the road ends beside a deep gully in the edge of the mountains. A burro trail goes on across the pass to Chandler Well. Mohave Tank is in the bed of the gully about 100 yards south of the end of the wagon road. The tank occupies a hole formed by flood waters pouring over a cliff about 15 feet high in the canyon bed. When visited in October, 1917, a pool of water 12 to 15 feet in diameter and 2 to 3 feet deep stood in the little basin. A large amount of sand and gravel filled the bottom of the hole, so the actual water content was probably con-
siderably greater than it appeared on the surface. The surrounding rocks are granite gneiss, and a vertical fracture transverse to the canyon seems to have produced the tank, the rock above the fracture having resisted erosion while that below has been gouged away. The cliff so formed on the south and the steep walls on the east and west afford good protection from the sun, and water remains here for a long time in good condition after the tank is filled by rains. Natives say that it has never been known to be entirely dry. The tank is a favorite watering place for mountain sheep and other wild animals, of which signs are plentiful. Its remoteness from roads and settlements, however, causes it to be of small importance to travelers.

*Mortmar* is a station on the Southern Pacific Railroad about 8 miles southeast of Mecca and 1 mile off the road to Dos Palmas. Water is hauled from Mecca, but flowing wells also exist in the neighborhood. It constitutes a possible watering place but is off the usual lines of travel.

*Mule Springs* are described in nearly every publication on the desert of southeastern California, and their location is generally given as somewhere near Wiley Well. The writer was unable to discover any indication of the springs or any person who knew their location and does not believe that they exist. There was once a Mule Springs Station on the old Ehrenberg stage road, and its ruins are still visible 5.8 miles west of Wiley Well. A well formerly existed in the wash near the ruins, but the well is filled up and utterly obliterated. Its location is said to have been near two mesquite trees that are still standing.

*Packard Well*, also called Packer Well, is about 2 miles west of Adams Well, at the west base of the Palen Mountains. It is near the border line between Tps. 2 and 3 S., R. 18 E., and its sectional location is doubtful. The road that once led east past Adams Well and connected with Brown Well and McCoy Spring is now impassable. However, a plain and apparently passable road leads southwest from the well. This road connects with Palen Well, Boulder Well, and other places in the Chuckwalla Valley but has long been unused. It is probably passable for wagons. At the well is a county signpost which points east and says "Brown's Well 20 miles." The wreck of a hand windlass stood over the well in November, 1917, and a battered bucket and baling wire afforded a means of getting water. The well stood open, however, and the water was full of filth and debris and was very uninviting. It is said to be poor but drinkable when clean. An analysis of the water is given on page 283 (No. 37). The well is on the south side of a small wash, and just south of it rises a sharp ridge of brown or yellow marble in which a small prospect tunnel shows up rather conspicuously about 50 feet from the well. In the wash grow several clumps of rank mesquite. The well passes through a few feet of wash gravel into marble and granite bedrock. It measured 28 feet deep, and the depth to water was 18 feet. The available supply is probably small, and the well is reported to have been nearly dry at times.

*Palen Well* is in sec. 35, T. 4 S., R. 16 E., about 4 miles east of Boulder Well. It is on the west edge of Palen Dry Lake, and the water is said to be shallow, 12 or 14 feet, but the well is reported now to be filled up, and water is probably not obtainable there. The water is said to have been brackish. An old road leads to the place and on northeast to Packard Well but is probably in very poor condition.

*Palm Spring*, San Diego County, should not be confused with Palm Springs village in Riverside County. Neither are there palm trees near it, although some are said to have grown there years ago. It is in sec. 25, T. 14 S., R. 7 E. about half a mile north of a trail leading down the dry bed of Vallecito Creek from Vallecito to Carrizo. It can be reached by turning aside from the trail. There are mesquite trees at the place. A small seep of water issues from the base of some clay hills, but it is said to be necessary sometimes to dig for water. The place was not visited during this investigation.

*Palm Wash*, in secs. 21 and 22, T. 10 S., R. 9 E., contains several little seeps of water marked by a few palm trees. They can be reached by following an arroyo west
from the Coachella-Brawley road, but the place is hard to find. The arroyo is crossed 8½ miles of Fish Spring, and the springs are about 3 miles away. The water is bitter and undrinkable. Drinkable water is said to have been found at places in the arroyo by digging pits and using the water continuously.

**Pinkham Well** is a water hole developed by C. A. Pinkham, of Mecca, somewhere in an arroyo draining north out of the Cottonwood Mountains about 7 miles from Cottonwood Spring, from which it can be reached by a poor wagon road. The supply is said to be reliable, and the well is used by prospectors.

**Priest Well** is in T. 2 S., R. 20 E., probably in sec. 8, and is reached by a branch road that turns west from the Blythe-Rice road 3.7 miles from Rice. It is in the Blythe Junction Basin, about 2 miles north of Brown Well and 1 mile from the base of Arica Mountain. The well was drilled in the summer of 1917 by a mining man named Priest. In October, 1917, there was a pumping plant at the well which delivered water to the Assets Realizing Mining Co.'s gold mine, 2 miles to the west, in the summit of Arica Mountain. The plant was equipped with No. 3½ Dow duplex pumps driven by 20-horsepower gasoline engines. This pumping outfit is said not to produce any noticeable drawdown in the water, but no tests for capacity of the well have been made. Mr. Cox, superintendent of the mine and pumping plant, reported the depth of the well as 587 feet and the depth to water as 507 feet. The casing is 10 inches in diameter at the top and 4 inches at the bottom. The water is salty and is not used for domestic purposes. (See analysis No. 42, p. 283.)

**Red Butte Spring** is a little-known spring reliably reported to exist in the north end of the Palo Verde Mountains near a prominent peak called Red Butte, in T. 9 S., R. 20 E., probably in sec. 9 or 10. No roads lead to the spring, and it is reached only by burro trails. The location is given as a quarter of a mile northeast of the base of Red Butte, in a little canyon coming from that mountain. The place should be easily found, as Red Butte, which is really not a butte but a sharp-pointed round peak, possibly a volcanic neck, is an unmistakable landmark. When viewed from the north or east it appears as an isolated red peak at the north end of the Palo Verde Mountains, not far from the Flat Top Mountains, two broad table-like summits that are easily distinguished to the west. The water is said to seep out of rock in the canyon. The flow is small but unfailing. Mr. Wiley, of Palo Verde. The name Clapp Spring has also been used for it but does not seem to be very widely accepted.

**Salton** is a station on the Southern Pacific Railroad at the northeast corner of Salton Sea. The place was once important as the center of salt-mining activity in the Salton Basin, but the flooding of the basin has ended the industry. Salton is accessible by a road from Dos Palmas or by a wagon road along the railroad. Both are bad, and the place is not often visited. It consists of a few buildings owned by the railroad company. Water is hauled from Mecca by the railroad, and travelers can get water there if necessary.

**Seven Palms** is an artesian spring about 3 miles east of Palm Springs Station, in sec. 18, T. 3 S., R. 5 E. It is on a poor wagon road leading from Palm Springs Station to Edom and is seldom frequented by travelers. A pool of water several feet in diameter directly by the roadside issues from a little basin in alluvial soil at the base of a large cluster of wild palm trees. There is a dense mat of arrow weed, cane, and mesquite about the pool. The water appears to be of good quality. The region is one of shallow ground water, caused by a damming of the underflow contributed to upper Coachella Valley as it nears the Indio Hills. (See p. 75.) The supply is probably several gallons a minute.

**Seventeen Palms** is a spring in the badlands south of the Santa Rosa Mountains, on the south line of sec. 35, T. 10 S., R. 8 E. The spring is seldom visited at present.
except by prospectors, and the road to it is almost impassable. The writer attempted to visit it but failed to find the way. The following description is given by Mendenhall:

Seventeen Palms Springs lie at an elevation of 410 feet (U. S. Geological Survey), near the junction of three washes, in the clay hills south of the Santa Rosa Moun­tains. At present only eight or nine palm trees stand near them, the remainder of the seventeen from which the springs were named having been destroyed by fire. The springs are about 12 miles by wagon road east from Borego Spring, or 45 miles from Julian, but the road is little used, is dim, and may be difficult to follow, particularly after the winter rains. Broken clay hills and deep washes surround the springs. Grass and wood in small quantity may be found near them. When they are kept open the water is fairly good, but it becomes bitter and bad by neglect and disuse. The soil is impregnated with alkaline salts.

Later information indicates that the place can be reached by a trail that goes northeast from the Warner-Brawley road (see p. 226) at a point near the north end of Borego Mountain. (See Pl. II.)

Soda Springs are in sec. 36, T. 10 S., R. 9 E., about 2½ miles north of McCain Spring and the same distance west of the Coachella-Brawley road. They are in a wash leading up to Seventeen Palms and are probably accessible if the right arroyo is found on leaving the main road. The springs are at the base of a prominent hill called Clay Point, which is just above the old beach line. The water is very bitter, almost undrinkable. The springs were not visited.

Stirrup Tank, 2½ miles south and a little west of White Tank, in the north edge of the Hexie Mountains, is a natural rock tank said to contain water at times. It is in an inaccessible and little visited locality and is of use and importance only to prospectors.

Stubby Spring is in the SE. ¼ sec. 27, T. 2 S., R. 7 E., near the summit of the Cottonwood Mountains. A wagon road, said not to be very good, leads east to the Lost Horse Well, about 7 miles away, and a trail once led south to Indio past a place called Thousand Palms Canyon but is now impassable. The spring is said to yield about a miner's inch (11 gallons a minute) of good water and is always reliable.

Sunset Spring is in sec. 7, T. 14 S., R. 16 E., in the east side of Imperial Valley. It is a seep of water from moist alkaline soil and is due to the escape of imperfectly confined artesian water in the Holtville area. The spring is now in the center of a field and is important only historically and as an indication of ground-water conditions. It was once a useful watering place, but its location is at present almost unknown even to local residents.

Talmadge Well is a flowing well owned by W. S. Talmadge in sec. 8, T. 3 S., R. 5 E., in upper Coachella Valley. It is about half a mile northeast of Seven Palms and 3½ miles from Palm Springs Station on the road to Edom. This road is bad and seldom traveled. The well has a 12-inch casing and is about 300 feet deep. A barrel is fitted over the top of the casing, and water flows into the barrel and out through a pipe into an earthen reservoir about 100 feet square. The flow is about 15 gallons a minute. It is used to irrigate a small plot of land and to water stock. Water is shallow in this area, owing to the damming of underground drainage behind the Indio Hills. (See p. 75.) Analysis (No. 48, p. 283) shows a rather high mineral content, particularly of sulphate, but the water tastes good and is freely used for drinking. There are no buildings at the well.

Thousand Palms Canyon is a celebrated but rather difficultly accessible water hole in the northeast corner of T. 4 S., R. 6 E. It was not visited, but considerable second-hand information about it is available. The canyon is cut through the Indio Hills, which at that point probably consist of folded Tertiary sediments. Water rises over some obstruction and flows in a considerable stream. C. W. King, of Indio,
saying that there is probably 150 miner's inches (3 second-feet) of water of fair quality. A survey made by the Southern Pacific Co. for a gravity water supply for Indio indicates an estimate of several hundred gallons a minute available here. The canyon can be reached by a poor wagon trail from Indio, but the exact route is unknown. The trail once led on to Stubby Spring. There is a remarkably large grove of palms in the canyon.30

In the western part of T. 11 S., R. 21 E., are a group of manganese claims that were developed commercially in 1918, owing to the demand created by the war. Owners of one property, called the Tolbard mine, are reliably reported to have made a well about 2 miles south of the mine in a large arroyo leading northeast and obtained good water for use at this mining camp.

Toro Springs are on the western border of the southern part of Coachella Valley and were once important desert watering places. They are now off the main lines of travel and are important chiefly to the Indians of the surrounding reservation. The springs are in sec. 1, T. 7 S., R. 7 E. They are understood to be of the artesian variety. They are accessible by various roads of the network now existing in Coachella Valley.

Willow Holes should not be confused with Willow Spring, in the Maria Mountains. It is a spring in sec. 21, T. 3 S., R. 5 E., and originates in a ciénaga in the Indie Hills very similar to the Thousand Palms Canyon, according to report. It was not visited by the Survey party, but information concerning it is reliable. There is a small stream of good water the year around, which rises in a wash or canyon passing through the hills. It is probably brought to the surface by a natural rock dam. The place is accessible by a poor wagon road from Palm Springs Station or from Edom.

It is reported on good authority that a little-used but reliable water hole called Willow Spring exists in a canyon in the east end of the Maria Mountains. Its approximate location is shown on the map (Pl. III). The spring is accessible by a trail that branches from an old road leading up the west side of Colorado River from Blythe Intake toward Parker. This trail is said to turn west about 7 or 8 miles north of the intake and not far from an abandoned limekiln. It leads up a canyon to Willow Spring, which is about 3 miles away and which yields a small flow of good water. A number of willows give the place its name. A burro trail is said to lead west to an unnamed tank in the Maria Mountains. Nothing is known of the condition of the roads that lead to Willow Spring except that they are very little used and were never very good.

Zacaton Spring is shown on the United States Geological Survey reconnaissance topographic map of Salton Sink in sec. 8, T. 11 S., R. 9 E., about halfway between Soda Springs and Seventeen Palms, in the same arroyo. Nothing more is known of it. It is probably a seep of bitter water from clay hills or in the bed of an arroyo.

### ANALYSES.

Mineral analyses and classification of waters in the Salton Sea region, California.

[Parts per million except as otherwise stated.]

**Desert watering places.** (See Figs. II and III.)

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<th>Owner</th>
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<td>Dec. 4, 1917</td>
<td>M. D. Foster.</td>
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<td>C. H. Kidwell.</td>
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<td>Desert Laboratory, Carnegie Institution, Tucson, Ariz.</td>
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<td>Nov. 6, 1917</td>
<td>A. T. Geiger.</td>
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<td>Dec. 4, 1917</td>
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<td>A. T. Geiger.</td>
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Wells in Holtville area, Imperial Valley. (See pp. 83-84 and Fig. 7.)

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Determined quantities.

Desert watering places. (See Pis. II and III.)
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Na-COs. Bad......
Ca-COs . Poor.....
Na-COs. ...do.....
Na-SO«. Very bad.
Na-SOi. Fair.....
Na-Cl... ...do.....
Ca-Cl... ...do.....
Na-Cl... ...do.....
Ca-COs . Poor.....
Ca-COj . ...do.....
Na-Cl... Very bad.
Na-Cl... ...do.....
Na-COs. ...do.....
Na-Cl... ...do.....
Na-SOi. Bad......
Na-Cl... Very bad.
Na-SOi. ...do .....
Na-Cl... ...do.....
Na-SO*. ...do.....
Na-Cl... ...do.....
Ca-COs . Poor. ....
Na-Cl... Very bad.
Na-COs. Good ....
Na-COs. Fair.....
Na-Cl... Very bad.
Na-COs. Good ....
Na-COs. Fair.....
Na-COs. Good ....
Na-CO». ...do.....
Na-Cl... Very bad.

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Mineral analyses and classification of water in the Salton Sea region, California Continued.

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| 34 | 35 | 36 | 37 | 38 | 39 | 40 | 41 | 42 | 43 | 44 | 45 | 46 | 47 | 48 | 49 | 50 | 51 | 52 | 53 | 54 | 55 | 56 | 57 | 58 | 59 | 60 |
|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|
| 33 | .68 | 19 | 11 | 219 | .0 | 356 | 77 | 137 | 2.2 | 11 | 708 | 93 | 130 | 500 | 4.7 | High | Na-Cl | Very bad | Fair | Poor |
| 35 | 2.0 | 29 | 17 | 238 | .0 | 170 | 158 | 252 | .34 | 3.8 | 818 | 142 | 150 | 640 | 7.4 | ...do | Na-Cl | ...do | ...do | ...do | Fair |
| 36 | 26 | 43 | 18 | 138 | .0 | 134 | 109 | 140 | 1.7 | 5.1 | 555 | 129 | 140 | 370 | 13 | ...do | Na-Cl | Bad | ...do | ...do | Do |
| 37 | 74 | .37 | 352 | 42 | 408 | .0 | 283 | 170 | 1,074 | 4.6 | 61 | 2,377 | 1,030 | 1,200 | 1,100 | 1.9 | Very high | Na-Cl | Very bad | Unfit | Poor |
| 38 | 54 | .24 | 1.7 | .39 | 72 | 40 | 25 | 39 | 32 | Trace. | 2.1 | 243 | 6 | 60 | 190 | 14 | Moderate | Na-Cl | Good | Fair |
| 39 | 21 | .67 | 64 | 27 | 153 | .0 | 189 | 214 | 102 | Trace. | 6.6 | 729 | 271 | 250 | 410 | 16 | ...do | Na-Cl | Very bad | Fair | Do |
| 40 | 27 | .21 | 100 | 44 | 196 | .0 | 319 | 386 | 181 | 3.0 | 24 | 1,094 | 840 | 480 | 530 | 9.9 | ...do | Na-SO4 | ...do | Poor | Do |
| 41 | 39 | 1.6 | 38 | 6.8 | 355 | .0 | 111 | 324 | 343 | .70 | 2.4 | 1,199 | 121 | 160 | 990 | 5.3 | ...do | Na-Cl | ...do | Fair | Poor |
| 42 | 28 | 1.1 | 82 | 29 | 811 | .0 | 95 | 766 | 842 | 25 | 18 | 2,851 | 324 | 320 | 2,300 | 2.2 | Very high | Na-Cl | ...do | Bad | Do |
| 43 | 20 | .28 | 63 | 20 | 146 | .0 | 281 | 175 | 101 | 1.5 | 5.6 | 635 | 240 | 245 | 390 | 16 | High | Na-Cl | Poor | Fair | Fair |
| #44 | 12 | .60 | 298 | 272 | (b) | 114 | | | | | | 2,079 | 7,876 | | | | | | | | | | | | | | |
| #45 | 63 | 40 | 622 | 250 | /2.721 | 11 | | 134 | 3,539 | 3,221 | 1.8 | 238 | 10,995 | 2,600 | 2,300 | 7,300 | .5 | ...do | Na-Cl | ...do | ...do | Do |
| 46 | 0.58 | 27 | 1.9 | 125 | 14 | 224 | 77 | 39 | 1.3 | 4.6 | 436 | 71 | 130 | 340 | 8.3 | Moderate | Na-Cl | Bad | Good | Fair | |
| 47 | 64 | 1.5 | 80 | 12 | 18 | .0 | 300 | 13 | 13 | 12 | 5.4 | 379 | 249 | 320 | 49 | .20 | ...do | Ca-SO4 | Poor | Fair | Good |
| 48 | 20 | .08 | 86 | 24 | 139 | .0 | 101 | 439 | 53 | 1.6 | 12 | 838 | 313 | 810 | 380 | 24 | High | Na-SO4 | ...do | Do |
| 49 | 53 | .... | 10 | 44 | 286 | Trace. | 255 | 507 | 152 | Trace. | 40 | 1,376 | 433 | 420 | 770 | 9.7 | ...do | Na-SO4 | Very bad | Poor | Fair | |
| 50 | 74 | 1.6 | 21 | 57 | 11 | 2.8 | 57 | 11 | 2.8 | 57 | 93 | 38 | 89 | 240 | 16 | ...do | Na-Cl | Very bad | Good | Fair | |
| 51 | 46 | 26 | 4.3 | /15 | | 120 | 24 | 5.3 | 135 | 96 | 110 | 40 | 23 | ...do | Ca-SO4 | Good | ...do | ...do | Good |
| 52 | 69 | .17 | 152 | 15 | 177 | 16 | 225 | 376 | 151 | 12 | 8.3 | 1,234 | 2,430 | 150 | 480 | 12 | High | Na-SO4 | Very bad | Poor | Fair | |
| 53 | 43 | 18 | 326 | 115 | 174 | 178 | 282 | 1,457 | 832 | 5.6 | 2.2 | 3,746 | 1,290 | 1,200 | 2,000 | 2.2 | Very High | Na-SO4 | ...do | Unfit | Poor | |

* Computations and classifications follow the system used by Dole and described in Water-Supply Paper 308.
* Sodium and potassium are computed but are included under determined quantities in order to maintain the usual arrangement of bases and acids.
* Depth in inches of water which would yield on evaporation sufficient alkali to render a 4-foot depth of soil injurious to the most sensitive plants.
* Reported by Southern Pacific Co. In hypotetical combinations in grains per gallon; recalculated into ionic form in parts per million; carbonate expressed as bicarbonate; total solids by summation.
* Includes iron and aluminum.
* / Determined.
* Published in Geol. Rev., June, 1917, p. 408.
* Determined; Na=5.258; K=57.
* Determined at 110°C.
* Expressed in milligrams per liter.

Wells in Holtville area, Imperial Valley. (See pp. 88-84 and Fig. 7.)
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