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GEOLOGY AND MINERAL DEPOSITS OF SOUTHERN YUMA COUNTY ARIZONA

BY
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HOMER LEROY SHANTZ, PH.D., SC.D. .... President of the University

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PREFACE

One of the things that the Arizona Bureau of Mines has always wished to do is to issue reports that cover the geology and mineral resources of parts of Arizona that are known to be mineralized, but concerning which little or no information is in print. There are certainly vast areas of this kind in the State, but the Bureau has been unable to do much along this line because the funds needed have not been available. Several bulletins of the type under consideration have been issued, however, and they have been very well received. It is to be hoped that, in the future, the Bureau will be supported more adequately and that it can much more rapidly secure and disseminate information concerning parts of the State that have never previously been described. There is a very great demand for such publications, and, if they are available, interest in the areas involved will undoubtedly be aroused and capital may be attracted to Arizona.

The following report on "The Geology and Mineral Deposits of Southern Yuma County" is the most pretentious bulletin of the kind that has yet been issued by the Bureau, and it is fortunate that it can be distributed at just this time when so much interest is being shown in prospecting, particularly for gold. Because of the climatic conditions that prevail there and the lack of good roads in many parts of the county, it has not been easy to prospect southern Yuma County at all thoroughly, but, in spite of these facts, that area has already produced over $10,000,000 worth of metals. It is, therefore, at least possible that other deposits that can be worked profitably under existing conditions may exist there and may be discovered by the determined, courageous prospectors that will undoubtedly seek for gold there within the next year or two. It is hoped that the information contained in this bulletin will be found helpful to them and may lead to increased prosperity for southwestern Arizona.

G. M. BUTLER.

Feb. 15, 1933.

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CHAPTER I — INTRODUCTION

SITUATION AND EXTENT OF AREA

Yuma County, constituting the southwesternmost portion of Arizona, is bounded on the south by Sonora, Mexico, and is separated on the west from California and Lower California by the Colorado River. In maximum width, the county extends westward from longitude 113° 20′ to near longitude 114° 29′, a distance of some 87 miles. *Southern* Yuma County, as considered in this report, reaches north for a maximum length of 100 miles, to Township 2 North, Gila and Salt River Base Line, and includes an area of some 6,656 square miles, or more than that of the states of Connecticut and Rhode Island combined.

PURPOSE AND SCOPE OF WORK

The field work for this report was begun in December, 1929, and continued at intervals during 1930, 1931, and 1932. In all, the writer spent approximately six months within the area. The purpose of this work was to obtain general facts regarding the geology and mineral deposits of the whole region, together with information of a more detailed character about certain districts and critical areas. Heretofore, no systematic geologic investigation, even of a reconnaissance nature, has dealt with the mineral deposits over all of southern Yuma County, although since 1858 these deposits have possessed unusual glamor to prospectors. Many important features of the region's geology and geography have remained but vaguely known, and some of its mountain ranges have never before been visited by a geologist.

For this report, the general geologic features of all the mountain ranges were studied and mapped (see Plate 1). Topographic base maps, issued by the U. S. Geological Survey, were available for an area of some 2,400 square miles along the Gila River. Less detailed topographic maps, prepared by the International Boundary Commission, were used for an irregular strip, from one to five miles wide, along the international boundary. The outlines given by the Geologic Map of Arizona, issued by the Arizona Bureau of Mines, for the northern Trigo Mountains, western Middle Range, western Chocolate Mountains, northeastern Little Horn Mountains, Gila Bend Mountains, Cemetery Ridge, and Clanton Hills were modified by reconaissance compass traverses. All of the other mountain ranges in the area were re-mapped, on a scale of two miles per inch, by plane table, using the known mountain peaks, U. S. General Land Office Survey corners, or international boundary monuments for control.

All of the more important known mineral deposits, as represented by more than 145 mines and prospects, were examined, but could not, in the time available, be studied in great detail. A few relatively unimportant prospects, because of their scientific interest or local accessibility, received brief attention.

ACKNOWLEDGMENTS

The mining people of this region extended generous hospitality and all possible cooperation. Only a few concerns failed to respond to requests for information.

At the University of Arizona, Professor B. S. Butler gave the writer valuable advice upon many problems. Mr. J. B. Tenney, of the Arizona Bureau of Mines, compiled data on the history and production of the principal mining districts. Mr. Robert Heineman, of the Arizona Bureau of Mines, made various chemical tests, prepared many laboratory photographs and petrographic slides, and aided the writer during one week in the field. Professor J. J. Thornber identified several botanical specimens.

Inasmuch as part of this report was prepared during the winter of 1931-32, while the writer was at Harvard University, acknowledgments are due the Division of Geology of that institution for the use of certain laboratory equipment. There, also, Professors L. C. Graton and D. H. McLaughlin offered valuable suggestions upon certain general problems relating to the mineral deposits. Professor Kirk Bryan, with first-hand knowledge of the regional geology and physiography, critically read part of the manuscript, and contributed many important ideas. Professor E. S. Larsen pointed out solutions for certain petrographic and petrogenetic problems. Mr. E. A. Goranson aided the writer in some of the microscopic work.

Acknowledgments to the earlier investigators who have worked within southern Yuma County are given in the Appendix (page 222).

DRAINAGE

Colorado River: One of the principal rivers of the United States, the Colorado,[1] forms Yuma County's western boundary.

Gila River: The Gila River extends westward across southern Yuma County to join the Colorado River twenty miles upstream from the international boundary. Except for occasional floods, the Gila River bed is now dry and in places brushy. Before the expansion of irrigation that followed construction of the Roosevelt, Gillespie, and Coolidge dams, however, this river was of considerable magnitude and difficult to cross except at favorable fords. In 1700, according to Kino,[2] it contained abundant fish throughout the year. Bancroft[3] states that, in 1849, the Gila River was navigable by a sixteen-foot flatboat, equipped with wheels for use on land, as far upstream as the Pima villages (near the mouth of the Salt River). In the summer of 1899, according to Ross,[4] it contained five or six feet of clear water that flowed between cottonwood-lined banks through strips of good grazing land.

Ephemeral washes: Except for the Colorado River, no perennial stream exists in this area, but branching, interlacing, ephemeral washes, which head in the mountain canyons and in numerous rills on the plains, carry to the Colorado and Gila rivers the surface waters that escape evaporation, absorption by the alluvium, and transpiration by the vegetation. At times, they are augmented by sheet floods.

RELIEF

This region consists of great plains, ridged with abrupt, sharply eroded mountains. As shown by Plate I, some 32 ranges or groups of mountains lie within southern Yuma County and occupy a total of approximately 1,750 square miles, or 26.3 percent of the area. These ranges have a general northwestward trend, except in the northwestern quarter of the area where they strike northward or slightly northeastward. They are from eight to 36 miles long by less than ⅛ to more than sixteen miles wide. Their width generally varies with their height, but bears no relation to their length. Most of the peaks are less than 2,000 feet, but the highest are probably 4,000 feet above sea level. As a rule, no transitional zone exists between the plains and the mountains many of which slope from 30° to 45° or more.

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[1] For accounts of the lower Colorado River, see Sykes, Godfrey, The delta and estuary of the Colorado River: Geog. Review, vol. 16, pp. 232-255, April, 1926; also La Rue, E. C., Colorado River and its utilization: U. S. Geol. Survey Water-Supply Paper 395. 1916.

[2] Bolton, H. E., Kino's historical memoir of Pimeria Alta, vol. 1. 1919.

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

[4] Ross, C. P., The lower Gila region, Arizona: U. S. Geol. Survey Water-Supply Paper 498, pp. 66-67. 1923.

The plains are from ½ to 25 miles wide, and, except where terraced, form relatively gentle slopes.

The northern and southern portions of this area differ somewhat in relief.

North of the Gila River, the mountains consist largely of irregular, blocky ridges, buttes, and spires together with steep-sided mesas. Their surrounding plains rise some 1,600 feet in a distance of forty miles from the Gila River, and, except near the Colorado and Gila rivers, are relatively free from dune sand. Because of their gradient, these plains have been dissected by numerous arroyos which are from three to twenty feet deep.

South of the Gila River, most of the mountains are made up of narrow, steep-sided, sharp-crested ridges. Their side limits, although ragged in detail, general conform to straight or gently curved lines. Their surrounding plains, which are relatively low and extensively mantled with wind-blown sand, have been notably dissected only near the mountains.

CLIMATE

Southwestern Arizona, southeastern California, and northwestern Sonora constitute one of North America's most pronounced deserts, where the climate is characterized by intense heat in summer, sharp chill in winter, and long periods of aridity separated by violent storms. Practically no snow falls in this region.

Rainfall: Each fall of rain here is an episode, but annual and mean rainfalls show in a marked way the complex influences of geographic features. As Sykes [5] says, "So far there is no tangible evidence of any conditions approaching a climatic cycle or pulsation; but, on the other hand, features of surface relief, even apart from the question of altitude, seem to be determining factors in inducing or deterring precipitation."

At Yuma (elevation 141 feet above sea level), the average yearly rainfall from 1870 to 1921, inclusive, was 3.33 inches,[6] but, for the 47 years prior to 1929, it amounted to only 3.10 inches.[7] There, April, May, June, and July have been the driest months, with an avrage, for May, of 0.03 inch, and, for June, 0.00 inch. Mohawk, which is some fifty miles farther east and 538 feet above sea level, has an average yearly rainfall of 3.69 inches. Certain portions of the region may receive practically no rain for a year or more at a time, or, again, they may receive unprecedented deluges. Floods may destroy portions of a railway where, for

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[5] Sykes, Godfrey, Rainfall investigations in Arizona and Sonora by means of long-period rain gauges: Geog. Review, vol. 21, pp. 229-233. April, 1931.

[6] Bryan, Kirk, The Papago country, Arizona: U. S. Geol. Survey Water-Supply Paper 499, p. 32. 1925.

[7] Smith, H. V., Climate of Arizona: Univ. of Ariz. Agri. Exp. Sta. Bul. 130, table 13. 1930.

several years, automobile tracks in the soil have remained unobliterated. As Bryan [8] says, "Yuma has had as little as 0.6 inch in 1899 and as high as 11.41 inches in 1905. The highest monthly rainfall in 51 years occurred in August, 1909, when 6.25 inches fell — nearly twice the normal annual rainfall. On September 30, 1921, 3.63 inches of rain fell in 24 hours. . . . On August 16, 1909, 3.33 inches fell. The effect of such storms in erosion and in the transportation of debris by floods on ephemeral streams is obvious." At Tule Tanks, which is near the Mexican border and nearly 1,400 feet above sea level, Sykes [9] made the following observations on the quantity of rainfall for successive six-month periods: 1.15, 6.50, 1.26, 0.00, 0.70, 0.00 inches. He states that the high figure of 6.50 inches was accumulated during a single storm period in October, which is generally considered to be one of the dry months in the year, and that less than two inches of rain fell in the two-year period following this great downpour. A recent example of the surprisingly torrential character of such occasional storms occurred during February, 1931, when serious floods from the south, in Coyote Wash, swept away part of the town of Wellton, together with several neighboring stretches of railroad and highway, and drowned one person.

Sykes [10] groups the distribution of rainfall in southern Arizona and northern Sonora as follows: winter, comprising December, January, February, and March, 35 percent of yearly total; spring, April, May, and June, 10 percent; summer, July, August, and September, 45 percent; and autumn, October and November, 10 percent. He states, further, that most of the winter and summer rain is frequently concentrated into a few heavy storms.

Temperature: According to Smith,[11] the extremes of low and high temperature on record for southern Yuma County are as follows: Yuma, 22° and 119°; Mohawk, 22° and 126°; and Quartzsite, 9° and 125°. During summer, the daily range in temperature may be as much as 75° or more. The effect of such daily and seasonal variations of temperature upon rock disintegration is discussed elsewhere in this report.

From October to April, inclusive, the climate tends to be very pleasant. Due to low humidity, the high temperatures of summer are endurable to a healthy person amply supplied with drinking water. Nevertheless, inexperienced travelers should not forget that distances between many of the watering places are still rather great, especially for a person on foot, and that 24 hours of thirst in hot weather may be fatal.

Evaporation: Smith [12] states that the natural evaporation pos-

[8] Bryan, Kirk, work cited, p. 31.
[9] Work cited, p. 233.
[10] Work cited, page 229.
[11] Smith, H. V., work cited.
[12] Work cited.

sible at the Yuma Citrus Station, eight miles southwest of Yuma, amounts to 121.4 inches of water per year, or more than thirty times the annual rainfall there.

Winds: At Yuma, the winds from October to March are prevailingly from the north, but, during the rest of the year, are almost entirely from the southwest or west. Although dust storms often occur, wind erosion is of very minor importance.

VEGETATION

The mountains, whose rocky surfaces have moist soil only in a few protected crevices, support very little vegetation, and, from a distance, appear as quite bare rock. Scattered sahuaro, cholla, creosote, ironwood, ocotillo, and palo verde, are present. In favorable, sheltered spots, certain grasses thrive, and, in some of the ranges, the tall, slender, desert milkweed, *Asclepias subulata,* of interest because of its rubber content, is conspicuous. In certain montane valleys, an Indian wheat, Trigo *(Plantago ignota),* much relished by cattle, is abundant. The mountain canyons that contain shallow ground water support cottonwood and sycamore trees. In some of the canyons of the S. H. or Kofa range, wild palm trees occur.

On pediments and alluvial slopes, creosote brush, ocotillo, various cacti, and sage-like brushes predominate in a relatively thin growth that seldom exceeds a few feet in height.

On the plains, sahuaro, palo verde, mesquite, screwbean, ironwood, and catsclaw grow more or less sparsely. Along the temporary water courses, or arroyos, these plants, along with more or less desert willow, hackberry, and ghost tree *(Parosela spinosa),* form linear thickets, in places fifteen or even thirty feet high.

The sand dunes in places support a sparse growth of desert buckwheat and various shrubs. On some of the silt flats, or playas, mesquite and several varieties of grass thrive.

Along the bottom lands of the Colorado and Gila rivers are jungles of arrow weed, willow, mesquite, reed grass, and salt grass. The mesquite and cottonwood groves that once fluorished there have been largely chopped out.

Relation of the vegetation to ground water:[13] As stated by Meinzer, "Perhaps the most outstanding feature of the flora of the desert is its relation or lack of relation to the water table. On the one hand are the plants which are adapted to extreme economy of water. . . . On the other hand are plants that habitually grow where they can send their roots down to the water table." Meinzer uses the term "ground water" to designate the water in the zone of saturation, or the zone below the water table. Ac-

[13] Meinzer, O. E., Plants as indicators of ground water: U. S. Geol. Survey Water-Supply Paper 577. 1927.
Bryan, Kirk, Change in plant associations by change in ground water level: Ecology, vol. IX, pp. 474-478. Oct., 1928.

cording to Bryan, plants are the best indicators of ground water if they are living under the stress of being near their natural environmental limits.

As an adequate discussion of these important relations is obviously beyond the scope of this bulletin, the reader desiring further information upon the subject is referred to the publications of Meinzer and of Bryan.

FAUNA

Many species of animals live in southern Yuma County, but generally the individuals of each species are not abundant. Coyote, fox, several rodents, ratlesankes, various lizards, scorpions, vinegaroons, and tarantulas are noticeable. Mountain sheep, if unmolested, would thrive in the roughest of the mountains, but at present they are facing extermination by lawless hunters. Beaver, protected by Arizona law, thrive along remote portions of the Colorado River, but trappers from the California side are said to be seriously menacing them. According to Mearns,[14] scarcely any beaver have been reported on the Lower Gila since the flood of 1891. Numerous bats inhabit certain caves and old mine workings. The principal birds to be seen are raven, buzzard, eagle, rock wren, and humming bird. At certain seasons, wild ducks frequent the Colorado River region.

For a more complete account of the fauna of this region, the reader is referred to the publication by Mearns.

HISTORY[15]

The first white men known to have reached this region were in the Spanish party of Hernando de Alarçon, who, in 1540, ascended the Colorado River for some distance by boats in an effort to join Coronado's search for the mirage-like Seven Cities of Cibola. Later in the same year, Melchior Diaz marched from Sonora to this river and was thus the first white man known to enter the region by land. In 1699, Padre Eusebio Francisco Kino, a Jesuit missionary, located the present route of the Camino del Diablo,[16] as far as the north end of the Gila range. During several following years, he made successive journeys through this territory, prepared its first map, and named the Gila and Colorado rivers. In 1743, Padre Jacobo Sedelmair traveled from near Agua Caliente, on the Gila, to the Colorado near Ehrenberg.

In 1767, the King of Spain expelled the Jesuits from Arizona, and replaced them with Franciscans. Between 1768 and 1781,

[14] Mearns, E. A., Mammals of the Mexican boundary of the United States: U. S. National Museum Bul. 56. 1907.

[15] For more detailed historical information see Farish, T. E., History of Arizona, Phoenix, 1916; also Ransome, F. L., and Bryan, Kirk, in U. S. Geol. Survey Water-Supply Paper 499, pp. 3-23. 1925.

[16] See page 24 for a description of this road.

Fray Francisco Garces, aided at times by Font, Anza, and Juan Diaz, made many trips into the Yuma region. In 1780, orders were received to establish a combined mission, presidio, and colony at Yuma, but, a few months later, the Yuma Indians destroyed the whole establishment. Thenceforth the Spaniards attempted no further settlement along the Colorado. From 1822, when Mexico separated from Spain, until the Gadsden Purchase, in 1854, the Spanish establishments were practically abandoned. In 1846, during the Mexican War, Lieut. W. H. Emory accompanied Gen. S. W. Kearney, Scout Kit Carson, and 200 dragoons down the Gila, making important observations upon the local geography.[17]

In 1848, the treaty of Guadalupe-Hidalgo gave all of Arizona north of the Gila to the United States. As a result, the first Boundary Commission began work in 1849, and a protecting army post was established at Fort Yuma.

During the California gold rush of 1849-50, many emigrants from the United States and Mexico went to California by way of the Gila or along the Camino del Diablo. Many died of thirst or of violence along the way, but, during these two years, at least 10,000[18] are estimated to have crossed the Colorado near the mouth of the Gila. Unaware of the mineral wealth nearby, and in haste to reach California, they did no prospecting. According to Hamilton,[19] a Dr. Lincoln and others established a ferry at the present site of Yuma to accommodate this gold-rush traffic, but hostile Indians soon wiped out the enterprise. In 1851, Major Heintzelman, commanding the local army post, subdued the Yuma Indians.

The first steamer reached Camp Yuma in 1852. Subsequent voyages added to the general knowledge of the country near the river.

The Gadsden Purchase, which included that part of Arizona south of the Gila River, was consummated in 1854. During the same year, Lieut. J. G. Parke conducted a railway surveying party[20] eastward from Camp Yuma. This year, also, the United States Boundary Commission, under W. H. Emory, began its survey of the new boundary. Travel and resultant business by that time prompted the establishment of Arizona City, on the site of Yuma. In 1855, a geologist, Thomas Antisell, accompanied Lieutenant Parke on an expedition up the Gila.

The year 1857 marked the establishment of a semi-weekly overland mail service along the Gila and through Yuma. A year later, the Butterfield Stages took over this line and maintained,

[17] Emory, W. H., Notes on a military reconnaissance from Ft. Leavenworth to San Diego: 30th Cong., 1st sess., S. Ex. Doc. 7 (H. Ex. Doc. 41), pp. 1-416. 1848.

[18] Guinn, J. M., A history of California: Calif. Hist. Soc. 1907.

[19] Hamilton, P., Resources of Arizona, 1st ed., pp. 30-31. 1881.

[20] U. S. Pacific R. R. Expl., vol. 2. 1855.

until the outbreak of the Civil War, 22-day trips from St. Louis to San Francisco. Stage stations along the route grew into small settlements and prompted the first irrigation farming by white men along the Gila.

Early in 1858, Lieutenant Ives, with a small steamboat, the "Explorer" tested the navigability of the Colorado River as far upstream as the Mojave Villages.

The discovery of the Gila City placers, near the present site of Dome, was anounced in 1858. Prospecting was thereby greatly stimulated and other mineral discoveries resulted. At the outbreak of the Civil War, all troops were withdrawn from this region, and the country was left, for a time, to the meager Indian population and a few self-sufficient white men.

After 1863, when Arizona became a territory, development in this region progressed rapidly. By 1870, Yuma, which was then the distributing point for nearly all of southern Arizona and part of New Mexico, had a population of 1,150. All activities in the county were greatly furthered in 1872 when the Colorado Steam Navigation Company established a regular line of carriers between San Francisco and Yuma. Likewise, the completion, during the seventies, of the Southern Pacific Railroad between Yuma and the coast provided safer, quicker transportation, and further opened up the country.

The next important historical epoch was that of gold-vein mining from 1895 to 1911. Its decline has left agriculture, along the Colorado and Gila valleys, as the principal basic industry of the area.

GENERAL MINING HISTORY

There is no record of the first mining in this region, but Raymond [21] and Blake [22] state that the first prospectors who reached the Castle Dome lead district, in 1863, found ancient surface workings, overgrown by mesquite and palo verde trees, and old, well-worn trails leading from these pits to the ruins of rude smelting furnaces on the banks of the Gila River.

According to former State Historian Hall,[23] the Gila City gold placers became known to certain trappers in the middle forties of the past century, although their discovery was not made public until 1858. This discovery greatly stimulated prospecting in the surrounding country, which, at that time, was rather wild and difficult of access. The La Paz gold placers, near the Colorado River, but north of the area included in this report, were found in 1862.

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[21] Raymond, R. W., Statistics of mines and mining west of the Rocky mountains. 1872.

[22] Blake, W. P., Report of the Territorial Geologist, 1899 (Report of the Governor of Arizona, 1899): Dept. Int. Misc. Repts. 1899.

[23] Personal communication.

Among the early discoveries, were the Eureka and Silver districts which, because of their nearness to the Colorado River, were rather accessible. In 1863, the Castle Dome district became known. Although activity in these silver-lead camps has varied according to metal prices, the Castle Dome district has produced nearly every year. A few additional, though relatively small, gold placers have been found from time to time in southern Yuma County, and, although their cream was skimmed within a few years, they are still worked intermittently. In 1864, according to Farish,[24] about 100 placer miners were operating on the western side of the Colorado River, near Fort Yuma; about 100 men were mining silver ore at Castle Dome, and as many were working in the Eureka district.

The rich La Fortuna gold vein was found in 1895 and worked until the end of 1901. Even more productive was the King of Arizona gold deposit, discovered in 1896 and worked until 1910. The near-by North Star vein was found in 1906 and worked until 1911. During the past two decades, several small districts in southern Yuma County have been promoted or worked for a short time, but none of them have yet become notable producers.

More detailed mining history is given elsewhere in this report, with the descriptions of individual districts.

PRODUCTION

As shown in the following table (page 23), southern Yuma County has produced more than $10,649,900 worth of minerals. For the years since 1904, these statistics have been gathered largely from the Mineral Resources of the United States.[25] Most of the production records for the years prior to 1906, however, are very incomplete. For instance, no record of placer production prior to 1870 is available, and so only a conservative estimate of it is given here. Likewise, only very incomplete records of the lead production prior to 1905 exist, and Heikes[26] has esmiated it only for the Castle Dome district. Partial statistics of gold and silver production from 1879 to 1888 are given in the reports of the Director of the Mint, but no figures for the succeeding eight years are known. From 1896 to 1904, inclusive, only the partial records given by the technical press are available.

The lack of data for certain years in the table means that no figures are known, but does not necessarily imply that no production was made during those years. Further details on production are given with the descriptions of the individual districts.

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[24] Farish, T. E., History of Arizona, vol. 3, p. 251. 1916.

[25] Published annually by the U. S. Geological Survey until 1924, and by the U. S. Bureau of Mines since 1924.

[26] Heikes, V. C., in Mineral Resources for 1925, pt. I, p. 599. 1927.

PRODUCTION OF PRINCIPAL MINING DISTRICTS IN SOUTHERN YUMA COUNTY, ARIZONA, 1852 TO 1929, INCLUSIVE.
Data compiled by J. B. Tenney

District	Total value	Remarks
Kofa	$ 4,645,243	Gold-quartz veins and placers
La Fortuna	2,612,987	Gold-quartz vein
Silver	1,696,170	Lead-silver veins
Castle Dome Mountains	1,061,930	Lead, silver, gold placers, fluorspar, and copper
Gila City placers	500,000	Estimated
Laguna placers	100,000	Estimated
Sheep Tanks	33,570	Gold and silver
Total	$10,649,900	

POPULATION AND INDUSTRIES

In 1930, according to United States census figures, the area considered in this report had a population of 15,662. Most of these people live in the valley towns of Yuma, Somerton, Gadsden, and Wellton, or occupy farms on the irrigable areas along the Colorado and Gila rivers. A few dwell in the smaller towns, at highway service stations and railway sidings, or on desert homesteads. Except for a relatively narrow belt along its northern and western margins, that portion of Yuma County south of the Southern Pacific Railway and east of the Colorado River has not one permanent inhabitant.

On the irrigable areas, the basic industry is raising citrus, cotton, alfalfa, dates, pecans, lettuce, bees, hemp, etc.

The plains and mountains, except in the northern portion of the area, are mostly too bare or waterless for cattle grazing. In fact, a large portion of this vast region is devoid of any present economic promise other than that of possible mineral deposits. During various portions of the year, several hundred people are engaged in mining or prospecting within southern Yuma County, but the aridity and inaccessibility of the desert always have somewhat handicapped their efforts.

ROUTES OF ACCESS AND TRANSPORTATION

RAILROADS

The Southern Pacific Railway extends eastward across Yuma County from the Colorado River at Yuma, and its Phoenix loop branches northeastward at Wellton, some 39 miles farther east. The Yuma Valley Railway follows the Colorado River downstream from Yuma to the border, but it is a U. S. Reclamation Service utility, not a common carrier. A branch of the Santa Fe Railway crosses northern Yuma County, but is some twenty miles north of the limits of the area studied.

By rail, Yuma is 218 miles from San Diego and 252 miles from Los Angeles. Freight rates to various smelters are given on page 228.

ROADS

Because of the scarcity of water-holes, and the long distances involved, nearly every prospector of this region now travels by automobile rather than by animal transportation. An oiled highway, U. S. 80, follows the general course of the Southern Pacific, through Yuma, Wellton, and Aztec, across southern Yuma County. An improved county highway crosses the Gila River at McPhaul bridge, a few miles west of Dome, and leads northward to Castle Dome, Kofa, Cibola Valley, and Quartzsite. Many roads, mostly unimproved, lead from these highways to the mountain ranges and into the mineralized districts (see map, Plate I). In the less traveled regions, general route conditions and locations have not changed greatly from the excellent guidebook descriptions prepared by Bryan [27] and by Ross [28] in 1918. Although many new routes have come into use, and present-day automobiles are much more desert-worthy than were those of fifteen years ago, the traveler can not depend upon averaging more than eight miles per hour over many of these roads, and should plan his equipment accordingly. While preparing for the desert, he must realize that a brief rain storm may send destructive floods down harmless-looking arroyos, or render silt-flats impassible for several days.

Camino del Diablo: The Camino del Diablo, because of its historical interest and present-day utility, is worthy of a brief description here, although very adequate accounts of it have already been published by Bryan [29] and by Sykes.[30] Connecting certain Mexican settlements of Sonora with California, this route, as shown by the map (Plate 1), follows near the international boundary westward to Tinajas Altas, whence it forks into two branches that lead northward. One branch leads to Wellton, while the other, after crossing a low divide in the Tinajas Altas Range, leads past the Fortuna Mine to the Yuma highway. The

[27] Bryan, Kirk, Routes to desert watering places in the Papago country, Arizona: U. S. Geol. Survey Water-Supply Paper 490-d. 1922.

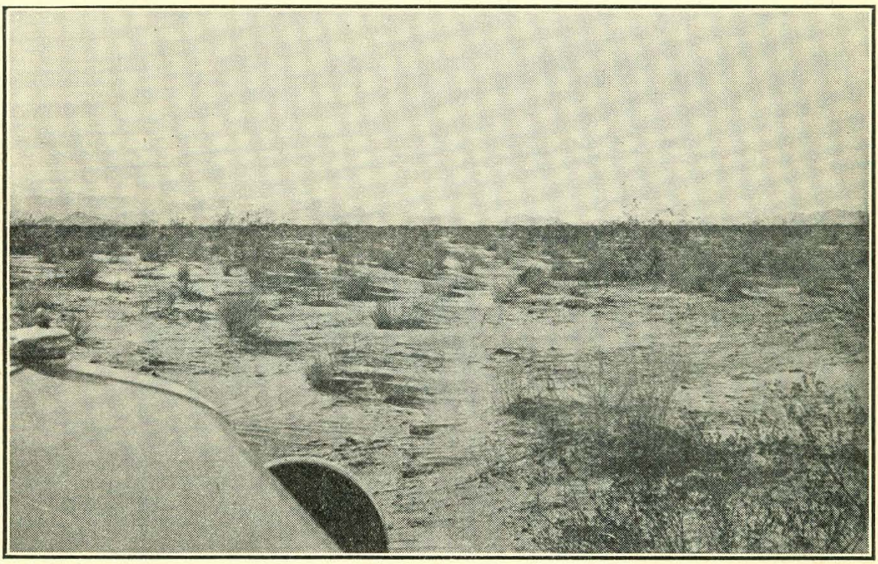
[28] Ross, C. P., Routes to desert watering places in the lower Gila region, Arizona: U. S. Geol. Survey Water-Supply Paper 490-c. 1922.

[29] Bryan, Kirk, The Papago country: U. S. Geol. Survey Water-Supply Paper 499, pp. 413-423. 1925.

[30] Sykes, Godfrey, The Camino del Diablo, with notes on a journey in 1925: Geog. Review, vol. 17, No. 1, pp. 67-74. 1927.

watering places of this region have always been few, but in earlier days they consisted solely of natural rock tanks and charcos that were quite inadequate for the needs of very many people and animals. Sykes says: "It was during the period of the first great overland rush to California, beginning in 1849 and lasting through the early fifties, that travel along the Camino del Diablo reached its maximum and the loss of life became most appalling. Parties were hurriedly and inadequately organized and equipped at various points along the Texas frontier and did not realize the danger involved. . . . . .

"Various estimates have been made as to the deaths from thirst and other mischance between Sonoita and the Colorado during these few years of wild excitement; some placing the numbers at hundreds, others at thousands. The facts can never be known, but it is significant that over fifty rude graves can be counted still in one small area at the foot of the rocky chine which contains the Tinajas Altas. Numerous others can be found along the route, in spite of the obliteration due to time, wind, and occasional torrential rains, and of the probability that the actual line of travel was several miles in width except at certain focal points such as the Tinajas.



—Photograph by Robt. E. Heineman.

Plate 2.—Camino del Diablo west of Pinacate lava—Tule Mountains in distance.

"Placer gold was discovered at various places in the Colorado Valley just before 1860, and another wave of excited gold seekers began to pass over the desert to reach the new camps. These travelers were mostly Mexicans from Sonora and other near-by

Mexican states. The loss of life was again very heavy, and in a few years the road was almost abandoned, even by these native Sonorans, as being too dangerous. The alternative route along the Gila was commonly used before the mid-sixties."

Today, long stretches of the Camino del Diablo may have no vehicular traffic for months at a time. Although an experienced, adequately equipped person usually meets with no great difficulty anywhere in this region, the absence of population and rarity of travelers may, as Bryan [31] says, make serious disasters out of accidents that, in other places, would be mere incidents of travel.

[31] Work cited, p. 413.

CHAPTER II — GENERAL GEOLOGY

Schist, gneiss, granite, various dike rocks, volcanic rocks, and sedimentary rocks are exposed in southern Yuma County. Plate 1 shows the surface distribution of the major formations or mapping units that were recognized during field work for the present report. Because fossils are lacking in most of these formations, the age correlations shown on Plate 1 are based mainly upon indirect geologic evidence.

METAMORPHIC ROCKS

This classification includes schists and gneisses which are of both sedimentary and igneous origin.

Schists: The oldest rocks of southern Yuma County are schists which outcrop, as shown by Plate 1, in most of the mountain ranges of the area. Regionally and locally, these schists show numerous minor variations in composition and texture, but, predominately, are gray to black aggregates of medium- to fine-grained quartz, feldspar, hornblende, and biotite. In places, muscovite, sericite, chlorite, pyroxene, andalusite, actinolite, tourmaline, and other minerals produced by regional, contact, and hydrothermal metamorphism are present. Quartzitic members are fairly common, and, in the northern portion of the Gila Mountains, marble members are prominent.

For the most part, these schists represent arkoses, sandstones, and other sedimentary rocks, together with minor igneous masses, which have been subjected to moderate regional metamorphism. In general, they are coarsely laminated parallel to their original bedding. This lamination prevailingly strikes at right angles to the trend of the mountain mass, and dips steeply. The total thickness of the series in any of the ranges is unknown.

Because of their metamorphic character, these schists have long been regarded as pre-Cambrian in age, but the possibility that part of them are younger can not be denied. Although no fossils have been found within them, certain marble members of the Gila Mountains give off abundant hydrogen sulphide when struck by a hammer, which indicates that the waters from which they were deposited contained prolific organisms. Furthermore, as shown by the analyses given on page 207, these marbles are very low in magnesia content, whereas Daly has demonstrated that pre-Cambrian limestones should be strongly magnesian.[32]

The schists of southern Yuma County are the host-rocks of important gold-quartz veins and minor argentiferous galena veins.

[32] Daly, R. A., The limeless ocean of pre-Cambrian time: Am. Jour. Sci., 4th ser., vol. 23, pp. 93-115. 1907. Also, First calcareous fossils and the evolution of the limestones: Geol. Soc. Amer. Bul. 20, pp. 153-170. 1909.

Gneisses: Apparently younger than the schists are gneisses which form large areas in the Gila, Copper, Muggins, and Laguna mountains and smaller outcrops in several other ranges.

The typical gneiss consists of a grayish-white, dark-streaked, coarsely laminated aggregate of medium to coarse-grained quartz, orthoclase, plagioclase, biotite, and muscovite. Much of the formation probably represents regionally metamorphosed granitic rocks, but, in certain areas, such as the Gila Mountains, it contains sufficient quartz to have a possible sedimentary origin. Its lamination, which, from a distance, is rather easily confused with jointing, generally strikes across the trend of the mountain range.

The gneisses have been regarded as pre-Cambrian in age, but like the schists, they may be younger. A few small, gold-bearing quartz veins, but no deposits of economic importance, have been found within them.

IGNEOUS ROCKS

Fully two-thirds of the mountains of southern Yuma County are made up of igneous rocks.

Granite: As shown by Plate 1, granite constitutes a large portion of the mountains south of the Gila River, but it outcrops only at a few places in the northern half of the area.

South of the Gila River, this granite consists, rather uniformly, of a medium- to coarse-grained aggregate of quartz, orthoclase, microcline, plagioclase, biotite, hornblende, and accessory magnetite. The plagioclase, which ranges in composition from albite to acid labradorite, generally constitutes about half of the feldspars.

In this part of the area, the rock is typically grayish-white, but, locally, as in the northern portion of the Gila Mountains, hornblendic phases are dark gray to black (see page 185).

North of the Gila River, the granite exposures have this same general composition, but, except in the Palomas Mountains, they are commonly darker colored and more altered. The small area of syenite that outcrops in the Castle Dome Mountains (see page 79) may represent a border phase of the normal granite.

The age of the granite of southern Yuma County has not been determined, but it is tentatively regarded as Mesozoic. Few, if any, rocks of this sodic composition occur in the pre-Cambrian of the Southwest, but they are rather characteristic of the Mesozoic and early Tertiary. Because of its abundantly visible plagioclase, Bryan [33] regarded the granite of the O'Neil, Tule, and Tinajas Altas ranges as probable Mesozoic. On the basis of its lack of dynamic metamorphism, Jones [34] believed the granite of the

[33] Bryan, Kirk, The Papago country, Arizona: U. S. Geol. Survey Water-Supply Paper 499, pp. 58-59. 1925.

[34] Jones, E. L., Jr., A reconnaissance in the Kofa mountains, Arizona: U. S. Geol. Survey Bul. 620, p. 155. 1915.

S. H. or Kofa Mountains to be of Mesozoic age. Similar granite in the Castle Dome Mountains does not appear to intrude the Cretaceous (?) sedimentary rocks.

This formation contains minor copper deposits in the Copper, S. H., Gila, Palomas, and other ranges, and has been quarried for crushed rock in the Gila Mountains and in the hills at Yuma.

Dike rocks: Dikes of pegmatite, aplite, diorite-porphyry, rhyolite porphyry, granite-porphyry, monzonite-porphyry, lamprophyre, and basalt occur in this region. The pegmatite and aplite cut only granite, gneiss, and schist. The diorite-porphyry cuts only formations older than the Tertiary lavas, but the remaining dikes mentioned intrude formations older than the probable Quaternary basalts. In the Castle Dome Mountains, the diorite and rhyolite porphyrys form one of the most remarkable dike groups known in the United States (see Plate 9).

Petrographic details of some of these dike rocks are given in the descriptions of the various mountain ranges.

Tertiary volcanic rocks: A thick series of rhyolites, andesites, dacites, trachytes, tuffs, and breccias makes up a large portion of the mountains north of the Gila River, but it appears only in the Cabeza Prieta and Aguila ranges south of the river. No complete study of these well-exposed rocks has been made, but many of their details are given in the descriptions of the various mountain ranges.

This volcanic series overlies sedimentary rocks of probably Cretaceous age and is believed to be younger than the arkosic sandstones which contain no volcanic fragments. In the Cibola region, it unconformably underlies sedimentary rocks that are regarded as Miocene or Pliocene in age.[35]

The Tertiary volcanic rocks contain important mineral deposits in the S. H., Trigo, and Little Horn mountains, and minor deposits in a few other ranges.

Tertiary and Quaternary volcanic rocks: A series, up to several hundred feet thick, of basalts and tuffs is represented in nearly every mountain range north of the Gila River and in several ranges in the southern part of the region. The tuffs are grayish-white, but the basalts are gray on fresh fracture and dark brown to jet-black on weathered surfaces.

Since the eruption of these rocks, most of the mountains have been subjected to renewed uplift and deep dissection, probably in Quaternary time. Bryan[36] regards these uplifted, dissected basalts as late Tertiary in age, but they may be early Quarternary.

In the Pinacate and Sentinel lava fields, basalt flows from a few inches up to probably 100 feet thick rest upon the Tertiary and

[35] Wilson, Eldred D., Marine Tertiary in Arizona: Science, vol. 74, pp. 567-568. Dec. 4, 1931.

[36] Bryan, Kirk, work cited, pp. 64-65.

Quarternary sediments of the plain. This lava is associated with numerous small cinder cones and has a strikingly fresh appearance. The Indians of the Pinacate region state that their ancestors witnessed volcanic eruption in this area.

The basalts of southern Yuma County, so far as known, are barren of mineral deposits.

SEDIMENTARY ROCKS

No Paleozoic rocks that have been recognized outcrop in southern Yuma County, but Mesozoic and Tertiary sedimentary beds constitute notable areas. Tertiary and Quaternary sediments fill the deep, intermont troughs.

Mesozoic beds: A series of slightly metamorphosed, gray to brown shales, arkosic sandstones, quartzites, conglomerates, and limestones occurs prominently in the Castle Dome, Middle, S. H., and Tank mountains, as indicated by Plate 1. These beds, which are described more fully on pages 79-80, make up a total thickness of more than 1,000 feet. They underlie the Tertiary volcanic rocks, appear to overlie granite, and are in fault contact with schist. For reasons stated on page 80, their age is regarded as probable Cretaceous.

These Mesozoic sedimentary rocks contain the principal mineral-bearing veins of the Castle Dome and Middle ranges and form the footwall of the North Star gold-quartz vein of the S. H. Mountains.

Clanton Hills sedimentary rocks: The Clanton Hills, in the northeastern portion of the area mapped on Plate 1, contain a few hundred feet of gray, cherty, impure limestones and shales together with minor amounts of reddish sandstone. They are intruded by dikes of rhyolitic composition and overlain by rhyolites and tuffs. Ross,[37] who found these strata to contain replacements of small Cypridian crustaceans, believed them to be of Tertiary age.

Tertiary (?) red beds: More than 1,000 feet of tilted, faulted, reddish-brown to gray conglomerates, arkosic sandstones, and shales are exposed in the Baker Peaks, Antelope Hills, and Mohawk Mountains. This formation, which is described in detail on pages 151, 169, rests upon granite and gneiss. As its exposures in this region contain no lava fragments and are associated with no volcanic rocks, the formation is regarded as older than the Tertiary volcanic series. It is lithologically similar to the red beds of the McDowell and Tempe regions, more than 100 miles farther northeast, which underlie Tertiary lavas and were regarded by Lee [38] and by Bryan [39] as Tertiary in age. They also resemble red

[37] Ross, C. P., Geology of the lower Gila region, Arizona: U. S. Geol. Survey Prof. Paper 129, p. 188. 1922.

[38] Lee, W. T., Underground waters of the Salt River valley, Arizona: U. S. Geol. Survey Water-Supply Paper 136, p. 97, figs. 15, 16. 1905.

[39] Work cited, pp. 59-60. 1925.

beds in Osborne Wash, east of Parker, which underlie strata of Miocene or Pliocene age.

Somewhat similar, but weakly consolidated, strata outcrop at the northern end of the Gila Mountains and northwest of McPhaul bridge. Their relation to the indurated beds just described is unknown.

Firmly cemented conglomerates, which consist largely of angular granitic boulders, outcrop at the Yuma bridge and, west of Laguna dam, underlie basalt. These conglomerates are probably of Tertiary age and may be equivalent to the basal portion of the red-bed series.

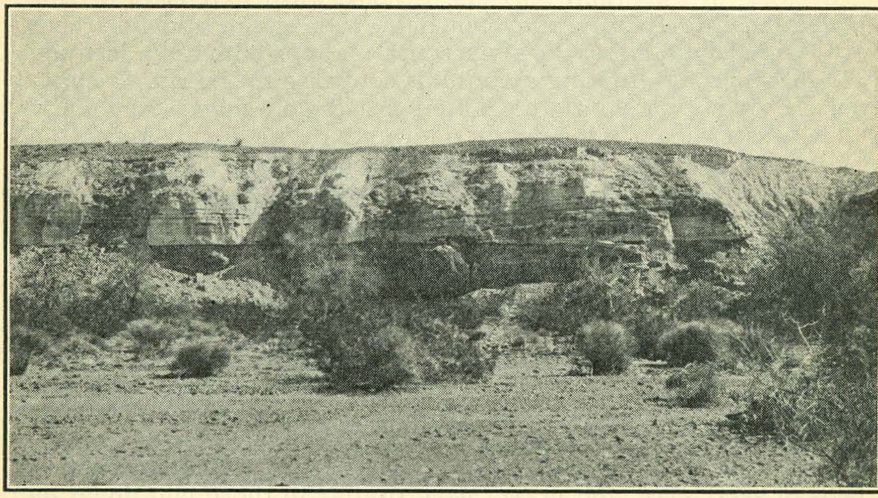


Plate 3.—Marine Tertiary beds southeast of Cibola.

Miocene or Pliocene beds:[40] Approximately 1,000 feet of well-stratified, weakly consolidated marls and sandstones, which alternate with chalky, dense limestones (see Plate 3), outcrop as several areas in the wide, terraced, dissected plains that border the Colorado River in the Cibola region, north of latitude 33° 10′. Near its base, this formation is conglomeratic to sandy and is cross-bedded on a large scale. East and southeast of Cibola, it underlies silts, sands, and gravels, and it unconformably overlies the roughly eroded schist, granite, and Tertiary lava slopes of the Trigo Mountains. In Osborne Wash, east of Parker, the same formation underlies basalt and rests upon tilted, beveled, red beds. At that locality, Blanchard [41] and Ross [42] found it to con-

[40] Wilson, Eldred D., Marine Tertiary in Arizona: Science, vol. 74, pp. 567-568. Dec. 4, 1931.

[41] Blanchard, R. C., Geology of the western Buckskin mountains, Arizona: Columbia Univ. Contr. Geol. Dept., vol. 26, No. 1, p. 39. 1913.

[42] Ross, C. P., work cited, pp. 189, 190, 195.

tain two brackish-water fossil species, and on the California side of the river, Brown [43] collected similar forms.

Near Cibola, its calcareous members contain the following fossils, as identified by Dr. W. P. Woodring, of the U. S. Geological Survey: Cerithid, *Pisidium* (?), *Corbicula* (?), barnacle, ostracode, calcareous algae, and *chara* (?) encrusted with algae (?). These forms do not determine the exact age, but Dr. Woodring [44] states: "Perhaps this marine invasion is the same as the one recorded in the southwestern part of the Colorado Desert (California), which I regard as Miocene, but which most California geologists consider Pliocene."

Because of mountain barriers, the eastward extension of this formation into Arizona may not have been great, and no traces of it were found along the river south of, approximately, latitude 33° 10′ where its limiting mountains converge to the river's channel. Brown's [45] map of the Salton Sea region shows that many wide passes separate the mountain ranges of the area between the Salton Sea and this section of the Colorado River. Consequently, the seaway in which these beds were deposited probably curved westward towards the Salton-Carrizo region, and thence extended southeastward to the Gulf of California rather than along the present Colorado River channel.

Younger alluvium: Bryan [46] has described this formation as follows:

"Along Gila River, there is a more or less continuous terrace from Gila Bend to Yuma. This terrace, cut into promontories by tributary streams, stands about 75 feet above the river. The surface is mantled with a coating of pebbles, in places only one pebble deep. Below the pebbles the terrace is composed of alternating beds of sand, clay, and gravel very similar to those laid down by the present river. The terrace therefore represents a period of aggrading of Gila River, at the conclusion of which the river stood at least 75 feet higher than it does now. All the tributaries were adjusted to this grade, and consequently the stream-built slopes of the adjacent mountains of the interior valleys slope to the top of the terrace. The cutting down of Gila River to or perhaps below its present level changed the base-level of the tributary streams, which with increased grade have cut valleys through the terrace. This headward cutting has been very effective on some of the tributaries north of Gila River, but the tributaries on the south have been too feeble to dissect to any large extent the valleys which they drain.

"Near Ligurta, seven miles east of Dome, fossil bones were found on two promontories of the terrace that project into the flood plain of the river. The bones lay on the surface as part of

[43] Brown, J. S., The Salton Sea region, California: U. S. Geol. Survey Water-Supply Paper 497, p. 46. 1923.

[44] Written communication.

[45] Brown, John, work cited, plate 12.

[46] Work cited, pp. 67-68.

the layer of pebbles resulting from the erosion of the materials which form the terrace. Near the river, underlying beds are exposed in the bluff and consist of brown sand, gravel, and sandy clay similar to material now carried by Gila River. The clay has round, smooth concretions three to twelve inches in diameter. The brown sand has also many concretions, but they are rough on the surface and irregular in shape. A small sliver of bone was found in place in the brown sand, so that the bones are undoubtedly derived from it and probably are enclosed in the concretions. The bones were probably transported some distance before deposition, but it seems most reasonable to assume that the animals died on the river flood plain during the period of deposition of the brown sand.

"A small collection of these bones was referred to J. W. Gidley, of the United States National Museum, who identified the phalanx of a horse *(Equus* sp.) and the basal portion of the antler of a deer probably belonging to the genus *Odocoileus.* According to Doctor Gidley, 'These fossils do not determine the age more closely than that they are Pleistocene, though the presence of the horse remains suggests one of the older phases of the Pleistocene.' "

Moodie[47] has described water-worn fossil bones of a Pleistocene mammoth that were collected from the terrace a few miles east of Wellton. The neck joints of this animal had been curiously ossified during life. He also mentions fragments of probable mastodon from the loose detritus of the mesa in Yuma. Late Pleistocene horse teeth have been collected from the sands of this mesa.

Petrified wood formation: The probable equivalent of Bryan's younger alluvium caps the Colorado River terraces and, in places, along former courses of the river, extends inland for several miles. In general, this formation consists of sand, clay, and small, well-rounded pebbles, together with sandy concretions and thin calcareous lenses similar to those that occur in the Gila River terrace. Many of the pebbes include Paleozoic fossils which do not occur abundantly in place nearer than the Grand Canyon region.

In certain areas, as the one seven miles northwest of Dome, this formation contains abundant fossil wood. This material consists of broken trunk segments up to a few feet long by less than one foot in diameter, together with a few stump remains. Few, if any, small roots and twigs are present. A few small, water-worn fragments of fossil bone are locally associated with the material. The original wood probably grew in this vicinity, but it may have been transported for short distances by water. The logs consist of chalcedony which has faithfully replaced the original wood, so that its growth-rings and cell structure are clearly visible on

[47] Moodie, R. L., The ancient life of Yuma County, Arizona: Scientific Monthly, pp. 401-407. Nov., 1930.

weathered surfaces as well as in thin section. This material is gray to brown in color, and closely resembles fragments of present day desert hardwood.

A few samples of this fossil wood were referred to the Carnegie Institution of Washington. Regarding their identification, Dr. John C. Merriam writes: "We are advised that the specimens are from some species of the Leguminosae. The anatomical features of this family have never been carefully studied, and consequently it does not seem desirable to assign this wood to any genus at present. It may belong to Acacia, Cercidium, Olnea, or Parkinsonia; in short, it may belong to any of the southwestern arborescent genera of legumes."

The structure of similar fossil wood from the California side of the river has been described by Schaeffer.[48]

Quaternary gravels: The mountain pediments are more or less mantled by loosely consolidated, poorly stratified masses of gravels and boulders that mostly have been derived by erosion of the adjacent mountains, but are also partly residual from erosion of underlying Tertiary (?) beds. These gravels contain the gold placers of the region.

GENERAL STRUCTURE

Folds: The rocks of southern Yuma County show no folds except the minor ones that accompanied normal faulting. Although the regional metamorphism that affected the schists and gneisses largely resulted from compression, no accompanying folds are readily apparent. In general, the lamination of these rocks is across the trend of the ranges, which indicates that the regional compression acted in a northwest or southeast direction.

There is little knowledge of the nature of the mountain-making movements that preceded the erosional removal of great thicknesses of pre-Tertiary formations.

Faults: The present mountains are believed to represent horsts, or fault blocks which were elevated in reference to the intervening, relatively depressed fault blocks, or grabens, that underlie the plains. In places, as at the northern end of the Gila Mountains, such mountain-bordering faults are visible. No mountains capable of supplying coarse-grained detritus existed in the vicinity when the fine-grained sediments that generally extend to the margins of the ranges were deposited. Moderately hilly areas of faulted schist, gneiss, and granite together with minor amounts of faulted, tilted Mesozoic and Tertiary sedimentary rocks existed prior to the eruption of the Tertiary lavas, but the present mountains were largely uplifted after this period of volcanic activity. In many of the ranges, renewed uplift has elevated pediments, mountain valleys, and late Tertiary or early Quaternary

[48] Schaeffer, Geo. C., in Blake, Wm. P., Report of a geological reconnaissance in California: New York. 1858.

basalts above over-steepened slopes. The earlier periods of faulting were characterized by pronounced monoclinal tilting, whereas this Quaternary uplift tilted the basalts generally less than 10° from their original attitude.

Within the mountains, several directions and systems of faulting are visible, as is described in Part II of this report. Most of these faults dip steeply and none of reverse character are readily apparent. Part of them were earlier than the dikes, some cut the dikes but preceded the deposition of the veins, and some displaced the veins. Not enough detailed work has been done to determine the magnitude of displacement on these faults. In some cases, it amounts to only a few feet, but, in others, it probably is on the order of several hundred feet. In places, the movement was distributed throughout shear zones of considerable width.

Joints: As described in Part II of this report, the various mountain ranges are intersected by several systems of jointing. These features are best developed within the schists, gneisses, and granites in some of which they constitute rather intense sheeting. In general, the joints dip steeply, and their strongest systems strike parallel and at right angles to the trends of the mountain ranges.

PHYSIOGRAPHY

Scope of discussion: The features of relief common to southern Yuma County have been briefly outlined on page 15, and are described in further detail in Part II. As a detailed discussion of the origin of these land forms is beyond the scope of this report, only some of their general features will be considered here. For details, reference should be made to the physiographic analysis given by Bryan.[49]

General features: Erosion has produced the impressive topography of this region partly because of the climate and partly because of the kind and structure of the rock masses.

Plentiful evidences of large-scale mechanical erosion due to this climate, which has already been described on pages 16-18, are apparent. With practically no vegatative shade present, the summer sun daily heats the exposed rock surfaces to temperatures of 150° F. or more and each night cools them to 75° F. or less. They are also subjected to rapid cooling by the occasional summer rains and to alternate freezing and thawing during winter. As analyzed by Lawson,[50] Bryan,[51] and Leonard,[52] the differential expansion and contraction due to such repeated temperature

[49] Bryan, Kirk, The Papago Country, Arizona: U. S. Geol. Survey Water-Supply Paper 499. 1925.

[50] Lawson, A. C., Epigene profiles of the desert: Univ. Calif. Pub. Geol., vol. 9, pp. 29-48. 1915.

[51] Bryan, Kirk, work cited, pp. 79-86.

[52] Leonard, R. J., Pedestal rocks resulting from disintegration: Jour. Geol. Vol. 35, pp. 469-474. 1927.

changes are believed to cause spalling and granular disintegration.

Blackwelder,[53] on the other hand, states that spalling due to solar heat is open to serious doubts, and he concludes that hydration and similar chemical processes are more important factors in desert rock disintegration. In this region, chemical processes are responsible for slight surface decay of rock minerals, for desert varnish, and for thin, indurated crusts on certain granite boulders. However, if chemical weathering predominated, the surface decay of rock minerals would be much deeper, all newly formed talus would not be angular, and the feldspars and micas of fine-grained granitic detritus would not have their prevailing freshness.

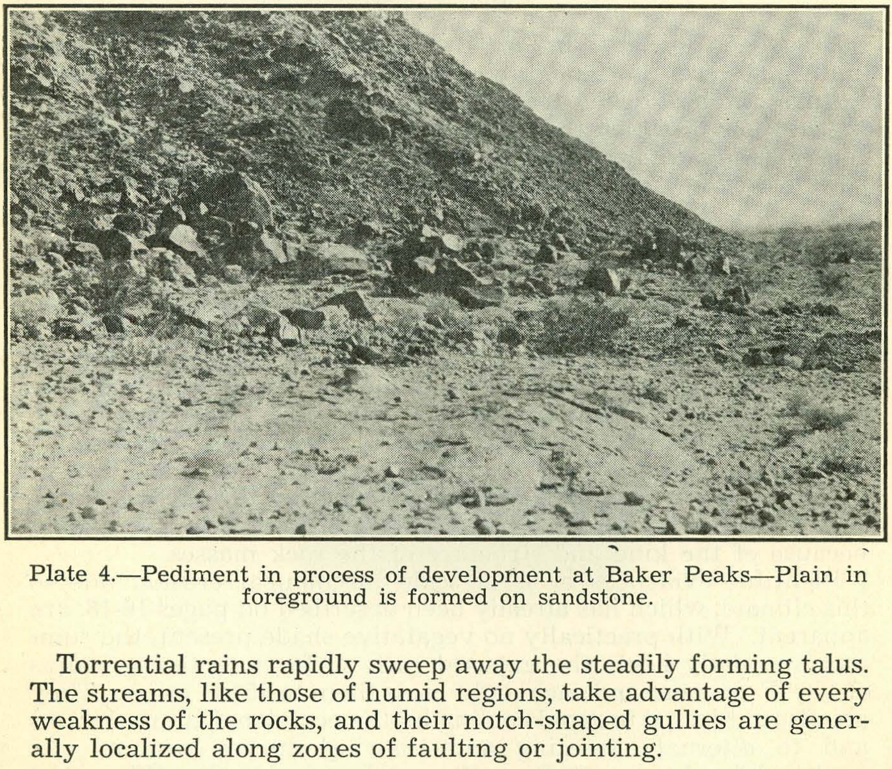


Plate 4.—Pediment in process of development at Baker Peaks—Plain in foreground is formed on sandstone.

Torrential rains rapidly sweep away the steadily forming talus. The streams, like those of humid regions, take advantage of every weakness of the rocks, and their notch-shaped gullies are generally localized along zones of faulting or jointing.

Bryan [54] has shown how the steepness of desert mountain slopes is generally proportional to the size of the spalls, which in turn is governed by the spacing of the joints. Many of the mountain slopes follow the dips of major joints, faults, bedding, and lamination. In the schist, gneiss, and granite, such major structural

[53] Blackwelder, E., Exfoliation as a phase of rock weathering: Jour. Geol. vol. 33, pp. 793-806. 1925.
[54] Work cited, pp. 84-85.

features dip steeply. The cliff-like slopes of lava mesas follow joints which are at right angles to the bedding.

Weakly resistant rocks, such as the Mesozoic shales, tend to form pediments and hills of low relief (see Plates 7, 10).

Pediments: Bryan [55] has defined a pediment as a plain that has been formed on rock by combined erosion and transportation at the base of a desert mountain and is largely without alluvial cover. It is the approximate equivalent of Lawson's [56] "subaerial platform," Davis' [57] "rock floor," Paige's [58] "rock cut surface," Penck's [59] "Haldenhang," Waibel's [60] "Felsfussebene," and Johnson's [61] "rock fan."

In this region, pediments are simply the mountain stumps above which erosion operates. One in the process of formation is shown in Plate 4. As described on page 46, most of the mining districts are associated with pediments.

[55] Bryan, Kirk, work cited, p. 93.

[56] Lawson, A. C., work cited.

[57] Davis, W. M., Rock floors in arid and humid climates: Jour. Geol., vol. 38, pp. 1-27, 136-158. 1930.

[58] Paige, S., Rock-cut surfaces in the desert ranges: Jour. Geol., vol. 20, pp. 442-450. 1912.

[59] Penck, W., Morphologische Analyse: Penck's Abhl. 1925.

[60] Waibel, L., Die Inselberglandschaft von Arizona und Sonora: Z. der Gesell. für Erdk. zu Berlin, Sonderabdruck aus dem Jubilaums-Sonderband, pp. 68-91. 1928.

[61] Johnson, D. W., Rock fans of arid regions: Am. Jour. Sci., vol. 23, pp. 389-416. May, 1932.

CHAPTER III — MINERAL DEPOSITS

MINERALOGY

The following species occur in, or are associated with, the mineral deposits of southern Yuma County. The metallic minerals are described in the approximate order of their economic importance, and the gangue and non-metallic minerals in the order of their abundance.

LIST OF SPECIES

Gold: Native gold

Silver: Cerargyrite, Argentite, Native silver

Lead: Galena, Cerussite, Anglesite, Massicot (?), Mimetite

Zinc: Smithsonite, Calamine, Sphalerite, Hydrozincite

Copper: Chalcocite, Malachite, Chrysocolla, Brochantite, Azurite, Cuprite, Tenorite, Copper pitch, Covellite, Chalcopyrite

Molybdenum: Wulfenite

Vanadium: Vanadinite, Vanadiferous mimetite

Manganese: Pyrolusite, Manganiferous calcite

Iron: Limonite, Hematite, Magnetite, Pyrite, Jarosite

Bismuth: Bismutite (?)

Gangue and non-metallic minerals: Quartz, Fluorite, Calcite, Barite, Sericite, Chlorite, Gypsum, Adularia, Kaolinite, Muscovite, Biotite, Chalcedony, Andalusite, Dumortierite, Cyanite, Epidote, Garnet, Tourmaline, Vesuvianite, Ankerite, Actinolite, Aragonite, Montmorillonite

GENERAL OCCURRENCE [62]

Gold: Native gold has constituted more than two-thirds of the mineral wealth mined in southern Yuma County. It occurs within quartz veins in many of the mountains, particularly the Gila, Kofa, Tank, Laguna, Wellton, Copper, Castle Dome, and Trigo ranges, and is also present in several placer deposits, as summarized on pages 46-49. All of this gold contains small percentages of metallic silver.

[62] The percentage compositions given are for strictly pure material.

No tellurides of gold have been found in southern Yuma County.

Cerargyrite or horn silver: Silver chloride, containing 75.3 percent silver. Occurs especially in the oxidized portions of veins in the Silver and Castle Dome districts.

Argentite or silver glance: Silver sulphide, containing 87.1 percent silver. Important quantities of this mineral are said to have been mined from the Princess and other veins in the Silver district, but none was found during the present investigation.[63]

The silver of the argentiferous galena from the Castle Dome, Silver, and Eureka districts probably is in the form of microscopic inclusions of argentite.

Silver: Native silver was not observed by the writer in this region, but metallic silver occurs in combination with the gold.

Galena: Lead sulphide, containing 86.6 percent lead. Occurs prominently in the Castle Dome, Eureka, Silver, Middle, and Neversweat districts and, to a minor extent, in the Kofa and Sheep Tanks regions.

Cerussite: Lead carbonate, containing 77.5 percent lead. Occurs, generally with more or less anglesite and yellow lead oxide (massicot [?]), as an alteration product of galena in the lead deposits of the region. Commonly forms small, gray to yellowish-white, orthorhombic crystals and sandy or cellular masses.

Anglesite: Lead sulphate, containing 68.3 percent lead. Commonly occurs as concentric, dark to light-gray layers surrounding nodules of galena in the lead deposits of the region. Brush [64] described the material from Castle Dome as follows: "The compact anglesite occurs in banded layers, sometimes with a nucleus of unoxidized and perfectly bright cleavable galena; while in other specimens the galena has entirely disappeared and the bands are symmetrically arranged in continuous circular or elliptical lines, as so often seen in agate. The bands or layers next the galena are frequently almost black, fading from a dark brownish-gray to a light grayish-white at the point farthest from the nucleus of the galena, and the outer layer is sometimes exteriorly coated with minute, almost microscopic, crystals of transparent colorless anglesite. The thickness of the layers of compact anglesite in the specimens examined was from one-half to one inch. The specific gravity of the light colored variety was about 6.0, while some of the dark mineral gave a density as high as 6.44. The hardness is three.

"A fire assay yielded 16.87 ounces of silver to the ton of 2,000 lbs., while the galena was found to contain 27.3 ounces per ton. . . . . ."

[63] Emmons, S. F., and Becker, G. F., Statistics and technology of the precious metals: Census Office Report, Washington, p. 52. 1885.

[64] Brush, G. J., On a compact anglesite from Arizona: Am. Jour. Sci., 3d ser., vol. 5, pp. 421-422. 1873.

Yellow lead oxide (massicot [?]): Occurs as small, earthy, pulverent masses coating cerussite in the lead deposits of the region.

Mimetite: A lead chloroarsenate, occurring, according to Blake,[65] in the old workings at Castle Dome, where it is associated with wulfenite and grades into vanadinite.

Smithsonite: Zinc carbonate, containing 52.1 percent zinc. Occurs as small crystals and porous incrustations in the oxidized portions of veins in the southern portion of the Silver district and in the Eureka district.

Calamine: Hydrous zinc silicate, containing 37.2 percent zinc. Occurs in minor amounts associated with smithsonite.

Sphalerite or zinc blende: Zinc sulphide, containing 67 percent zinc. A black, ferriferous variety of sphalerite (marmatite) occurs associated with galena in the Eureka district.

Hydrozincite: A basic zinc carbonate, containing approximately sixty percent zinc. Occurs as aggregated micaceous layers in the oxidized portions of certain veins in the Castle Dome district.

Chalcocite or copper glance: Copper sulphide, containing 79.8 percent copper. Generally as small masses partly altered to malachite and chrysocolla, chalcocite occurs prominently in the Thumb Butte district of the Castle Dome Mountains, and in minor amounts in many mountain ranges of the region. In all of these occurrences, the mineral is probably of supergene origin.

Malachite: A basic copper carbonate containing 57.4 percent copper. Associated generally with chrysocolla, occurs in the Thumb Butte district, the Copper Mountains, and many other mountain ranges. Is generally an oxidation product of chalcocite.

Chrysocolla: A hydrous copper silicate containing 36 percent copper. Occurs prominently in the oxidized portions of veins in the Copper Mountains, and, to a less extent, in many of the other ranges.

Azurite: A basic copper carbonate containing 55.2 percent copper. Associated with malachite and chrysocolla, occurs in the Thumb Butte district and in the Blue Butte vein of the Gila Mountains.

Brochantite: A basic copper sulphate containing 56.3 percent copper. Occurs associated with gypsum in the Venegas prospect of the Tule Mountains.

Cuprite: A copper oxide containing 88.8 percent copper. Occurs sparingly with the oxidized copper minerals of the region.

Tenorite: Black copper oxide containing 79.8 percent copper. Occurs sparingly with the oxidized copper minerals of the region.

Copper pitch: An impure, dark-brown to black oxide containing variable amounts of copper, zinc, manganese, iron, and alumi-

[65] Blake, Wm. P., On the occurrence of vanadates of lead at the Castle Dome mines in Arizona: Am. Jour. Sci., 3d ser., vol. 22, pp. 410-411. 1881.

num oxides, together with considerable silica and water. Occurs in small amounts in the oxidized portions of certain veins of the Copper Mountains.

Covellite: Blue copper sulphide containing 66.4 percent copper. Occurs as microscopic blades derived from chalcocite in the Copper Mountains.

Chalcopyrite: Hypogene copper-iron sulphide containing 34.5 percent copper. Occurs sparingly in the Engesser vein of the Tank Mountains and in the Collins prospect of Cemetery Ridge. Was probably present in all of the copper-bearing deposits of the region, prior to their oxidation.

Wulfenite: Lead molybdate containing 26.14 percent molybdenum and 56.43 percent lead. Occurs rather commonly in the oxidized veins of the Silver and Castle Dome districts and sparingly in many of the other districts.

Foshag[66] describes bright orange-red crystals from the Red Cloud mine, in the Silver district, as follows: "The wulfenites are found in the cavities and interstices, loosely attached by edge or corner, so that a sharp blow breaks off many of the larger crystals. The crystals reach a size of three cm. or more, are thick tabular and of brilliant luster. They are simple in habit, the base and pyramid being the usual combination."

He also describes material from the Castle Dome district as follows:[67] "The wulfenites are of a bright lemon-yellow color, and though small, are brilliant and well formed. The common habit is first and second order pyramids and a large base. They range up to one cm. in size and are profusely scattered over etched crystals of anglesite, making very showy specimens."

Vanadinite: Lead chlorovanadate containing 19.4 percent vanadium pentoxide. Associated with wulfenite, occurs rathers commonly in the Silver and Castle Dome districts.

Vanadiferous mimetite: According to Blake,[68] vanadiferous mimetite is associated with wulfenite, vanadinite, and mimetite in some of the old workings at Castle Dome.

Pyrolusite: Manganese dioxide containing 63 percent manganese. Occurs abundantly in the Sheep Tanks and Silver districts and in Cemetery Ridge. Minor amounts are present in many of the mountain ranges.

Manganiferous calcite: Black, manganiferous calcite occurs as veins of hypogene origin in the Sheep Tanks and Kofa districts, where, through surface alteration, it has been the source of the pyrolusite.

Limonite: Hydrous iron oxide. Occurs more or less abundantly in the oxidized zone of most of the mineralized districts.

Hematite: Iron oxide. Occurs, principally as the earthy variety, associated with limonite.

[66] Foshag, Wm. F., Famous mineral localities: Yuma County, Arizona: Am. Mineralogist, vol. 4, pp. 149-150. Dec., 1919.
[67] Work cited.
[68] Blake, Wm. P., work cited.

Magnetite: Magnetic iron oxide. Occurs as an accessory in the granites; as a vein mineral at the Engesser prospect in the Tank Mountains, and at the Collins prospect in Cemetery Ridge; as small masses, chiefly of the lodestone variety, in the pegmatites, especially south of the Gila River; and as an abundant constituent of black sand in the gold placers.

Pyrite: Iron sulphide. Occurs prominently in the North Star vein; as a minor vein mineral in the Eureka, Cibola, Engesser, and Cemetery regions; and as metacrysts in the Mesozoic shales of the Castle Dome, S. H., and Tank mountains. Oxidation of pyrite probably has furnished a large portion of the limonite and hematite of this region.

Jarosite: A hydrous sulphate of iron and potassium. Occurs as small, flaky, yellow masses associated with limonite at the Engesser prospect, in the Copper Mountains, and probably in several other districts.

Bismutite (?): An amorphous, yellow bismuth compound occurs sparingly within fractures in granite west of the Geronimo claims of the Silver district.

Quartz: Silicon dioxide. The most abundant gangue mineral of the region is quartz. As shown on pages 138, 195, the quartz of the epithermal gold-bearing veins is fine grained to chalcedonic in texture and of pale greenish-yellow color, but that of the deeper-seated, gold-bearing veins is distinctly coarser grained and of pale straw-yellow to white color. Essentially all of the vein quartz is hypogene, or primary, in origin, but that associated with the chrysocolla of the Copper Mountains (described on page 167) is probably supergene.

Fluorite: Calcium fluoride. As coarsely crystalline, white, green, and purple masses, forms an abundant gangue of the galena veins in the Castle Dome district; as finer-grained masses, is a rather abundant gangue in the Silver district; as medium-grained masses, it occurs in the Yellow Breast prospect of the Gila Bend Mountains.

Calcite: Calcium carbonate is a common wall-rock alteration product accompanying the various vein deposits. The white, crystalline material, together with more or less of the brown (ferriferous) and black (manganiferous) varieties, are commonly present in the veins of all the districts in this region.

Barite or heavy spar: Barium sulphate. Occurs as an abundant gangue in the veins of the Silver, Castle Dome, Sheep Tanks, and Neversweat districts. Forms relatively pure veins in the Mohawk, Neversweat, and Silver districts.

Sericite: Hydrous potassium-aluminum silicate. This fine, scaly variety of muscovite occurs abundantly as a wall-rock alteration product of hydrothermal origin, accompanying the epithermal and mesothermal veins. In the epithermal type, it is finer grained than in the deeper-seated veins. Occurs in the older schists as a product of regional metamorphism.

Chlorite: Hydrous aluminum-iron-magnesium silicate. Occurs abundantly as a wall-rock alteration product of hydrothermal origin accompanying the epithermal veins.

Gypsum: Hydrous calcium sulphate. Massive and crystalline varieties are present in the upper portions of veins in the Castle Dome, Silver, and Neversweat districts and in decomposed, mica-bearing pegamtites of the Gila Mountains.

Adularia or vein orthoclase: Potassium-aluminum silicate. Occurs in most of the epithermal gold-bearing quartz veins (see page 45).

Kaolinite: Hydrous aluminum silicate. The earthy variety occurs in decomposed, mica-bearing pegamtites of the Gila Mountains and as a near-surface decomposition product of feldspars.

Muscovite mica: Hydrous potassium-aluminum-silicate. Minor amounts are present in the granites and constitute locally abundant segregations in the pegamtites.

Biotite mica: Hydrous potassium-magnesium-iron-aluminum silicate. Is an important constituent of many of the igneous and metamorphic rocks and of the Tertiary (?) arkose. Occurs as large books in some of the pegmatites.

Chalcedony: Oxide of silicon. Forms the principal constituent of the petrified wood northwest of Dome.

Andalusite: Aluminum silicate. Associated with pyroxene, occurs as prismatic crystals in the schist adjacent to the Fortuna vein.

Dumortierite: Aluminum borosilicate. Associated with minor amounts of cyanite, dumortierite occurs as needle-like crystals penetrating quartzose schist boulders within the Colorado River terrace gravels downstream from Clip, as described by Diller,[69] Ford,[70] and Schaller.[71]

Similar material, occurring on the California side of the river, has been described by Wolff.[72]

Cyanite: Aluminum silicate. Associated with dumortierite, occurs as long bladed crystals in quartzose schist boulders within the Colorado River terrace gravels downstream from Clip.

Epidote: Calcium-aluminum-iron silicate. Occurs as a product of metamorphism in calcic rocks of many portions of the region.

Garnet: Calcium-aluminum silicate and calcium-iron silicate. Occurs abundantly in pegamtites of the Fortuna region, and in certain portions of the marble deposits of the Gila Mountains.

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[69] Diller, J. S., and Whitfield, J. E., Dumortierite from Harlem, N. Y., and Clip, Arizona: Am. Jour. Sci., 3d ser., vol. 37, pp. 216-220. 1889.

[70] Ford, W. E., On the chemical composition of dumortierite (from Clip, Arizona): Am. Jour. Sci., 4th ser., vol. 14, pp. 426-430. 1902.

[71] Schaller, W. T., Dumortierite (from Clip, Arizona): Am. Jour. Sci., 4th ser., vol. 19, pp. 211-224. 1905. Also, U. S. Geol. Survey Bul. 262, pp. 91-120. 1905.

[72] Wolff, John E., Dumortierite from Imperial County, Calif.: Am. Mineralogist, vol. 15, pp. 188-193. May, 1930.

Tourmaline: Complex silicate of aluminum and boron, principally. Is present in and near many of the pegmatites.

Vesuvianite: Principally calcium-aluminum silicate. Occurs in the contact zone of the marble deposits of the Gila Mountains.

Ankerite: Calcium-magnesium-iron carbonate. Forms thin, brownish-gray veins that cut schist and gneiss in the northern portion of the Mohawk Mountains.

Actinolite: Calcium-magnesium-iron silicate. The bladed green variety occurs as a rock-forming mineral of amphibolite dikes east of Deadman Tank, in Cemetery Ridge. Adjacent to these dikes, the grayish, asbestiform variety is developed within schist.

Aragonite: Calcium carbonate. A few occurrences of the compact, stalactitic variety were observed in the Castle Dome district.

Montmorillonite: Hydrous aluminum silicate. The peach-red variety occurs as small incrustations near the surface of a prospect on one of the Mabel claims, in the Castle Dome district.

TYPES OF DEPOSITS

The mineral deposits of southern Yuma County occur principally in veins and placers. The granite of the Gila Mountains has been quarried for crushed rock, and the sandstone of the Antelope Hills has been used for building stone. Marble deposits are present in the Gila Mountains, and clays of potential economic importance occur at the southern margins of the Muggins and Laguna ranges.

VEINS

ORIGIN

Mineral veins are present in a large proportion of the mountain ranges of this area and have been of economic importance in approximately eighteen districts.

These veins were deposited in fault or fissure zones by hydrothermal solutions that ascended from crystallizing igneous masses. The ascent of the mineralizing solutions was governed by the relation of the pressure behind them to the permeability of available avenues of passage. Where such solutions found open fissures, or were under sufficient pressure to force apart the walls of available closed fissures, veins were deposited. Butler[73] has shown that the richest ore deposits of Utah are generally localized in the vicinity of the apices of stocks, where the hydrothermal solutions are most concentrated and under great pressure. In southern Yuma County, very few apically truncated stocks have been recognized, although, in certain districts, the distribution of dikes indicates the presence of stocks somewhere beneath.

[73] Butler, B. S., Relation of ore deposits to different types of intrusive bodies in Utah: Econ. Geol., vol. 10, pp. 101-122. 1915.

TEMPERATURE-DEPTH ZONES

The veins of this area include mesothermal and epithermal types.

Mesothermal veins: Representative of the mesothermal type are the gold-bearing quartz veins of the Gila, Laguna, Wellton, Copper, Tank, and Gila Bend ranges, and the argentiferous galena veins of the Castle Dome, Middle, and Eureka districts.

Veins of this type were deposited under conditions of moderately high temperature, at depths of more than 3,000 feet below what was then the surface. In general, they are persistent and are characterized by rather regular form; localization by fractures with even to smooth walls; coarse-grained texture; banding due mainly to shearing and replacement; and wall-rock alteration to carbonate, quartz, and rather coarse-grained sericite. Most of the veins listed in this class do not possess all of these characteristics, however. For instance, the Fortuna vein is of lenticular, branching, chimney-like form, and its walls do not show notable sericitization. As another exception, only the upper 250 feet of most of the Castle Dome veins have been of economic width.

Epithermal veins: Representative of the epithermal type are the gold-bearing quartz veins of the Kofa and Sheep Tanks districts and the silver-lead and barite veins of the Silver, Mohawk, and Neversweat districts.

Veins of this type were deposited under conditions of moderately low temperature, at depths generally less than 3,000 feet below what was then the surface, and are best developed in the Tertiary volcanic rocks. They are characterized by rather irregular form, with rich ore bodies relatively near the surface, only; fine-grained texture; strong banding or crustification; breccia inclusions; and wall-rock alteration to chlorite, carbonate, quartz, and fine-grained sericite. The gold-bearing quartz veins of this type are characteristically fine-grained to chalcedonic in texture and pale yellowish-green in color. They generally contain adularia and, locally, show lamellar structure pseudomorphic after calcite.

ORE SHOOTS

In general, the ore shoots of the veins occur where the vein zones are intersected by fissures, lamination, or bedding. Changes to harder, less permeable, or chemically different wall rock are commonly reflected by impoverishment.

The Fortuna vein, according to all reports, was cut off by a fault at the 800-foot level. The King of Arizona vein dropped below economic grade at a vertical depth of approximately 640 feet, and the veins of the Castle Dome and Silver districts generally have not been stoped below vertical depths of 250 feet.

In considering gold-bearing veins, the fact that a twenty-dollar gold ore contains slightly less than 0.0035 percent of gold should be remembered.

SUPERGENE ENRICHMENT

Secondary or supergene enrichment may have been of importance in the strongly manganiferous gold and silver veins such as occur in the Kofa, Silver, and Sheep Tanks districts. It has brought about concentrations of oxidized zinc, molybdenum, and vanadium minerals in the Silver and Castle Dome districts. In the Castle Dome district, it is responsible for the fact that the galena is richer in silver than are the oxidized lead minerals. All of the copper ore shipped from the region was a product of supergene enrichment.

AGE

The epithermal veins were deposited at the close of the Tertiary volcanic activity. The mesothermal lead-silver veins may also belong to this period, but the mesothermal gold-bearing quartz veins may be of late Mesozoic age.

RELATION TO PHYSIOGRAPHY

With few exceptions, the commercially important veins of southern Yuma County have been found on pediments or gentle slopes rather than on mountain sides or high ridges. This localization may be due primarily to the fact that, generally, the most intense pre-mineral faulting was along the margins of the present ranges. Where it was intense in the interior of a range, as in the Silver district, it has resulted in the developmnt of valleys and sharp ridges. As already stated, the mineralizing solutions ascended through those zones of structural weakness that afforded the most permeable channels available. The wall-rock alteration that accompanied the deposition of veins generally was of a type that offers weak resistance to erosion. After uplift of the mountains, the zones of greatest weakness suffer the most rapid erosion, and are the first to form gentle slopes, pediments, or valleys.

GOLD PLACERS

DISTRIBUTION

Several gold placers, a few of which have been of economic importance, occur in southern Yuma County. The most productive ones have been the Gila City (see page 208), Castle Dome (p. 90), Laguna (p. 217), Kofa or S. H. (p. 121), and Muggins (p. 219). No placers have been found in connection with the veins of the important gold mines.

HISTORY

The early Padres, if aware of any of these placers, certainly did not appreciate their richness. The Gila City placers, according to former State Historian Hall,[74] were known to certain trappers in the middle forties of the past century, but they were first

[74] Hall, Sharlot M., oral communication.

brought to public attention by Col. Jacob Snively in 1858. During the next few years, exploration of the region revealed most of the other gold placers that are now known.

The greatest production in each placer district was probably made within the first year or two after its discovery. The amount of this early production is difficult even to estimate because most of the gold was taken to distant places for spending, and no one was interested in keeping records. Probably eight or more percent of the total production was, however, made, prior to 1870. In that year, Raymond[75] stated: "Most of the placer mining of the vicinity is done by Mexicans and Indians, and for that reason it is very difficult to get any reliable data on their yield, unless the shipments of Wells Fargo and Co.'s office at Arizona City may be taken as a criterion. These amount to little less than $75,000 during the year, but much of this comes undoubtedly from other sources in the Territory."

The Mineral Resources volumes of the U. S. Geological Survey record the placer production of Yuma County only since 1904, and, in many instances, do not state the yield of each separate district. J. B. Tenney, of the Arizona Bureau of Mines, has estimated the total since 1858 for the following districts: Gila City placers, $500,000; Castle Dome placers, $101,173; Laguna placers, $100,000. During 1930-31, Mr. E. H. Rhodes,[76] storekeeper at Dome, purchased about $2,000 worth of gold, largely from the Gila City and Muggins placers. Besides this amount, some from these areas was marketed elsewhere.

GENERAL FEATURES

Every notable gold placer of southern Yuma County is near or in the mountains that supplied its gold. The gold-bearing material in general is a weakly consolidated aggregate of rather fresh, ill-assorted, subangular gravel, the texture and composition of which proclaim a derivation from the adjacent mountains. Most of this material was eroded and deposited during Pleistocene time, although part of it may have been deposited later.

In some of the districts, this gold-bearing gravel rests upon hard rocks, but, in the most productive areas, it unconformably overlies tilted, bevelled beds of weakly consolidated clay, sandstone, and conglomerate.

GOLD CONTENT

Because of the torrential, short-lived character of the ephemral streams of this region, the gold within the placers tends to be irregularly distributed. As a rule, the richest material is at or near bedrock. Some of the gold is rather finely divided, but much of it occurs as pieces 0.1 inch or more in diameter, and one nugget worth $88 was found in the Gila City placers during 1926. Origi-

[75] Raymond, R. W., Statistics of mines and mining in the states and territories west of the Rocky Mountains (1870), p. 272. Washington. 1872.
[76] Written communication from Mr. Rhodes.

nally, some of these placers were sufficiently rich for every miner to recover from $30 to $125 per day.[77] At present however, most of the gravels contain less than fifteen cents per cubic yard, except in local streaks or pockets, so that only a few industrious, expert dry-washers are able to earn a living from them.

Numerous extraction methods and devices have been tried in attempts to work the placers of southern Yuma County, but, because of mistaken design or erroneous sampling of the ground, all have failed. So far, only dry-washing, or panning where water is available, have been successful.

ORIGIN

Gold placers all result from slow milling and concentration processes incident to the natural erosion of pre-existing, gold-bearing rocks. The origin of most gold placers is traceable directly to veins, lodes, or replacement deposits which, in many instances, were not of high grade, but represented enormous tonnages. The negative conclusion that the principal placers of this region were so derived is reached by the fact that the richest and largest ones have not been traceable to veins or lodes of economic importance.

According to Lindgren,[78] the best conditions for such concentration of gold are found in moderately hilly regions where deep decay of the rocks has been followed by slight uplifts. In regions of rapid erosion, the streams of low gradients soon become overloaded with detrital material, which quickly diminishes their power to carry coarse gold. In southern Yuma County, where rapid erosion has prevailed throughout Pleistocene time, the gold placers are localized in or near mountains where the stream gradients are steep. Except in minute quantities, the gold is never distributed equally through a great thickness of gravels.

The high insolubility of gold in most surface waters is demonstrated by the fact that flake or flour gold, which often is in 2,000 particles per one cent's worth, may be carried by rivers of moderate gradient for hundreds of miles. On the other hand, any silver alloyed with gold is easily dissolved by surface waters, so that the fineness, or parts of unalloyed gold per thousand, of placer gold is generally greater than that of the vein gold of the same district.

According to Emmons,[79] placers are not apt to form from gold-bearing outcrops that contain notable manganese, chlorides, and iron sulphides, unless precipitating agents such as calcite, siderite, rhodochrosite, pyrrhotite, chalcocite, nepheline, olivine, or leucite are abundant, or unless erosion is very rapid. In other words, the gold might be dissolved and carried to shallow depths by means of natural chlorination processes that are operative when solu-

[77] Farish, T. E., History of Arizona, vol. 1, pp. 296-297. 1915.

[78] Lindgren, Waldemar, Mineral deposits, pp. 254, 263, 266. 1928.

[79] Emmons, W. H., The enrichment of ore deposits: U. S. Geol. Survey Bul. 625, pp. 305-324. 1917.

tions containing chlorides, together with sulphuric acid from the oxidation of iron sulphides, act upon manganese dioxide. Such solution and transportation of gold may have taken place in the King of Arizona and Sheep Tanks veins which contain abundant manganese and have yielded no placers. The failure of certain rich veins, like La Fortuna, to form notable placers is probably due primarily to the small area of their outcrops.

PART II — MOUNTAIN RANGES AND MINING DISTRICTS

CHAPTER I—TRIGO MOUNTAINS

SITUATION

The Trigo Mountains, as shown on most maps, are in the northwestern portion of the area considered in this report. Beginning at Weaver Pass, in the middle of T. 1 N., nine miles east of the Colorado River, they extend south-southwestward to a bend in the river at T. 5 S. They are 29 miles long, from five to twelve miles wide, and include an area of approximately 210 square miles. Most local settlers call them the Chocolate Mountains, and refer to the southern portion of the Dome Rock Range, north of Weaver Pass, as the Trigo Mountains. The name Trigo (Spanish for wheat) here alludes to a small, succulent, Indian wheat *(Plantago ignota)* that grows abundantly in the uplands of this region.

POPULATION AND ACCESSIBILITY

Besides a few transient prospectors, the population of the Trigo Mountains in 1930 consisted of watchmen at the Red Cloud, Blaine, and Riverview mines. In the farming region of Cibola, along the Colorado River, less than a dozen families live by raising bees, hemp, and vegetables.

As indicated by Plate 1, a highway to Cibola touches the northern end of this range, and a few auto-trails from the Cibola Valley reach its western margin. The southern portion of the range is entered by the Silver district road, but most of its eastern margin is accessible to vehicles only along sand washes. Because of their aridity and rugged topography, large portions of these mountains are rather difficult to reach, even on foot.

TOPOGRAPHY

The Trigo Mountains attain a maximum elevation of about 3,000 feet above sea level, or 2,800 feet above the Colorado River, but, for their height, are extremely rugged. Although a few portions of the range are of relatively even contour, most of it consists of a series of sawtooth ridges alternating with sharply dissected flats and steep-sided canyons. These ridges, which are generally parallel to the nearest margin of the range, in places give way to blunt, irregularly distributed pinnacles. Most of the rock surfaces are black with desert varnish, and many of them are pitted by small caverns.

The southern margin of the range borders the Colorado River, but the northwestern margin rises from a plain that is 600 feet above sea level opposite Cibola and twice that high at Weaver Pass. This sloping plain is dissected by many steep-sided westward-trending arroyos, separated by remarkably smooth benches. The eastern margin of the range, as shown by Plate I, is the most deeply indented. Its bordering plain stands from 100 to 1,400 feet above sea level and forms a drainage divide about twelve miles south of Weaver Pass. North of this divide, the run-off flows out from Weaver Pass into deep arroyos leading to the Colorado River, while the southward drainage flows by way of Yuma Wash to the river.

GENERAL GEOLOGY

As shown by Plate 1, the Trigo Mountains are made up of schist, granite, and volcanic rocks.

The schists, which are predominantly of sedimentary origin, strike generally northward. They form important areas in the mineralized districts of the southern and northwestern portions of the range.

Sodic granite, intrusive into the schists, outcrops as a few irregular areas within the Silver district, as described on page 54. A few dikes of aplite, probably offshoots from the granite magma, also intrude the schists.

Unconformably above the schists and granite is a thick series of trachytes, andesites, rhyolites, tuffs, and breccias that have been considerably affected by faults of prevailing N.-NW. trend. As indicated by Plate 1, these volcanic rocks constitute the major portion of the range. Opposite Cibola, they unconformably underlie sedimentary rocks that are regarded as Miocene or Pliocene in age.[80]

In the southeastern portion of the range, several square miles of essentially horizontal basalt and tuffs overlie the Tertiary volcanic rocks, and form prominent, irregular, black mesas.

MINERAL DEPOSITS

The Trigo Mountains contain vein deposits of silver, lead, zinc, gold, molybdenum, and vanadium, most of which appear to have been deposited in the epithermal zone, but are now rather thoroughly oxidized. The silver, lead, zinc, molybdenum, and vanadium deposits occur mainly in the Silver district, described on pages 53-70, and to a less extent in the Eureka district, described on pages 70-72. The gold-bearing veins are confined mainly to the Cibola region, described on pages 72-73.

Minor showings of copper and of bismuth are present northwest of the Silver district, but were not studied by the writer.

[80] Wilson, Eldred D., Marine Tertiary in Arizona: Science, vol. 74, pp. 567-568. Dec. 4, 1931.

MINING HISTORY AND PRODUCTION[81]

Because the Trigo Mountains are near the Colorado River, prospecting in them was carried on at an early date. This prospecting led, during the sixties of the past century, to discoveries in the Eureka district which lies immediately north of the Colorado River and 22 miles in air-line north of Yuma, the Silver district which is from three to ten miles farther north, and the gold-quartz veins east of Cibola. According to Raymond,[82] the Eureka district was organized in 1862, and, prior to 1870, had shipped notable amounts of argentiferous galena ore from veins near the river.

Hamilton[83] states that the Silver district was abandoned soon after its discovery, and remained idle until about 1879, at which time Messrs. George Sills, Neils Johnson, George W. Norton, and Gus Crawford relocated many of the abandoned claims and organized the district.

The Black Rock, Pacific, Papago, Red Cloud, Silver Glance, Hamburg, and Princess deposits were among the early locations, and the town of Silent, named after the Silent claim, was established near the Red Cloud mine. All the ores were freighted down a sand wash to Norton's Landing, on the Colorado River, and shipped by boats to the Selby Smelter at San Francisco. In 1880, a small smelter was built at Silent, but it operated only intermittently for about three years.

During the early eighties, a silver bonanza was discovered on the Silver Clip claim, five miles north of Silent. A ten-stamp mill, erected at the river, seven or eight miles by road northwest of the mine, was put into production by 1883. The town of Clip grew up around this mill.[84]

In 1883, the owners of the Black Rock mine erected a small furnace at the river and attempted to smelt their ore.

Other producers in the district during the early eighties were the Engineer, Emma, and Silver Plume, operated by Mr. Crawford, and the Pennant, operated by Messrs. Gilchrist and Davney. By 1884, this district was the foremost in Yuma County. During 1887, it shipped $124,000 worth of ore, chiefly from the Red Cloud and Black Rock mines. In 1889, a dry concentrator was erected to treat the Red Cloud dump, but the venture did not prove successful. As shown on page 53, the production of the district from 1879 to 1899, inclusive, amounted to more than $1,696,000 in silver and lead.

The Silver and Eureka districts ceased activity after the 1893

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[81] Based partly upon notes compiled by J. B. Tenney.

[82] Raymond, R. W., Statistics of mines and mining in the states and territories west of the Rocky Mountains. Washington. 1872.

[83] Hamilton, P., Resources of Arizona, 3d ed., San Francisco. 1884.

[84] Hamilton, P., work cited.

drop in silver prices, and the towns of Silent and Clip have long since passed out of existence.

A dry concentrator, erected at the Red Cloud mine during 1917, made a small production until a year later when it was destroyed by fire.

In 1927, a 100-ton cyanide plant was completed at the Clip or Blaine mine, and a pipe line was laid between the camp and a shallow well near the Colorado River. This mill, which never achieved success, was rebuilt in 1928 and treated about 700 tons of ore.

No production figures for the Eureka district are available, but it has shipped small lots of argentiferous lead ore and concentrates at various times.

PRODUCTION OF SILVER DISTRICT

(Figures compiled by J. B. Tenney)

Date	Prices		Pounds lead	Ounces silver	Total value	Remarks
	Lead	Silver				
1879-1880					$ 6,000	Census report
1880	0.05	1.15	300,000	30,000	49,500	Red Cloud mine
1881-1885	0.045	1.12	800,000	270,000	338,400	Red Cloud, Black Rock, Pacific, Engineer, Emma, Silver Plume, Remnant
1883					160,000	Clip or Blaine mine
1884-1887		1.04		913,461	950,000	Clip or Blaine mine
1887	0.045	0.98	400,000	124,200	139,716	Red Cloud and Black Rock (Mint report)
1888	0.044	0.94	104,345	13,248	16,104	Red Cloud
1889	0.039	0.94	300,000	22,500	32,850	Red Cloud concentrates
1929				7,000	3,600	Silver Mines Consolidated (Clip mine)
Total			1,904,345	1,380,409	$1,696,170	

SILVER DISTRICT

SITUATION AND ACCESSIBILITY

The Silver district, which lies in T. 3 and 4 S., R. 22 and 23 W., from three to ten miles from the Colorado River, is accessible from the railway at Dome by some 36 miles of road. It may also be reached from Cibola by an unimproved road leading along the river and up a long sand wash, but this route is frequently impassable.

TOPOGRAPHY

In this district, rugged, northward-trending ridges rise steeply to maximum elevations of approximately 2,000 feet above sea level, or 1,000 feet above the bottoms of the intervening gulches. For the most part, these ridges are separated by dissected, flat-bottomed valleys, but, in the southeastern portion, they alternate with rugged, V-shaped canyons. Branches of the drainage channels parallel the ridges, but their trunks cut through passes to flow southwestward towards the Colorado River.

Water has been struck in only one of the mines, the Red Cloud, where it stands at a depth of 535 feet on the incline, or approximately 400 feet below the surface.

GEOLOGY

The oldest rocks exposed in the Silver district are moderately fissile schists which consist of fine-grained quartz and sericitized feldspar alternating with bands of partly chloritized biotite. These rocks are predominantly of sedimentary origin and probably of pre-Cambrian age. They are of economic importance in the southern part of the district where they contain silver-lead veins.

Intruding the schists are irregular masses of gray granite which weathers into steep slopes. Examined microscopically in thin section, this rock is seen to consist of an aggregate of quartz, feldspar, and biotite, in grains up to 0.15 inch in diameter. The feldspar is about half orthoclase and half albite, making the rock a sodic granite. This rock has been regarded as of pre-Cam brian age, but may be Mesozoic. It constitutes the footwall of several of the veins.

In places, aplitic dikes, consistsing of fine-grained, white quartz and feldspar, intrude the schists. They may be offshoots from the granite magma.

Unconformably overlying the schists and granite is a thick series of volcanic flows, breccias, and tuffs, as indicated on Plate 5. These flows tend to form steep slopes, such as are shown by Plate 6. They consist mainly of andesites, trachytes, and rhyolites, of which the rhyolites are the youngest. The flow-breccias are mainly of andesitic and trachytic composition, but their age relations were not determined. The tuffs, which generally form slopes of low relief, are white, pink, or locally banded in color, and are in part of rhyolitic to andesitic composition. Of this series, the andesites, andesitic tuffs, and trachytes constitute one or both of the walls of many veins in the district.

STRUCTURE

In the Silver district, the lamination of the schists strikes generally northward and dips at various angles. The granite has been broken along several systems of joints, the major ones of which trend parallel to the ridges. The volcanic rocks generally strike north-northwest and dip at low angles.

Faults of considerable magnitude have affected all of the formations, and in places separate the volcanic rocks from the granite and schists. As indicated by Plate 5, the principal faults strike north-northwest, dip steeply, and are grouped into three roughly parallel zones. Thus, the ridge of pre-Cambrian and Tertiary rocks that separates the Dives from the Mendevil claim is a horst, and the lower, valley-like area of volcanic tuffs and flows that separates the Dives from the Red Cloud claim is a graben. Several systems of minor faults and fractures are present.

VEINS

The veins of the Silver district occur within the three groups of fault zones already mentioned. They range in width from less than one foot up to thirty or more feet, and some of them are traceable for several thousand feet. Their gangue consists mainly of banded calcite, fluorite, quartz, and barite, the order of deposition of which appears to be quartz, fluorite, later quartz, calcite, barite, and later calcite. Their metallic minerals are chiefly limonite, hematite, pyrolusite, cerussite, anglesite, smithsonite, calamine, argentiferous galena, wulfenite, vanadinite, yellow lead oxide, and cerargyrite. The zinc minerals are common only in the southern part of the district. Considerable argentite is reported to have been mined from some of the veins, but none was found by the writer. The silver of the galena probably occurs, however, as microscopic inclusions of argentite. No sulphides, other than galena, occur in the present workings, but, prior to oxidation, pyrite and sphalerite were doubtless locally abundant and some molybdenite was probably present.

The galena is regarded as of hypogene or primary origin. Its secondary products, cerussite and anglesite, have been oxidized essentially in their present positions, but the zinc minerals probably have undergone some downward migration. The cerargyrite, which was richest near the surface and in association with manganese dioxide, was apparently a product of supergene enrichment.

Wall-rock alteration along these veins consists of pronounced chloritization and carbonatization, with less sericitization and silicification. This alteration, together with the mineralogy, structure, and texture of these veins, points to deposition in the epithermal zone.

In the following descriptions, the mines and prospects occurring on the three groups of fault zones will be considered successively, beginning with the Silver Clip or Blaine mine in the northeastern portion of the area.

SILVER CLIP OR BLAINE MINE

Situation and accessibility: The old Silver Clip mine of the northern portion of the Silver district, in Sec. 25, T. 3 S., R. 23 W., is accessible from the Red Cloud mine by some five miles of rather temporary road. An old road to the river at Clip millsite, in the northwestern corner of this township, was almost impassable for automobiles in 1930.

History and production: This deposit became known in the early eighties of the past century, and was immediately recognized as a small bonanza. A ten-stamp mill, erected at the Colorado River, some five miles in air line farther northwest, was connected by wagon road with the mine and and put into production by 1883. The mine was operated by Messrs. Hubbard and Bowers until April, 1887, after which the mill was run on tailings until the end of that year. Production during 1883, according to Hamilton,[85] amounted to more than $160,000. From 1884 to 1887, inclusive, it was approximately $950,000, giving the mine a total yield of more than $1,000,000 in silver. In 1897, the Silver Clip claim was surveyed for patent as the Jas. G. Blaine claim, but it remained practically idle until 1925. During part of that year, Messrs. Thompson, Shiner, Fields, and Bates milled some of its ore at Norton's Landing.[86] In 1925, the Silver Mines Consolidated Company built a 100-ton cyanide mill at the mine and laid a pipe-line to a shallow well near Norton's Landing. All supplies were hauled from Yuma by way of Picacho, California, and ferried across the river. None of the operations were very successful, and once even the ferry capsized with more than 200 pounds of cased cyanide. This mill was rebuilt during 1928, but its design was still unsuccessful. Only about 700 tons of ore, which yielded some 7,000 ounces of silver worth $3,600, were treated during 1928 and 1929.

The Jas. G. Blaine claim is now held by the United Silver Mines Co., of Yuma.

Local geology: Here, lava flows, tuffs, and breccias, mainly of andesitic composition, form sharp, northward-trending ridges. Their beds, which generally dip at low angles, are extensively shattered in several directions. The most extensive fissuring trends N. 25° E., with steep westward dip, and another prominent system strikes northward, with steep eastward dip. Many faults of undetermined throw strike north-northeast, north, and north-northwest, with westward dips.

Vein: The Clip vein occurs within a fault zone that strikes from N. 30° E. to N. 10° W. and dips from 60° to 70° W. This

[85] Hamilton, P., Resources of Arizona, 3d ed., p. 238, San Francisco. 1884.

[86] Oral communication from Mr. J. M. Odell.

vein is made up chiefly of calcite, quartz, fluorite, barite, hematite, limonite, and pyrolusite, together with more or less gouge and brecciated wall rock. The calcite, which contains considerable manganese and iron, is coarsely crystalline and dark gray. The quartz forms finely crystalline, banded to vuggy masses. In places, the fluorite is visibly crystalline, but generally it occurs as dense, purplish bands which coat the quartz and are in turn coated by white calcite. The barite commonly occurs as crystalline masses and thin blades cutting the quartz and fluorite. The hematite, limonite, and pyrolusite occupy fissures, cavities, and vugs. Locally associated with them are small, irregular masses of chlorite, cerussite, lead oxide, cerargyrite, vanadinite, and malachite. No sulphides and no zinc minerals were observed in the present workings.

This vein is traceable for more than 750 feet, beyond which point it becomes a narrow streak of iron-stained gouge and breccia together with minor amounts of barite and carbonate. As indicated by underground workings, it ranges in width from less than one foot up to about eight feet, with perhaps half of its length more than three feet wide. As indicated by stoping, it was of commercial grade only for a maximum depth of about 120 feet on the dip. According to Mr. A. B. Ming,[87] one of the later owners of the Jas. G. Blaine claim, the ore mined ran from 20 to 140 ounces of silver per ton. The vein walls, which are rather wavy, show deep alteration to chlorite, limonite, and calcite. In places, horses of altered wall rock, from a few inches up to several feet through, are present. A few smaller veins, parallel and similar to the main vein, occur a few feet away from it. Certain cross-fractures are mineralized, but mainly with barren calcite.

Workings: Workings on the Clip vein include five levels of drifts at approximately forty-foot intervals of depth. The first and second levels are largely semi-filled stopes. Figure 1 is a sketch of the principal workings on the third, fourth, and lowest levels.

As indicated by Figure 1, two stopes on the vein extend from the fourth level to the surface. Underground, the larger stope is from 100 to 150 feet long by a maximum of fifteen feet wide, and the smaller is about forty feet long by a maximum of ten or more feet wide. Near the surface, these stopes are several times wider.

The lowest level shows a width of from eight to eighteen inches of manganiferous calcite and barite, together with a few small bunches of cerussite and yellow lead oxide.

On the fourth level, the southern end of the drift shows the vein there to be only one foot wide, mainly of bladed barite, and it contains, according to Mr. Odell, only seven ounces of silver per ton. The northern end of this level is in a shattered zone, about

[87] Oral communication.

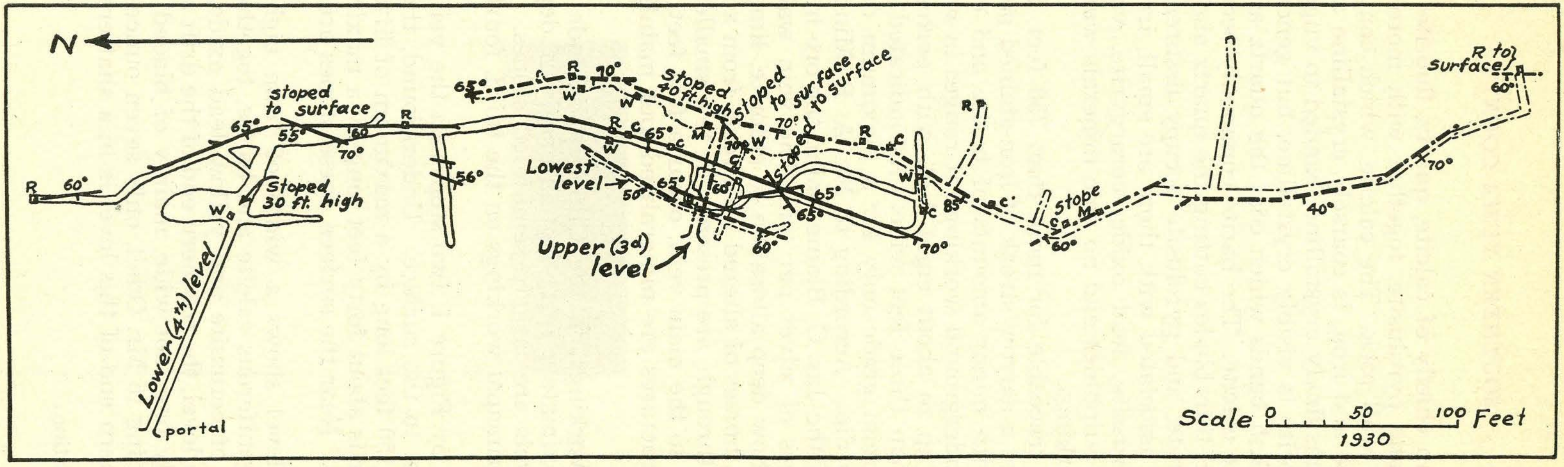

Fig. 1.—Plan of principal workings, Clip mine—R, raise; C, chute; W, winze; M, manway; heavy lines indicate faults.

two feet wide, that shows chiefly calcite and barite between iron-stained walls.

On the third level, the southernmost workings show the vein at that place to be less than one foot wide and mainly of iron-stained barite and breccia. At the northern end of this level, the vein is up to 2½ feet wide and consists of barite, hematite, and breccia.

Surface equipment: In 1930, surface equipment at this mine included a 100-ton cyanide mill, a machine shop, two 25-hp. hot-head engines, a 2-drill portable compressor, an assay office, and several buildings. In 1930, the well near Norton's Landing was about twenty feet deep and contained three or four feet of water that apparently enters from the northeastern side, rather than from the river, but has never been pumped dry. This well was equipped with a 15-hp. gasoline engine to operate a Douglas lifter pump and a Rumsey triplex pump which boosted the water to the mill.

AMELIA OR GALLO CLAIM

The Amelia claim, formerly known as the Gallo and now held by the United Silver Mines Company, of Yuma, is some 1,500 feet southwest of the Jas. G. Blaine. This claim yielded a considerable amount of silver ore during the eighties, but nothing of its history is recorded.

Here, low, rugged, southward-trending ridges of lava, tuff, and breccia display several directions of rather extensive fracturing. Differential erosion acting along these fractures has carved out numerous caves, niches, and windows. The former name of the claim, Gallo (Spanish for Rooster), alludes to an erosional form containing a window and resembling a rooster's head.

The principal vein occurs within a fault zone that strikes S. 35° E., dips 60° E., and cuts andesitic or trachytic breccia and tuff. This vein consists mainly of crystalline and bladed barite, finely crystalline quartz, manganiferous and ferruginous calcite, hematite, and limonite. Certain open spaces in this material are lined with crystalline cerussite. The vein walls show considerable chloritization, silicification, and iron staining.

Workings on the Amelia vein include 200 or more feet of tunnel connected with two raises to the surface, two winzes, and one stope to the surface. In the principal winze, which is sixty feet deep, the vein has a width of four feet and a content, according to Mr. W. D. Riley,[88] of less than one percent lead and from five to twelve ounces of silver per ton. The stope, which is up to fifty feet long, fifty feet high, and nine feet wide, shows the vein to be from four to five feet wide. According to Mr. Riley, samples taken at its ends ran less than one percent lead and from 8.6 to 9.8 ounces of silver per ton. A surface cut continues north-

[88] Personal communication.

ward from this stope, for a length of about fifty feet, with a width of from four to six feet and a depth of from five to twenty feet.

A few hundred feet west of these workings, a similar vein occurs within a fracture zone that strikes northwest and dips 50° NE. It has been prospected by a short tunnel connecting with a shallow winze, and a surface stope that is up to thirty feet long, six or eight feet wide, and 35 feet deep. This vein is more extensively iron stained than the other vein.

REVELATION CLAIM

The Revelation No. 2 claim, held by Mr. H. L. Duty, of Yuma, joins the Amelia on the south.

Here, andesitic and trachytic lavas are separated from granite and schist on the west by a fault zone that strikes north-northwest and dips about 80° E. A vein, with a width of from twenty to forty feet, occupies this fault zone for a length of some 500 feet. It consists mainly of manganiferous calcite, barite, vuggy quartz, and brecciated wall rock, together with irregular masses of hematite and small, cellular bodies of cerussite and smithsonite. The vein walls show considerable chloritization.

Workings on this claim consist of a few shallow cuts.

MENDEVIL CLAIM

The Mendevil claim, 3,000 feet south-southeast from the Revelation No. 2 claim, was surveyed for patent in 1887 for Mr. S. S. Draper, but, so far as is known, has never produced any ore. It is now held by Messrs. W. D. Riley, A. B. Ming, and R. A. McPherson, of Yuma.

Here, as shown by Plate 5, a fault zone continues from the Revelation claims and separates lavas and tuffs from granite and schist on the west. Microscopic examination of the lava at this point shows it to be andesite and to consist of zoned phenocrysts of plagioclase, up to 0.15 inch in diameter, set in a dense, feldspathic groundmass. The fault zone, which strikes N. 10° W. and dips steeply northeast, contains veins, up to several feet wide, of manganiferous calcite, barite, and quartz. In places, the barite forms veins up to two feet wide. Certain vugs within the calcite contain cerussite and yellow lead oxide. The vein walls are somewhat chloritized.

This vein zone continues for some 1,600 feet south and 2,000 feet north of the Mendevil claim. Workings on it consist of a few shallow cuts. According to Mr. W. D. Riley,[89] certain portions of it contain five percent lead and fifteen ounces of silver per ton.

CHLORIDE, MANDARIN, AND CASH ENTRY CLAIMS

The Chloride, Mandarin, and Cash Entry claims, held in 1930 by the Neal Mining Company, are in the southeastern portion of

[89] Personal communication.

the area mapped on Plate 5. Considerable prospecting has been done on these claims, but, so far as known, no ore has been produced from them.

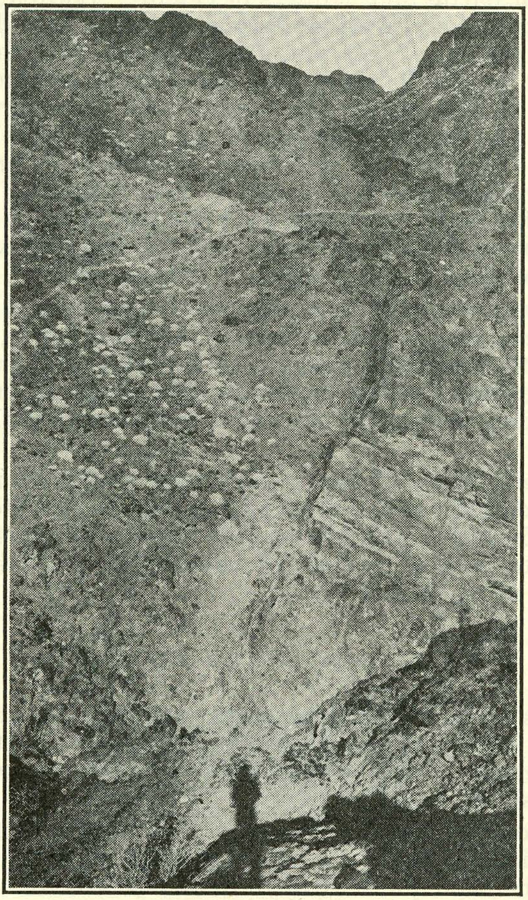

Plate 6.—Banded quartz-fluorite-barite vein in fault fissure on Chloride claims.

In this vicinity, trachytic to andesitic lavas, tuffs, and breccias and the underlying granite have been eroded into rugged, steep-sided ridges. These rocks have been extensively faulted and fractured. The major faults, as indicated by Plate 5, strike northward and northwestward, but many unmapped, minor faults strike in other directions. The principal jointing in the granite strikes S. 70° W. and dips steeply southeast.

On the Chloride No. 1 claim, the principal fault strikes N. 10° W., dips from 60° to 70° SW., and appears to have a throw of from 35 to 55 feet. It contains a vein (see Plate 6) that is from three to five feet thick, but it thins out near the southern end of the claim. This vein consists mainly of successive bands, up to 1/4 inch wide, of finely crystalline quartz and fluorite, cut by bladed crystals of barite and veinlets of calcite. Locally, the fluorite is coarser grained and manganiferous calcite is abundant. Microscopic examination of this material indicates that the fluorite is intermediate in age between two generations of the quartz and that the barite and calcite are successively later. In places, the vein contains a few small masses of galena and streaks of yellow lead oxide. Crystals of wulfenite, smithsonite, and cerussite occur within fractures and vugs. A few streaks of chrysocolla and malachite mark fractures near the edges of the vein. The vein walls are stained by limonite, and the hanging wall, particularly, is chloritized for a distance of several feet.

On the Mandarin claims, a northwestward-trending fault zone in trachyte contains a narrow vein of fluorite, barite, and calcite, together with abundant gouge and breccia. It has been prospected by several shallow workings that show, according to Mr. Robert Morgan, certain portions of it to contain a little silver and lead.

On the Cash Entry Claim, a fault zone which cuts the granite and lavas contains veinlets of manganiferous calcite and finely crystalline fluorite. Certain narrow fissures are lined with tiny cherry-red to yellow crystals of vanadinite. It has been prospected by a short tunnel.

DIVES OR SAXON MINE

The Dives claim, formerly known as the Saxon and now held by the Neal Mining Company, is about 1½ miles northeast of the Red Cloud mine. This claim has produced one or two car loads of high-grade silver ore.

In this vicinity, a fault zone separates andesitic and rhyolitic lavas, breccias, and tuffs on the west from schist and granite on the east. The main fault, which strikes N. 20° W. and dips 60° SW., is joined near the center of the claim by a branch fault that strikes N. 10° W. These faults contain veins of similar character, but the main one is wider, longer, and more strongly mineralized. This vein, which is traceable southward for some 2,000 feet, is about ten feet wide in the vicinity of the intersecting vein, but narrows southward. It is a few feet from the schist and granite in tuff and breccia which show considerable chloritization and carbonatization. The vein consists mainly of limonite, hematite, pyrolusite, barite, manganiferous calcite, and finely crystalline quartz, together with minor amounts of gypsum. Crystalline to sandy cerussite and smithsonite, locally with yellow lead oxide, occur in vugs and irregular masses. The richer portion, which is some 300 feet long and from a few inches to 1½ feet wide, occurs near the hanging wall of the wider portions of the vein. It is notably limonitic at the surface, and the mined portions of it were probably rich in silver chloride.

Workings on the Dives claim consist of an 86-foot vertical shaft with a 45-foot crosscut and several pits and short tunnels. The shaft and crosscut did not reach the main vein. All of the ore mined was from shallow surface cuts.

PRINCESS MINE

The Princess claim, about one mile northeast of the Red Cloud mine, produced silver ore during the eighties, but has long been idle. It was surveyed for patent early in 1880 for Messrs. Norton, Crawford, and Lambie and is now owned by Mrs. Rose Livingston, of Yuma.

The surface of this claim is made up of low, ruggedly dissected ridges of schist, granite, and volcanic rocks. As indicated by Plate 5, a curving fault that is traceable for a mile southward strikes north-northwest, dips 30° SW., and separates the schist from the granite and lavas. The Princess vein occurs within this fault zone, near the southern end of the claim and a short distance north of an offset in the fault. The hanging wall of the ore shoot is a carbonate vein about two feet thick, and the footwall is brecciated, silicified andesite about four feet thick, cemented with carbonate and barite. The ore shoot consists mainly of manganese-stained breccia cemented by carbonates, fine-grained vitreous quartz, and fluorite, together with irregular masses of hematite. It contains nuggets, up to several inches in diameter, of anglesite, cerussite, and yellow lead oxide, intermingled with less abundant smithsonite. A little vanadinite occurs within fractures and vugs. Emmons and Becker [90] reported also galena, argentite, and cerargyrite as present in this vein.

Workings on the Princess claim consist of an inclined shaft, about 100 feet deep on the dip of the vein, and open stopes which extend for a depth of fifty feet and a distance of 25 to 35 feet south of the shaft. These workings indicate that the ore shoot was from 1½ to 2 feet wide in places, but branched into seams only 1 or 2 inches thick.

HAMBURG CLAIMS

The Hamburg claim, held by the Neal Mining Company, joins the Princess on the south. During 1880-81, it was held by Mr. Wm. P. Blake [91] and associates who sank a sixty-foot inclined shaft on the vein, but, so far as known, mined no ore from it.

The geology and ore occurrences on this claim are similar to those of the Princess, and the vein occurs within the same fault zone. At the surface, this vein consists of dark-gray, ferruginous

[90] Emmons, S. F., and Becker, G. F., Statistics and technology of the precious metals: Census Office Report, Washington, p. 52. 1885.

[91] Blake, Wm. P., Castle Dome Mining and Smelting Company (private report), p. 25. 1881.

calcite, up to about eight feet thick, containing irregular bunches of hematite and coarse-grained, vitreous quartz. The dump shows masses of hematite and limonite, with smaller bodies of crystalline cerussite partly altered to yellow lead oxide. Some red lead oxide occupies vugs. Blake[92] mentions also the occurrence of vanadinite and wulfenite in this vein.

On the Hamburg No. 2 claim, which joins the Hamburg on the south, the fault zone contains several baritic veins up to ten inches thick. Near the southern end of the claim, one of these veins is six feet wide. It is about 75 percent barite, and the remainder consists of calcite, a little limonite, and a few scattered crystals of wulfenite.

SILVER KING CLAIM

The Silver King claim, held by Mr. S. P. Huss, of Yuma, joins the Princess and Hamburg claims on the east. It produced a few tons of silver ore in 1923. As indicated by Plate 5, schist, granite, and volcanic rocks cover this claim.

The volcanic rocks, which in the field resemble andesite, are traversed by a northward-trending brecciated zone more than 100 feet wide. Within this zone are narrow, pockety, quartz-fluorite veins which contain irregular masses of hematite, galena, anglesite, cerussite, and yellow lead oxide. Tiny crystals of wulfenite are present in vugs. Certain portions of the vein show a little manganese and copper stain.

Workings on the Silver King claim consist of a fifty-foot shaft and a few short tunnels distributed over a length of about 200 feet on the brecciated zone.

GERONIMO CLAIMS

The South Geronimo and North Geronimo claims, held by the Neal Mining Company, are about 1¼ miles northwest of the Red Cloud mine, west of the road to the Clip mine.

On the South Geronimo claim, bedded rhyolite tuffs and andesitic flows are faulted against granite, as indicated by Plate 5. Two veins, one a few feet and the other about fifty feet wide, occur within this fault zone which here strikes N. 27° W. and dips 65° NE. A tunnel on the wider vein shows it to contain abundant hematite, together with manganiferous calcite, flinty quartz, and irregular bunches of smithsonite, cerussite, yellow lead oxide, wulfenite, and vanadinite. A few hundred feet farther northwest, in the vicinity of a transverse fault, an old shaft, perhaps 100 feet deep, was sunk on the vein. Farther south, a tunnel and a winze in the granite showed comparatively little mineralization, except for manganese stain.

The North Geronimo claim is on rhyolite tuffs and andesitic flows, cut by a northward-trending fault zone that dips 35° E. An irregular vein, up to a few feet in maximum width, occurs

[92] Work cited, p. 25.

within this fault zone. Near the northern end of the claim, it has been prospected by an eighty-foot shaft with two short drifts on the 25-foot level. These workings show the vein to consist of hematite and limonite together with finely crystalline fluorite which is coated with vuggy manganiferous calcite and coarsely crystalline quartz. The vugs contain abundant crystals of wulfenite and vanadinite. A few streaks and bunches of galena, partly altered to anglesite, cerussite, and yellow oxide, occur near the footwall.

According to Mr. Robert Morgan,[93] the vein, as exposed by these workings, contains an average of six percent lead and eight ounces of silver per ton.

RED CLOUD MINE

Situation: The Red Cloud mine is in the northeastern portion of the Red Cloud claim, about a mile northwest of the Black Rock shaft.

History and production: This claim was one of the earliest locations in the district. According to Hamilton,[94] the early operators took more than $30,000 worth of silver ore from the croppings. Hamilton[95] also states that, prior to 1881, the mine was purchased by the Red Cloud Mining Company, of New York, which sank an incline following the dip of the vein for 274 feet and erected a twenty-ton furnace at the Colorado River. This smelter was operated intermittently for about three years, but without great success. In 1885, the claim was surveyed for patent for Messrs. Horton and Knapp. Later, it was acquired by Messrs. Hubbard and Bowers who, in 1889, shipped $32,850 worth of dry concentrates.

After 1899, the mine was practically idle until 1917 when the Red Cloud Consolidated Mines Company acquired it and installed a small dry-concentrator. This mill burned down before making more than a few test runs. Several years later, the E. R. Boericke Company obtained a short option on the claim, ran some drifts, sank several drill holes, and installed the present surface equipment, but attempted no production. In 1928, the Neal Mining Company acquired control of the Red Cloud and 45 other claims in the district.

Local geology: Here, the Tertiary tuffs and lavas floor a flat-bottomed valley that is bordered by ridges of lava, tuff, and sodic granite. The northwestward-trending channel of Red Cloud Wash dissects this area, and, some 1¼ miles farther downstream, cuts southwestward through the ridges toward the Colorado River. The Red Cloud mine is approximately 1,070 feet above sea level, and the granite ridge westward rises to a maximum of some 800 feet higher.

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[93] Oral communication.

[94] Hamilton, P., Resources of Arizona, 1884 ed., p. 238.

[95] Hamilton, P., Resources of Arizona, 1881 ed., p. 73.

The tuffs east of the mine strike southeastward and dip 30° NE. Faults and fractures trending in several directions have extensively affected all of the formations. The most prominent faults strike north-northwest and, in places, form the contacts between granite and lavas.

Vein and workings: The Red Cloud vein occurs within a fault zone of somewhat irregular strike and dip, separating the volcanic rocks on the east from the granite on the west. At the mine, this zone strikes about N. 15° W. and dips from 45° to 60° E. The vein is made up chiefly of limonite, hematite, quartz, fluorite, and calcite, together with considerable amounts of gouge and brecciated wall rocks, all more or less stained by pyrolusite. The quartz forms irregular, finely crystalline, vuggy masses which, in places, are cut by veinlets of coarser-grained quartz. Generally, it is interbanded with gray to purple fluorite which ranges in texture from dense to crystals 1/8 inch in diameter. The calcite is mostly a coarsely crystalline, dark gray, manganiferous variety, but some later, white calcite also occurs. The limonite and hematite, which occupy cavities and vugs within the other gangue minerals, are locally intermingled with irregular, cellular masses and vug-linings of cerussite, smithsonite, pyrolusite, vanadinite, wulfenite, and very minor malachite. In places, nodules of argentiferous galena, partly altered to black anglesite and pale-yellowish cerussite, occur. The silver of this galena is probably present as minute inclusions of argentite. No other sulphides occur in the mine. Cerargyrite, present as small, disseminated masses and streaks within the oxidized minerals, constitutes the principal silver mineral.

On the surface, the unmined portions of the Red Cloud vein are largely covered by dumps and hillside talus. Underground, the irregular shafts, drifts, and stopes indicated by Figure 2 have followed it for a length of some 560 feet and an inclined depth of 535 feet which is the water level. Most of the upper workings were made half a century ago, when the ore was sorted and screened underground and dragged up the incline in rawhide buckets. The stopes were supported by pillars, dry-wall fills, cottonwood timbers, and willow laggings which are still fairly intact. A more recent vertical shaft, approximately 200 feet deep, intersects the vein at a depth of 290 feet on the incline.

Down to 360 feet on the incline, the vein has a granite footwall, an andesitic breccia and tuff hanging wall, and a thickness of two to seven feet. Below that point, it has granite walls, steepens in general dip, and shows less mineralization. According to Mr. Robert Morgan,[96] engineer of the Neal Mining Company, the unmined portion of the vein, as exposed above the granite contact, contains an average of about six percent lead and ten ounces of silver per ton, but, in the granite, is less than half that rich. The grade improves but slightly at the water level.

[96] Personal communication.

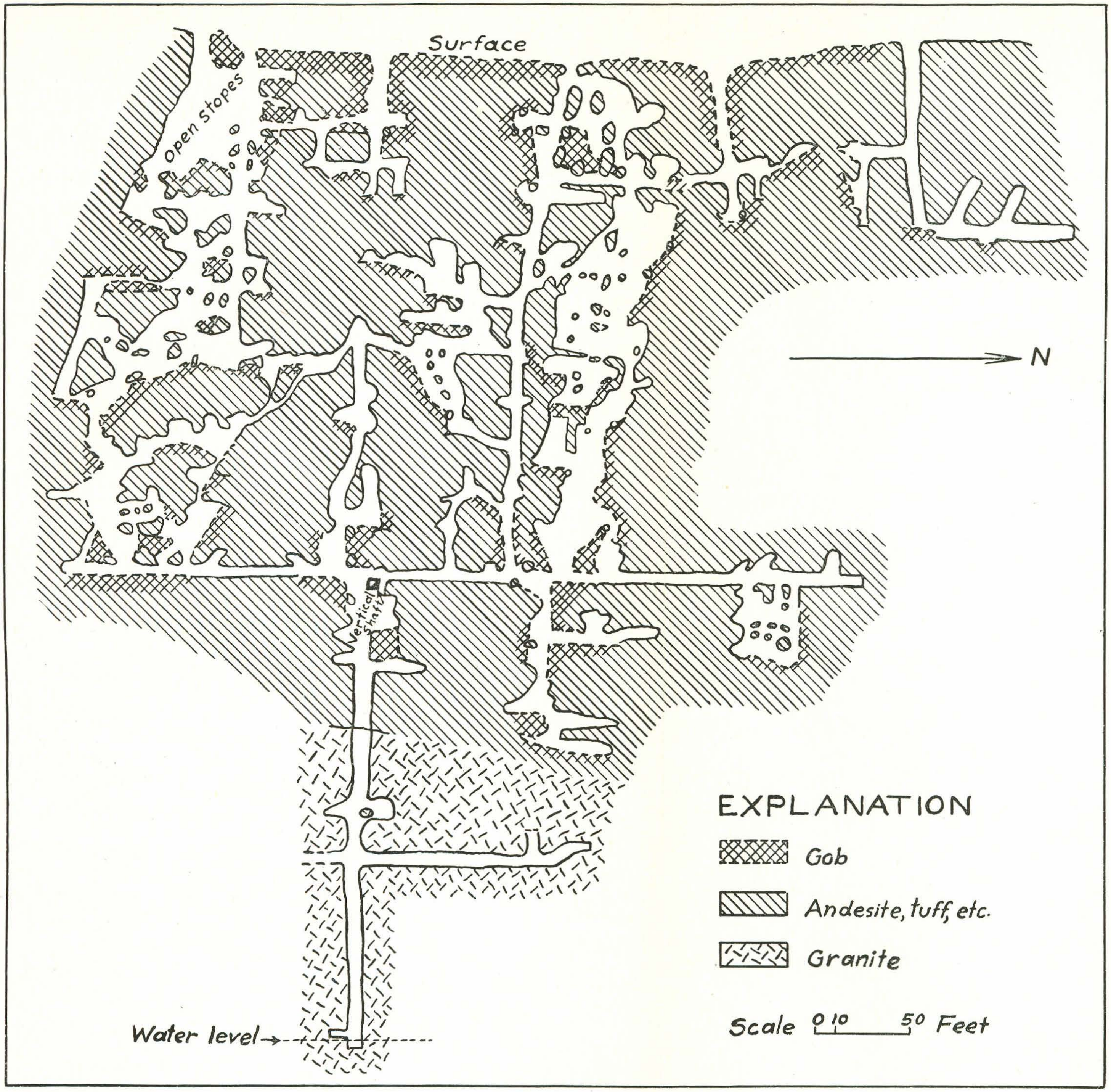

Fig. 2.—Sketch of geology and principal workings of Red Cloud mine—Section on plane of vein—Base map of workings supplied by Neal Mining Company.

As indicated by the stopes sketched in Figure 2, the vein contained two major ore shoots of which the southern one was from 35 to 110 feet long by 300 feet deep, and the northern one from 25 to 100 feet long by 410 feet deep. In the vicinity of these shoots, the vein shows more iron and manganese mineralization, and its walls are intersected by abundant transverse fractures.

Wall-rock alteration along the vein consists chiefly of sericitization and chloritization.

Equipment: In 1930, equipment at the Red Cloud mine included a 25-hp. gasoline hoist, a blacksmith shop, an assay office, and several buildings. Water for domestic use was hauled from the Blaine pipe line.

BLACK ROCK MINE

The Black Rock mine is in the southern portion of the area mapped on Plate 5, immediately north of the Silver district road at a point about 36 miles from Dome.

This claim was one of the early locations in the district, but very little of its history or production is known. By 1881, according to Hamilton,[97] the mine had been sold for $135,000 and some rich ore was produced from a 100-foot shaft. Prior to 1884, the owners sank this shaft to a depth of 420 feet and erected a small furnace at the Colorado River. How long this furnace operated is not recorded, but it is reported as turning out a ton of base bullion per day in June, 1883.[98] So far as known, the mine has not produced since 1887. The Black Rock claim was patented during the early eighties and is now owned by Mr. C. E. Batton.

In this vicinity, low, steep-sided, hilly ridges have been carved out by the drainage system of Black Rock Wash which drains westward to the Colorado River. These ridges rise to elevations of approximately 1,200 feet above sea level or 400 to 500 feet above the bed of the wash.

The prevailing rock on the Black Rock claim is schist which, in the southeastern portion, underlies the Tertiary volcanic series. This schist consists of fine-grained quartz and sericitized feldspar, alternating with bands of partly chloritized biotite. It weathers to blocky, moderately fissile, dark gray surfaces. On the Black Rock claim, its principal lamination strikes northwest and dips steeply northeast. Complex faulting and fracturing have affected this schist. Black Rock Wash appears to follow a fault zone.

The Black Rock vein occurs within a fault zone that strikes N. 65° W. and dips 40° NE. The vein, which consists mainly of manganese-stained calcite together with less amounts of silicified breccia, is traceable on the surface for a length of more than 600 feet and a maximum width of about 18 feet. Particularly near the hanging wall, it contains honeycombed and vuggy masses of fine-grained, brownish-gray quartz, fine-grained fluorite, and

[97] Hamilton, P., Resources of Arizona, 1881 ed., p. 73.

[98] Unpublished notes of J. B. Tenney.

later vitreous quartz. Occupying vugs and fissures are irregular masses of limonite, calcite, pyrolusite, smithsonite, cerussite, and minor galena altering to anglesite, cerussite, and yellow lead oxide. This mineralized portion of the vein has been followed underground for a maximum length of 175 feet and a depth, on the incline, of 270 feet. Its richer portion ranges from thin streaks to a width of probably not more than ten feet, but some silver-lead-zinc mineralization is traceable throughout the width of the vein. Several quartz-fluorite stringers occur near and parallel to the large vein, and are cut by branching veinlets of later calcite. For some fifty feet on each side of the main vein, the schist shows pronounced silicification, chloritization, and carbonatization.

The principal workings on the Black Rock claim include a 420-foot inclined shaft and more than 900 feet of drifts and tunnels connecting with it, as shown by Figure 3. The vein, as exposed above the 270-foot level in these workings, has been sampled by Mr. F. W. Giroux. According to Mr. Batton, these samples contained an average of 4.87 percent lead, 9.8 percent zinc, and 6.7 ounces of silver per ton.

The surface equipment at this mine was dismantled many years ago.

PACIFIC AND MANDAN CLAIMS

The Pacific claim, which joins the Black Rock on the northwest, was surveyed for patent in 1887 for Mr. M. L. Keith, and is now owned by Mr. C. E. Batton. It has produced some silver ore, but its history is unknown.

Here, schist similar to that which occurs on the Black Rock claim is intruded by granite, as shown in Plate 5. The principal mineralization occurs within a silicified fault zone that strikes north, but swings southeastward on the Mandan claim, and dips about 85° E. Prior to 1887, a 100-foot shaft was sunk where this zone is exposed on the northern bank of Black Rock Wash. Its dump shows finely crystalline, banded quartz together with masses of limonite, hematite, pyrolusite, and calcite. Some vugs in the quartz are lined with crystalline cerussite.

On the Mandan claim, which joins the Pacific on the southwest, several small cuts have been sunk on the vein. One of them exposes a few small nodules of altered galena. At a point near the southeast corner of the Pacific claim, the vein has been cut off by a transverse fault.

SLIVER GLANCE CLAIM

The Silver Glance claim, north of the Black Rock and east of the Pacific, was surveyed for patent in 1881 for Mr. A. H. Cargill, and is now held by Messrs. W. D. Riley, A. B. Ming, and R. A. McPherson, of Yuma. Nothing of its production is known.

Low, southward-trending ridges of quartz-sericite schist form

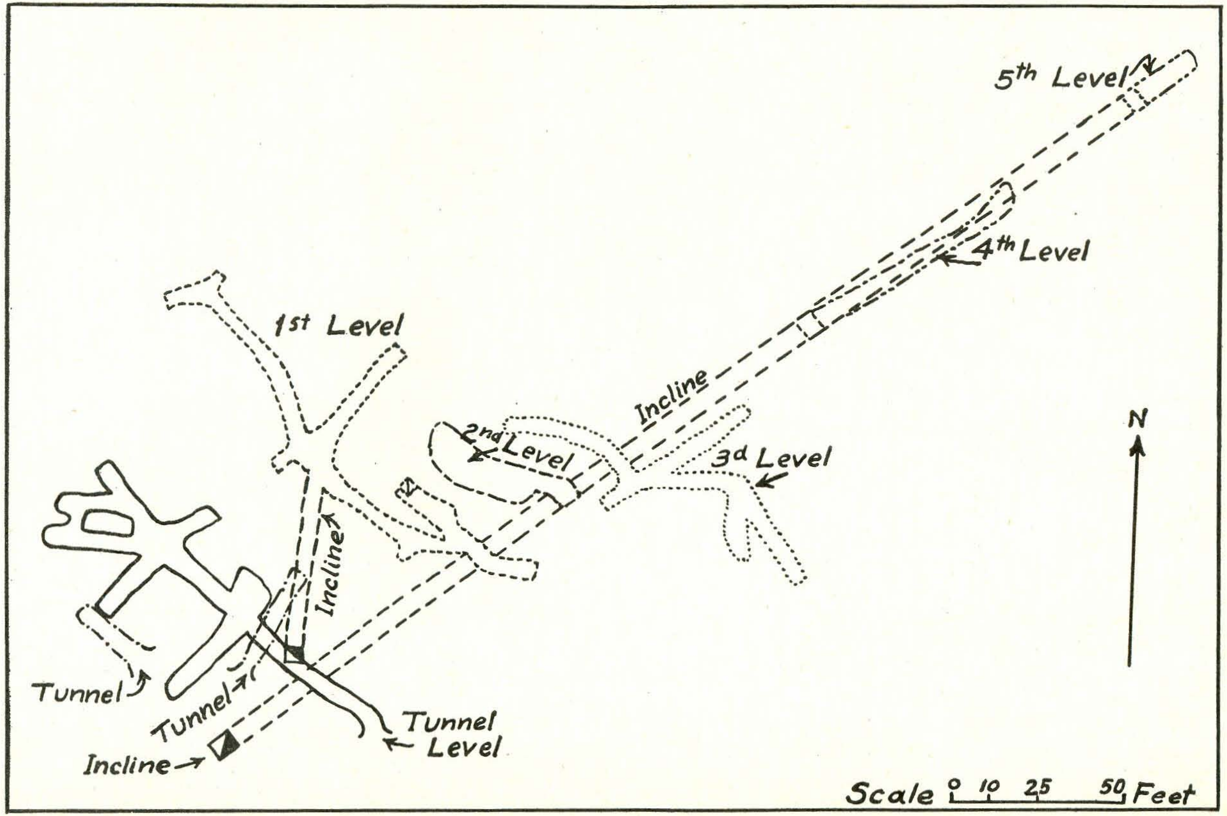

Fig. 3.—Plan of principal workings of Black Rock mine—Supplied by Mr. C. E. Batton.

the surface of this claim, but, eastward, the schist passes under gently southwestward-dipping lavas and tuffs. On the Silver Glance claim, a broad, brecciated fault zone, slightly offset by several transverse faults, strikes S. 15° W. and dips 45° SE., but it steepens somewhat in depth. Certain portions of this fault zone are cemented by vein material similar to that of the Black Rock vein, but more siliceous.

From near the eastern edge of the claim, a tunnel has been driven westward into a low ridge to intersect the vein. At a distance of some 150 feet in from the portal, it cuts a small lead that consists of quartz, limonite, and manganiferous calcite, together with a few small bunches of galena partly altered to anglesite, cerussite, and yellow lead oxide. The quartz, which is finely crystalline and traversed by veinlets of coarser-grained quartz, has cavities lined with limonite and crystals of wulfenite. The tunnel continues for 100 or more feet to an old shaft on the main lead. This shaft was said by Mr. Morgan to be 200 feet deep, but is partly filled with waste rock.

PAPAGO CLAIM

The Papago claim, held by Mr. W. M. Winn, of Yuma, is west of the Pacific and south of the Red Cloud claims. During the early days, under a different name, it produced a considerable tonnage of silver ore. At one time, a small, crude table and cyanide mill were operated here, but without success.

In this vicinity, a northward-trending, steeply eastward-dipping fault zone separates tuffs and andesitic lavas on the east from granite on the west. The vein, which occurs within this fault zone, but entirely mantled by the gravels of Black Rock Wash, was discovered by placer miners sinking to bed rock.

According to Mr. Robert Morgan,[99] the vein was narrow at the top, but widened downward. It thins out to nothing at the southern bank of the wash.

Workings on this vein include several shafts, now largely filled with gravel. According to Mr. Morgan, these shafts are from 125 to 250 feet deep, and connect with stopes of considerable extent. The dump at the main shaft indicates that the ore was similar to that of the Red Cloud mine, but more manganiferous. Some wulfenite and vanadinite are present. The gangue contains limonite, hematite, calcite, and two generations of quartz.

EUREKA DISTRICT

The Eureka district, which extends from the Colorado River northward towards the Silver district, is accessible by about four miles of trail that branches westward from the Silver district road at the mouth of Yuma Wash. It may also be reached by boat from Picacho, on the California side of the river.

[99] Oral communication.

This region is made up of rugged, steep-sided, serrated ridges, alternating with canyons that are several hundred feet deep and drain southward or southwestward to the Colorado River. The prevailing rocks are well-laminated gray quartz-sericite schists of probable sedimentary origin. They generally strike northward, dip at various angles, and display several systems of faults and fractures. A few aplitic dikes cut the schists.

The veins of this district occupy fault zones that strike about N. 70° E. and dip 45° or more NW. The veins range in width from less than one foot up to a general average of perhaps three feet, and, in a few spots, swell to widths of twenty or more feet. Some of them are traceable for nearly a mile, but the ore shoots so far found are rather pockety and tend to be localized in the vicinity of fissures that intersect the main faults at small angles. The vein filling consists predominately of manganiferous to ferruginous and white calcite, intermingled with masses of breccia and gouge.

In places, very cellular, crystalline, white quartz occurs. The ore shoots consist of limonite, hematite, cerussite, and smithsonite, with scattered bunches and narrow veins of galena and ferruginous, black sphalerite. Locally, a few thin streaks of copper stain appear. The vein walls contain abundant, small, pyrite metacrysts and show pronounced sericitization together with less abundant silicification and chloritization. The mineralogy, texture and wall-rock alteration of these veins point to deposition in the epithermal zone.

RIVERVIEW CLAIMS

Ten unpatented claims, held by the Riverview Mines Company, are a short distance north of the Colorado River, on the veins described on page 71.

Intermittent, small-scale mining has been done on these claims since about 1875, and occasional, small shipments of high-grade silver-lead ore and hand-jig concentrates have been made. At one time, a small concentrator, equipped with crusher, ball mill, and Cammett table, was erected, but was operated for only a short while. Water was obtained from a shallow well near the river.

Workings on these claims consist of numerous open cuts, several hundred feet of tunnels, and a few shallow winzes and shafts. The tunnels contain several small stopes, one of which is about 45 feet high, from six to eight feet wide, and from six to ten feet long. According to Mr. J. L. Griffith,[100] a test shipment, in 1927, of 16½ dry tons of concentrates from about 100 tons of ore from these workings contained 60.4 percent lead, 8.7 percent zinc, 6.9 percent sulphur, 3.0 percent iron, 27.7 ounces of silver, and 0.08 ounces of gold per ton.

[100] Personal communication.

MENDEVIL CLAIMS

Seven claims, held by Mr. Ysidro Mendevil, are in the rugged country east of the Riverview claims and within one mile of the Colorado River. According to Mr. Mendevil, these claims have produced a small amount of argentiferous lead ore, and, in 1929, yielded a few tons of sorted ore and concentrates worth about $80 per ton. A small mill, which consists of a crusher and one table, is located at the river.

These claims were not visited by the writer, but the ore being milled resembled that from the Riverview claims. According to Mr. Mendevil, it occurs in similar veins that strike east-northeast.

CIBOLA REGION

The small farming settlement of Cibola, along the flood-plain of the Colorado River in T. 1 S., is nearly 100 miles by road from Yuma. Ripley, California, its nearest railroad point, is reached by fourteen miles of road that connects with Taylor's ferry, on the river.

On the rugged, northwestern slope of the Trigo Mountains, about six miles east-southeast of Cibola, a few square miles of moderately fissile schists, intruded by granite, outcrop from beneath Tertiary lavas on the east and Tertiary and Quaternary sedimentary beds on the west. These schists, which are from grayish-white to green in color, consist largely of quartz, sericite, and chlorite. Certain phases of them appear to be of sedimentary origin, but others may represent metamorphosed igneous rocks. They strike north-northwest, dip nearly 90°, and are intruded by dikes and large, irregular granitic masses. Some small diorite-porphyry dikes cut both schist and granite.

A few narrow, branching quartz veins, which occupy fault zones within these schists, have yielded a small amount of gold.

HARDT MINE

The Hardt mine is accessible by ¼ mile of trail from the end of seven miles of road that branches eastward from a point near Cibola Postoffice. According to Mr. S. J. Blair, of Cibola, this mine was worked, in a small way, by Mexicans during the early nineties. Prior to 1900, when owned by a Mrs. Hardt, further work was done upon the vein and an attempt was made to treat the ore in a five-stamp mill at the river. Since mining and transporting the ore cost about $24 per ton, however, the mill made only three runs and the total production of gold amounted to only a few thousand dollars.

The vein outcrops on the steep mountain slope about 250 feet above the old camp at the end of the road. Here, the schists, which strike south-southeast and weather green to yellowish gray, are intruded by a few narrow dikes of granite porphyry. The vein occurs within a fault zone that cuts the schists in a S. 5° W.

direction and dips 65° E. at the surface, but steepens somewhat in depth. Along its outcrop, the vein is about eight inches wide and some 300 feet long. It consists of banded, dense, white quartz, in which numerous fractures and cellular cavities are filled with limonite, hematite, and ferruginous calcite. A few scattered spots of copper stain are present. Vein material on the dump contains also scattered crystals and isolated bunches of pyrite and numerous limonite pseudomorphs after pyrite.

Workings on the Hardt vein include an inclined shaft, said by Mr. Blair to be 140 feet deep on the dip of the vein, and several shallow cuts.

BOARDWAY PROSPECT

Two claims, held by Mr. C. E. Boardway, are located about two miles south of the old Hardt mine. They are accessible by some four miles of road from Blair's ranch, south of Cibola. These claims were originally located and prospected to some extent during the nineties by the Sparks brothers.

Here, lenticular schist inclusions in larger masses of granite are cut by narrow quartz veins which contain small limonitic pockets locally rich in gold. The principal vein strikes eastward and dips 15° S. Where followed by some 140 feet of tunnel, its width ranges from less than one foot up to 2½ feet. In this length, it shows three shoots, each from sixteen to twenty feet long, that contain small scattered pockets of limonite. In 1930, Mr. Boardway was recovering a little gold from this material by panning and had erected an experimental one-stamp mill near the river.

JUPITER CLAIM

The Jupiter claim, held by Messrs. S. J. and B. H. Blair, is about ½ mile north of the Boardway prospect and in a similar geologic setting. A twenty-foot tunnel has been run on a vein that dips about 15° S. This vein, which is about 1½ feet thick at the outcrop, branches near the surface and pinches and swells inward. It consists of dense, white quartz with considerable limonite in fractures and small pockets. In places, this limonite is accompanied by a little gold.

CHAPTER II — CHOCOLATE MOUNTAINS

SITUATION AND ACCESSIBILITY

Beginning at the Colorado River, near latitude 33°, the Chocolate Mountains extend northeastward for 25 miles. They have a maximum width of five miles and include an area of approximately 102 square miles.

These mountains are uninhabited. As shown by Plate 1, the Silver district road leads past their southwestern end, and the Yuma-Quartzsite highway skirts their northeastern margin.

TOPOGRAPHY AND GEOLOGY

A low, alluvium-floored gap, about three miles wide, separates this range into two segments. The northeastern segment, which is separated by low divides from the Castle Dome and Middle ranges, is topographically similar to the northern portion of the Trigo Mountains and rises to maximum elevations of more than 2,500 feet above sea level. The southwestern segment, although deeply dissected, is lower and much less rugged.

The Chocolate Mountains consist largely of Tertiary volcanic rocks similar to those of the Castle Dome and Trigo ranges. At the northeastern end of the range, a small area of probable Quaternary basalt overlies these flows.

MINERALIZATION

The Chocolate Mountains contain no mineral deposits that have been of economic importance. No prospects in this range are known to the writer.

CHAPTER III — MIDDLE MOUNTAINS

SITUATION AND ACCESSIBILITY

Nine miles east of the Colorado River, a low, narrow range, locally known as the Middle Mountains, extends for seventeen miles south from the pass that separates it from the Chocolate Mountains. The mass is from ½ to five miles wide and includes an area of approximately 42 square miles.

As shown by Plate 1, the Yuma-Quartzsite highway follows the eastern flank of this range, and the old road that connected Castle Dome with Castle Dome Landing crosses its southern portion. One branch from this road leads to the Annie lead mine, and another skirts the southwestern margin of the range.

TOPOGRAPHY

The Laguna topographic sheet, issued by the U. S. Geological Survey in 1929, includes the southern six miles of the Middle Mountains.

This range is made up of rough, irregular ridges and sharp peaks which rise only a few hundred feet above the plain. Its margins are flanked by an imperfectly developed pediment which, in places, attains a width of more than ½ mile. Several southwestward-trending canyons, which carry part of the run-off from the Castle Dome Mountains, cut through the range.

GEOLOGY

As shown by Plate 1, the Middle Mountains consist mainly of pre-Cambrian schist, Mesozoic sedimentary rocks, and Tertiary and Quaternary lavas.

Fine-grained gray schist, similar to the pre-Cambrian schist of the Trigo Mountains, outcrops along the southwestern margin of the range. It prevailingly strikes north and dips from 20° to 70° E., but it has locally been much displaced by faulting.

Apparently in fault contact with the eastern margin of the schist is a thick series of clay slates, impure limestones, sandstones, and conglomerates that are lithologically identical to the Mesozoic beds of the Castle Dome Mountains. These beds prevailingly strike north-northwest and dip from 20° to 40° NE., but locally this attitude has been modified by faulting.

Dikes of diorite-porphyry and rhyolite porphyry cut the schist and the sedimentary beds.

A thick series of Tertiary lavas and tuffs, similar to those of the Castle Dome Mountains, overlies the pre-Cambrian and Mesozoic rocks and forms most of the range. In places, it is overlain by relatively small masses of probable Quaternary basalt and tuff.

MINERAL DEPOSITS

Quartz veins: The schist of the Middle Mountains contains a few narrow, white, locally iron-stained quartz veins which have been prospected to some extent.

Annie lead mine: A thin vein of galena in the Mesozoic rocks occurs at the Annie mine which is seven miles by road from Castle Dome Landing and about 1½ miles north of the old Castle Dome road. According to the U. S. Geological Survey Mineral Resources, some ore was shipped from this mine in 1924 and 1926.

Here, a diorite-porphyry dike, approximately 150 feet wide, trends south-southwest and, near its eastern margin, is cut by a steeply northwestward-dipping fault zone that strikes S. 15° W. This zone, which is silicified for a width of two or three feet, contains irregular bunches of limonite, a few small spots and thin streaks of malachite, and a thin, bunchy vein of galena in a baritic gangue. The wall rock shows pronounced sericitization. As exposed by a 300-foot tunnel, this galena vein ranges from a fraction of an inch up to six inches in thickness.

CHAPTER IV — CASTLE DOME MOUNTAINS

SITUATION

The Castle Dome Mountains begin eighteen miles east of the Colorado River, near T. 1 N., and extend south-southeastward to T. 7 S., or to within seven miles of the Gila River. The range is about 35 miles long by two to fourteen miles wide, and includes an area of approximately 275 square miles.

POPULATION AND ACCESSIBILITY

A small mining settlement, Castle Dome, is at the western foot of the range, about midway between the ends, and a smaller place, named after Thumb Butte, is five miles farther south. Aside from a few miners and prospectors living at these places, the Castle Dome Mountains are uninhabited. A large portion of the range is very difficult to traverse, and, in a few places, virtually inaccessible. Water occurs only in a few mine shafts, wells, and natural rock tanks within this area.

As indicated on Plate 1, the Yuma-Quartzsite highway reaches the northwestern side of the Castle Dome Mountains at Stone Cabin. Branching eastward at this place, an improved road crosses a low divide in the range and continues towards Kofa. Farther south, another branch leads to Castle Dome settlement. The old Dome-Quartzsite road crosses the range northeast of Castle Dome, and recrosses northwestward, emerging at Stone Cabin. Branching from this road at a point six miles from Dome, a road leads, via Thumb Butte settlement, northeastward across the range, and connects with the Kofa road. The old Quartzsite-Kofa trail passes through the northern tip of the range, and a badly washed road, from Wellton and Roll to Kofa, skirts the eastern margin.

TOPOGRAPHY

On the north, a narrow plain, less than one mile wide, separates the Castle Dome and the S. H., or Kofa, ranges. The adjacent plains at this end are about 1,700 feet above sea level, but slope downward to some 1,100 feet lower at the southern end of the Castle Dome Mountains.

Much of this range rises with cliff-like abruptness to heights of 1,000 to 2,000 feet above the adjacent plains, but, in places, such as the Castle Dome district, the steeper slopes are separated from the plains by a rock-cut plain, or pediment, bordering on rounded foothills (see Plates 7, 10, 11). Throughout most of the mountain mass, steep or cliffy, bare rock slopes alternate with short, gentle slopes. Spires and dome-capped towers adorn the skyline of this blocky, ragged mass. The highest tower-like mass, Castle Dome Peak, was originally named "Capitol Dome" by the soldiers at Fort Yuma.

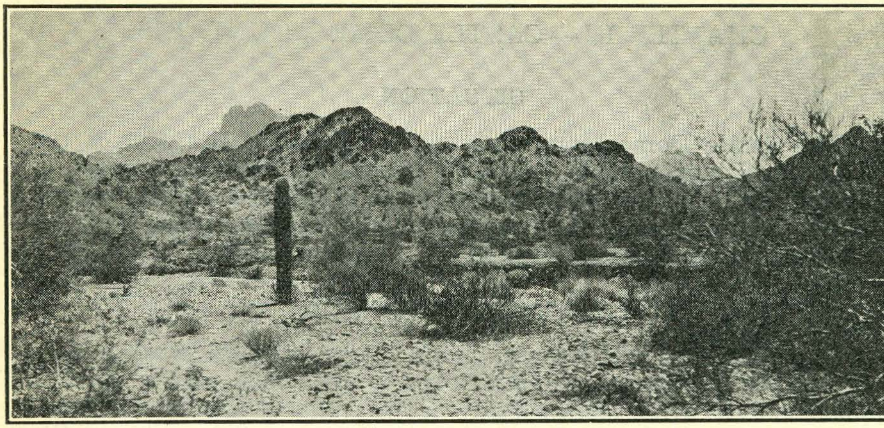

Plate 7.—Hills of Cretaceous (?) shale, with crest marked by dikes, on pediment in Castle Dome district.

Many canyon systems, which, headward, become box-like and end in falls, dissect the mountains. Where these canyons reach the plains, the mountain front is raggedly indented. Such indentation is particularly intense in the southern half of the range. Along the southeastern margin, numerous small hills are isolated from the main mountain mass.

Numerous steep-sided, deep arroyos carry the run-off from the canyons across the plains to the Gila and Colorado rivers. Most of these channels flow towards the southwest, south, or southeast, and only a minor number towards the northwest.

The Norton topographic sheet, issued by the U. S. Geological Survey in 1929, includes the southeastern ten miles of the range.

GENERAL GEOLOGY

The Castle Dome Mountains are made up of a basement of schist, gneiss, granite, and sedimentary rocks, all intruded by dikes of diorite-porphyry and overlain by a thick series of lavas cut by dikes of rhyolite porphyry.

Schist: The oldest rocks exposed in these mountains are schists that outcrop, as shown by Plate 1, in two areas totaling several square miles, in the southern portion of the range. These outcrops form narrow, rolling flats alternating with sharp ridges that usually mark the location of nearly vertical dikes.

In the area some four miles east of the Big Eye mine, the schist weathers dark brown to gray. Its well-developed fissility strikes northeastward and dips about 20° SE. Many dikes cut the schist of this area. Examined microscopically, it is seen to consist of rounded to subangular grains of quartz, together with minor amounts of orthoclase and acid plagioclase. Curving foils of muscovite and biotite separate the quartz grains, and considerable epidote is present. This schist clearly represents a metamorphosed sedimentary rock.

At the southern end of the range, northeast of the Tacna-Big Eye road, the weathered schists are dark brown and rather massive. Their principal lamination strikes S. 40° E. and dips about 45° NE. On fresh fracture, this lamination is seen to be marked by layers of partly chloritized biotite, and the remainder of the rock is largely coarse-grained quartz and feldspathic material. Certain phases, at least, of this mass are probably of igneous origin.

On the basis of their extreme metamorphism, these schists are regarded as pre-Cambrian in age. In places, they contain gold-quartz veins, but have produced very little ore.

Gneiss: Associated with the schist in the southeastern portion of the range, but not differentiated on Plate 1, are considerable areas of gneiss. This rock is typically coarse grained, with phenocrysts of quartz and feldspar up to ⅛ and ½ inch in diameter. It is rudely laminated by prominent bands of scaly biotite, but, on weathered slopes, this lamination is not apparent, and the rock resembles granite.

Field relations indicate that the gneiss was originally a granite that intruded the schist prior to its dynamic metamorphism. The age of the gneiss is regarded as pre-Cambrian. It contains a few small quartz veins, but no mineral deposits of economic importance have been found within it.

Granite: Medium-grained biotite granite outcrops in a small area two miles northeast of Thumb Butte, and as a small mass at the Sheep prospect, in the southeastern portion of the range. This granite, which unconformably underlies the Cretaceous (?) sedimentary rocks and intrudes the schist and gneiss, may be either pre-Cambrian or Mesozoic in age. Only a few, small gold-quartz veins are known to occur within it.

Syenite: A small area of greenish rock speckled with grayish feldspar, outcrops southeast of the Big Eye mine, northeast of Thumb Butte. Examined microscopically, this rock is seen to be chloritized, epidotized syenite. It apparently underlies the Cretaceous (?) sedimentary rocks, but its age is unknown. No mineral deposits have been found within it.

Cretaceous (?) sedimentary rocks: A thick series of well-bedded sedimentary rocks rests unconformably upon the granite of the Castle Dome Mountains. As indicated by Plate 1, these rocks make up an irregular area, nine miles long by eight miles wide, in the southern portion of the range. They constitute the principal formation in the Castle Dome district, and extend southeastward to Thumb Butte, whence they continue eastward nearly across the range, to where they are faulted against pre-Cambrian schist. Almost every exposure of them contains numerous dikes of diorite-porphyry and rhyolite porphyry. Their structural features are discussed on page 82.

These Cretaceous (?) rocks consist predominantly of greenish-gray thick-bedded shales and impure cherty limestones. In places, maroon shales and fairly pure limestone occur. Gray to brown arkosic sandstones, quartzites, and conglomerates are locally abundant. The gray slates contain considerable alumina and some magnesia, but very little lime carbonate. Examined microscopically in thin section, they are seen to be made up of very small, rounded to angular grains of quartz, orthoclase, and sodic plagioclase, embedded in a turbid matrix. Chloritic patches are locally plentiful. In the vicinity of the rhyolite porphyry dikes, sericitic alteration is evident, and pyrite metacrysts, more or less changed to limonite, are abundant.

Unless reinforced by dikes, all except the quartzitic members tend to form hills of moderate to low relief. In places, the quartzites constitute ridge-crests.

Due to faulting, the total thickness of these strata can not be measured, but it clearly amounts to more than 1,000 feet. As no fossils, except worm trails, have been found within them, their age can only be inferred on the basis of lithologic similarity to other formations in the Southwest. In 1880, Wm. P. Blake saw these rocks at Castle Dome, where they are locally thin bedded, steeply dipping, and visibly sericitized. He regarded them as pre-Cambrian, and that correlation has been followed for half a century. However, the series as a whole bears striking lithologic resemblances to the Cretaceous rocks of southern Arizona. It is practically identical to a formation, occurring thirty miles farther north, in the New Water Mountains, that was tentatively placed as Cretaceous on the Geologic Map of Arizona.[101] In these mountains, which lie only eight miles north of the Castle Dome range, the writer found, within this formation, limestone conglomerate pebbles containing upper Carboniferous fossils (see Plate 8). These pebbles must have been eroded from a land mass containing upper Carboniferous limestones. Upon the evidence of this conglomerate, together with that of the lithologic similarity already mentioned, the formation is tentatively regarded as Cretaceous. The possibility of its being Triassic or Jurassic can not be denied, but no similar formations of those ages are known to occur within a radius of several hundred miles.

The Cretaceous (?) beds of the Castle Dome Mountains are host rocks for argentiferous galena and fluorite veins in the Castle Dome district, and for copper-bearing veins near Thumb Butte.

Dike rocks: The Castle Dome Mountains, particularly in the vicinity of Castle Dome, contain one of the most remarkable dike swarms known in the United States (see Plate 9). These dikes are principally of dioritic and rhyolitic composition. The former variety appears to be older, and the latter is younger, than the lavas. Their outcrops generally form ridges from low relief up to fifty or more feet high.

[101] Published by the Arizona Bureau of Mines, in cooperation with the U. S. Geological Survey, 1924.

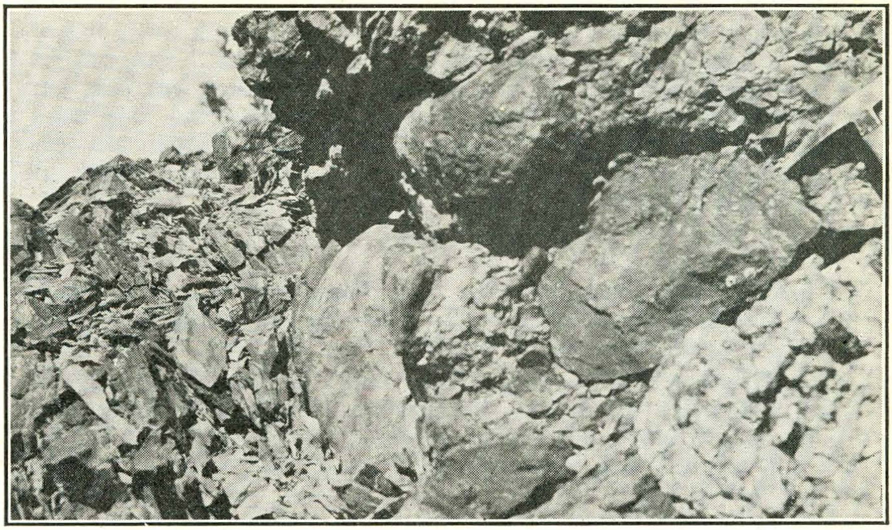

Plate 8.—Conglomerate member of Cretaceous (?) shales, New Water Mountains—The limestone boulder at the point of the pick contains Carboniferous fossils.

The diorite-porphyry weathers chocolate brown to gray, mottled with white spots up to about 0.10 inch in diameter. Examined microscopically in thin section, it is seen to consist of phenocrysts of feldspar, quartz, and biotite, set in a microcrystalline groundmass of feldspar and quartz. The quartz phenocrysts, which are relatively few, show corrosion by the groundmass. The feldspar is oligoclase-andesine in composition.

The rhyolitic porphyry weathers reddish brown, and, on fresh fracture, shows visible phenocrysts of quartz set in a dense, stony groundmass. As these quartz phenocrysts are so characteristic, this rock is referred to as quartz porphyry. Microscopically, it is seen to consist of phenocrysts of sodic plagioclase, orthoclase, and quartz, set in a spherulitic groundmass that corrodes the quartz. Wherever observed, this rock is more or less sericitized and contains pyrite metacrysts.

Volcanic rocks: As indicated by Plate 1, volcanic rocks of probable Tertiary age make up the major portion of the Castle Dome Mountains. In places, the erosion surface of the older rocks upon which they rest shows a relief of 200 or more feet. These volcanic rocks have not been studied, but they are known to include rhyolites, andesites, tuffs, and obsidians, with a total thickness of more than 2,000 feet. In places, they are covered by several hundred feet of basalts, probably of Quaternary age.

Locally, the Tertiary volcanic rocks are cut by dikes of quartz porphyry. The older flows contain a few gold-quartz veins of economic importance, but the basalts, so far as known, are barren of mineral deposits.

Gravels: Detrital gravels and sands of local origin floor many of the gulches and cover the outward margins of the mountain pediments. This material, which is of heterogeneous composition and texture, ranges in thickness from a thin veneer to some tens of feet. It is a hindrance to prospecting in that it conceals certain outcrops, but, in the southeastern portion of the range, it contains placer gold.

STRUCTURE

The schist, gneiss, and granite are traversed by several systems of joints. In general, their major systems are roughly parallel to the principal topographic features.

The Cretaceous (?) sedimentary rocks predominantly strike north-northwest, parallel to the general trend of the range, and dip west-southwest, but many local differences obtain. In the Castle Dome district, as shown by Plate 9, the dips are mostly from 30° to 70° SW.

As a rule, the dikes strike parallel to the major lamination, jointing, or bedding of the formation that they cut, and dip steeply. This relation is particularly true in the Castle Dome district, as shown by Plate 9.

The Tertiary volcanic rocks also prevailingly strike roughly parallel to the trend of the range, but they show many local departures from this rule. In the central portion of the range, they dip at angles of less than 30° W.-SW. Along the Stone Cabin-Kofa road, their dips are to the northeast. In the southern portion of the range other directions of dips are common.

The basalts lie essentially flat, or dip at angles of a few degrees.

Faulting of considerable magnitude and intensity has affected the rocks of the Castle Dome Mountains, but insufficient study of the key beds has been made to permit its analysis. The range as a whole is probably bounded by great faults that lie outward from the margins of the pediments. All of the changes in strike and dip, so far as known, are due to faulting. In the Castle Dome district, the principal faults discernible strike parallel to the Cretaceous (?) beds, dip steeply, and are followed by mineral-bearing veins. Many of the faults resulted in vertical displacements of several hundred feet, and some of them record a horizontal movement. In places, minor cross-faults and post-mineral movement are evident. No thrust faults and no folds of any consequence have been recognized in this range.

MINERAL DEPOSITS

The principal mineral deposits of the Castle Dome Mountains are the argentiferous galena-fluorite veins of the Castle Dome district, which is from 2½ to 5½ miles southwest of Castle Dome Peak. In the southeastern portion of the range, certain quartz veins contain gold and others carry principally manganese and silver. In the vicinity of Thumb Butte, several veins carry copper, gold, and silver. Gold placers occur in the southeastern portion of the range.

ARGENTIFEROUS GALENA — FLUORITF VEINS

The productive argentiferous galena veins of the Castle Dome district occur near the outward margin of the pediment, or rock-cut plain, and the outcrops of the widest ones are confined mainly to the suballuvial bench of this pediment. The veins occupy steeply dipping fault zones that cut both the slates and the diorite porphyry dikes. Although well represented within both of these rocks, the ore shoots are generally best where diorite porphyry forms one or both of the vein walls. The veins apparently favor the general vicinity of the quartz porphyry intrusions, but are poor within them.

In general, the major viens strike from north-northwest to northwest, and dip steeply. Those with westward dips are the steepest. Longitudinally, the veins are rather continuous, and one, the Buckeye, is traceable for about 5,000 feet, but is not commercially ore bearing for the entire distance. Most of the veins are less than five feet wide, but the widest one is as much as twelve feet across. Few of them have been productive below a vertical depth of 225 feet.

The vein outcrops are traceable as grayish-white streaks of weathered, crystalline fluorspar, calcite, and barite, together with more or less gypsum and, locally, a little quartz. In places, the croppings of gangue contain tabular to irregular masses of galena, superficially altered to anglesite, cerussite, and various lead oxides.

As seen underground, the gangue of the veins consists mainly of coarsely crystalline, varicolored fluorite, together with crystalline calcite, bladed to massive barite, and minor amounts of quartz. Portions of the veins show banding of the gangue minerals, as described on page 93, but the galena occurs as sheet-like masses or irregular, vein-like bunches scattered through the gangue. In places, nearly solid masses of galena, eight feet thick, were mined.[102]

In the shallower workings, particularly, the galena is superficially altered to black anglesite, grayish cerussite, and yellow and red lead oxides. Locally, certain channels and vugs contain hydrozincite, smithsonite, wulfenite, vanadinite, mimetite, quartz, calcite, and aragonite.

The galena now mined contains a maximum of about thirty ounces of silver per ton, but the lead carbonate generally carries less than six ounces. Microscopic examination of several polished sections of the galena revealed no silver minerals.

[102] Blake, Wm. P., Castle Dome Mining and Smelting Company (private report), p. 14. July, 1880.

Along the vein walls, the rocks show pronounced alteration to quartz, calcite, and sericite. Small pyrite metacrysts, more or less altered to limonite, are abundant. The shales show some chloritization.

These veins were originally deposited by hydrothermal solutions which forced their way up from a deep-seated magma. Field evidence suggests that these solutions followed the intrusion of the quartz porphyry dikes, and may have come from the same magmatic source. The continuity, structure, texture, and wall-rock alteration of these veins are typical of deposition in the mesothermal zone. The 2,000 or more feet of Tertiary lava flows that are present in the main mountain mass undoubtedly once extended over these veins. Post-Tertiary erosion, capable of carving out a mountain pediment of the breadth here displayed, removed a great thicknss, probably amounting to a few thousand feet, from the top of this lava pile. If the quartz porphyry dikes were intruded at the close of the Tertiary volcanic activity, as seems likely, the veins now exposed may have been formed at a depth of more than 4,000 feet beneath the surface then existing. Only the upper few hundred feet of the rocks below the lavas appear to have been sufficiently permeable to allow deposition of veins of economic width.

Prospecting for the veins that are hidden beneath surface gravels was carried on by sinking pits to the bedrock, and following to their source the nuggets of placer lead minerals found there. The early miners sank many shafts, because operations with windlasses, rawhide buckets, and hand drills permitted stoping of the veins only for distances of 25 to 50 feet from each shaft.

QUARTZ VEINS

In the Castle Dome district, quartz veins are rather abundant in the vicinity of the Joplin and Nevada claims and east of the Mabel claim. This quartz is fine grained, locally iron stained, and barren of valuable constituents.

In the southeastern portion of the range, gold-quartz veins occur in the vicinity of the Big Eye and Sheep properties, as described on pages 102-104, and manganiferous quartz-carbonate veins have been prospected on the Keystone property, as described on page 104.

COPPER-BEARING VEINS

In the Thumb Butte or old Montezuma district, veins of chalcocite, partly altered to copper carbonates, occur in the Cretaceous (?) shales, limestones, and arkoses. They produced, from 1918 to 1929, inclusive, about $4,000 worth of copper and gold. In 1930, the shaft of the principal mine, the Copper Glance, had long been abandoned, and no geologic study of these deposits has been made.

MINING HISTORY AND PRODUCTION [103]

Lead-silver mining: According to Blake,[104] the Castle Dome district was organized in 1863 by Messrs. Snively and Conner. The original discovery, however, had been made many years earlier. Blake states that the prospectors of 1863 found, on many of the veins, ancient excavations from six to fifteen feet deep and up to 100 feet long. These old workings, which appeared to have been made with long bars, served as reliable guides to ore. Their antiquity was abundantly shown by the slow-growing trees of that region, such as iron wood and palo verde, which were found growing in the old pits and on the piles of refuse thrown out. Well-worn trails leading to the Gila River, some eighteen miles away, and the ruins there of some adobe smelting furnaces, led Blake to believe that the ores were carried from Castle Dome on the backs of Indians, during the time of either the Aztecs or the early Spanish explorers. Blake [105] continues: "Much excitement followed the first discovery. The ore being extremely heavy and brilliant galena, with which the first prospectors were not familiar, led many of them to believe that they had found veins of nearly pure silver, and it was not until they had obtained much independent and confirmatory evidence by assays and returns from shipments that they were willing to accept the fact that the bulk of the ore was lead, carrying, however, about thirty ounces of silver to the ton."

Disappointed because the veins were not silver bonanzas, most of the prospectors who had flocked in went elsewhere.

For more than twenty years, mining was carried on in this district with no machinery of any kind. Except for a horse whim at one shaft, all hoisting was done by hand windlass. After careful hand sorting to a grade between 58 and 69 percent lead and $23 to $190 in silver, the ore was sacked and sent by teams to Castle Dome Landing on the Colorado River, some twenty miles west of the district. From there it was taken downstream by river boats and then transferred to clipper ships for freighting to the Selby Smelter in San Francisco.

In 1868, the ores shipped were said to contain sixty percent lead and $40 in silver, making a value of $90 per ton.[106] Mining and sacking cost $12, hauling to the Colorado River $15, and freight to San Francisco $18, leaving a profit of $45 per ton. Until about 1881, water for the miners had to be hauled from Castle Dome Landing, but could be augmented at times by rain water caught in artificial and natural rock tanks. The discovery of water in some of the deeper shafts of the district provided a more ade-

[103] Based largely upon notes compiled by J. B. Tenney.

[104] Blake, Wm. P., Castle Dome Mining and Smelting Company (private report), p. 38. New Haven, Conn. July, 1880.

[105] Blake, Wm. P., work cited.

[106] U. S. Commissioner of mining statistics, Rept. for 1863, p. 452.

quate supply, and, for several years, desert travelers bought water here.

During 1870, several owners and captains of Colorado River steamboats became interested in the deposits and organized companies to exploit certain properties. There were two principal mines, the Flora Temple, worked by Polhamus and Company, and the Castle Dome, worked by Miller and Nagle. In 1875, Captain Nagle erected a small smelter at Yuma, but, after the completion, in 1876, of the Southern Pacific Railroad between Los Angeles and Yuma, it was unable to compete with the Selby Smelter. For several years afterward, the Castle Dome ores were shipped from the Landing to Yuma by railway company barges, and on to San Francisco by rail, at a total cost of $11 per ton.[107] The river boats ceased regular operation after the completion, in 1883, of the Santa Fe Railroad across northern Arizona, and Dome siding became the district's nearest shipping point.

The total production from 1870 to 1876 is estimated at approximately 2,000 tons of ore, yielding some 2,200,000 pounds of lead and 100,000 ounces of silver, worth in all about $218,000. Due to its freedom from arsenic and antimony, this lead was in demand for white-lead manufacture, and commanded a premium. Blake[108] reported the following production for 1871: Buckeye, 250 tons; Flora Temple, 400 tons; Castle Dome and Castle Dome Extension, 600 tons; and Don Santiago, 30 tons.

No good records for the camp between 1877 and 1883 exist. In 1878, according to Hinton,[109] the district contained about forty locations, nearly all of which were worked to some extent. Messrs. Miller and Hopkins had sunk shafts to a depth of 250 feet and opened stopes down to the 220-foot level. During the first six months of 1879, shipments to San Francisco amounted to 438½ tons, averaging 69 percent lead and 26 ounces of silver, yielding $21,367, or an average of $48.73 per ton.[110] For the year ending May 31, 1880, shipments from Castle Dome totaled 1,100 tons, worth $37,488.[111]

During the late seventies, the Castle Dome Mining and Smelting Company, with Wm. P. Blake as President, acquired control of all the important claims in the district and began shipping ore to its own smelter at Melrose, California. This company was the principal producer of the district during 1883. From 1877 to 1883, the probable average yearly production was not greater than

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[107] Blake, Wm. P., work cited, pp. 11-12.

[108] Blake, Wm. P., Rept. Terr. Geologist (in Rept. Gov. Ariz.): Dept. Int., rept. fiscal year 1899, pp. 106-107.

[109] Hinton, R. J., Handbook to Arizona, San Francisco. 1878.

[110] Blake, Wm. P., Castle Dome Mining and Smelting Company (private report), p. 26.

[111] Emmons, S. F., and Becker, G. F., Statistics of the precious metals: Census Office Rept., p. 52. 1885.

500,000 pounds of lead and 15,000 ounces of silver, making a total gross value for the seven years of about $255,500.

Production from the district fell off sharply after 1883 and amounted to but little for several years. According to the U. S. Mint Reports, twelve tons of 60-percent lead ore, yielding $840 in silver, were produced in 1887.

In 1890, the camp was reopened by Messrs. Gondolfo and Sanguinetti, of Yuma, who made regular shipments to the Selby Smelter until August, 1896. These shipments amounted to 906 tons, yielding 1,000,000 pounds of lead and 25,000 ounces of silver, worth, in all, $57,000.

After 1896 and up to the end of 1904, shipments were probably made to El Paso, but no good records exist.

At the 1890-1896 rate, a conservative estimate for the period 1890-1905, inclusive, would be 2,300,000 pounds of lead and 70,000 ounces of silver, worth, in all, $170,600.

Since the end of 1904, more or less complete production records have been given in the yearly Mineral Resources volumes of the U. S. Gological Survey. In 1905, Castle Dome shipped ore yielding more than 150,000 pounds of lead. According to the estimates and compilation of J. B. Tenney, given on page 88, the total lead-silver production of the district from 1863 to 1929, inclusive, amounted to more than $923,000. Most of the material shipped was hand sorted, but part was concentrated on Stebbins dry tables.

Fluorspar mining: The first important mining of fluorspar, which is a plentiful gangue mineral at Castle Dome, began in 1902. During 1902, 1903, 1904, 1908, 1909, and 1913, carefully hand-sorted crystals and pure screenings from the De Luce claims were shipped to the Riverside Portland Cement Company's plant at Riverside, California, to be used as a flux in producing cement clinker. The potash shortage of the World War period prompted the Riverside Company to develop a potash-recovery method of cement manufacture, utilizing fluorspar. Consequently, from 1916 to 1918, inclusive, more than 1,000 tons of fluorspar were shipped from Castle Dome. The total gross production from the district since 1902 probably has amounted to about $30,000.

Gold vein mining: The eastern portion of the Castle Dome Mountains remained largely unprospected until the present century. For some time, gold-bearing veins were known to occur there, but they received little attention until 1912, when work was started on the Big Eye vein, some four miles south-southeast of Castle Dome Peak. With the aid of a small cyanide plant, operations were continued until the end of 1917. As shown by the table on page 89, the total production listed from this vein was $33,185.

Several other gold-quartz veins have been prospected in this region, but without noteworthy production.

PRODUCTION, CASTLE DOME DISTRICT
Data compiled by J. B. Tenney

Date	Prices		Tons ore	Pounds lead	Ozs. silver	Value	Remarks
	Lead	Silver					
1870-1876	0.04	1.30	2,000	2,200,000	100,000	$218,000	Estimated from early government reports by Browne and Raymond
1877-1883	0.04	1.10		3,500,000	100,000	250,000	Selby Smelter shipments by Gondolfo and Sanginetti
1890-1896	0.038	1.00	1,000	1,000,000	26,000	64,000	
1896-1905	0.040	0.65	2,000	1,300.000	44,000	106,600	Estimated
1906	0.057	0.68		140,900	9,000	14,051	Mineral Resources data
1907	0.053	0.66	100	140,000	9,000	13,360	Mineral Resources data
1908	0.042	0.53	55	72,243	1,668	3,918	Mineral Resources data
1909	0.043	0.52	75	92,339	2,443	5,241	Mineral Resources data
1910	0.044	0.54	40	46,555	965	2,570	Mineral Resources data
1911	0.045	0.53	370	72,073	1,597	4,090	Mineral Resources data
1912	0.045	0.615	1,500	239,753	5,702	14,413	Mineral Resources data
1913	0.044	0.604	1,930	325,020	7,000	18,529	Mineral Resources data
1914	0.039	0.553	650	169,055	5,948	9,882	Mineral Resources data
1915	0.047	0.507	300	94,351	2,500	5,702	Mineral Resources data
1916	0.069	0.658	200	115,020	2,500	9,581	Mineral Resources data
1917	0.086	0.824	3,000	53,665	1,403	5,604	Mineral Resources data
1918	0.071	1.000	2,000	183,519	4,275	17,305	Mineral Resources data
1919	0.053	1,120		454,639	6,146	30,979	Mineral Resources data
1920	0.080	1.090		379,801	4,760	35,677	Mineral Resources data
1921	0.045	1.000		38,689	500	2,241	Mineral Resources data
1922	0.055	1.000					Mineral Resources data
1923	0.070	0.820		50,000	500	4,000	Estimated
1924	0.080	0.670	183	192,183	4,012	18,084	Mineral Resources data
1925	0.087	0.694	438	215,626	3,857	21,436	Mineral Resources data
1926	0.080	0.624	306	211,698	4,286	19,616	Mineral Resources data
1927	0.063	0.567	401	171,930	2,622	12,413	Mineral Resources data
1928	0.058	0.585	490	196,773	2,157	13,019	Mineral Resources data
1929	0.063	0.523	117	36,572	610	3,305	Mineral Resources data
Total, 1870 to 1929, inc.				11,692,404	353,451	$923,616	

PRODUCTION, BIG EYE-THUMB BUTTE REGION
Data compiled by J. B. Tenney

Date	Price copper	Pounds copper	Gold Oz.	Gold Dollars	Total value	Remarks
1884-1908			3,628	75,000	$ 75,000	Placers (estimated)
1908			132	2,739	2,739	Placers (Mineral Resources data)
1909			106	2,200	2,200	Placers (Mineral Resources data)
1910			170	3,507	3,507	Placers (Mineral Resources data)
1911			68	1,414	1,414	Placers (Mineral Resources data)
1912			242	5,000	5,000	Placers (Mineral Resources data)
1913			38	790	790	Big Eye Mine (Mineral Resources data)
			242	5,000	5,000	Placers (Mineral Resources data)
1914			279	5,760	5,760	Big Eye Mine (Mineral Resources data)
			68	1,409	1,409	Placers (Mineral Resources data)
1915			449	9,276	9,276	Big Eye Mine (Mineral Resources data)
			53	1,101	1,101	Placers (Mineral Resources data)
1916			137	2,830	2,830	Big Eye Mine (Mineral Resources data)
			26	533	533	Placers (Mineral Resources data)
1917			703	14,529	14,529	Big Eye Mine (Mineral Resources data)
			88	1,822	1,822	Placers (Mineral Resources data)
1918	0.247	9,070	17	352	2,592	Copper Glance Mine (Mineral Resources data)
			9	193	193	Placers (Mineral Resources data)
1919			5	100	100	Placers (Mineral Resources data)
1921			35	724	724	Placers (Mineral Resources data)
1924			33	689	689	Copper Glance Mine (Mineral Resources data)
1925			21	431	431	Placers (Mineral Resources data)
1929	0.176	3,004	7	147	675	Copper Glance Mine (Mineral Resources data)
					$ 37,141....	....Mines
					101,173....	....Placers
Total		12,074	6,556	135,546	$138,314	

Copper mining: In the Thumb Butte, or old Montezuma, district, some six miles south of Castle Dome, copper-bearing veins have been known since the seventies. Intermittent, small-scale operations, largely on the Copper Glance vein from 1918 to 1929, inclusive, yielded about 12,000 pounds of copper and $1,194 in gold, worth, in all, $3,956.

Gold placer mining: The principal gold placers of the Castle Dome Mountains are south-southeast of the Big Eye mine, some twelve miles by road east-northeast of Thumb Butte settlement. They were discovered in 1884, but their production to the end of 1902 is unknown. The U. S. Mint Report for 1887 stated that the field was being worked in a crude way by Mexican dry-washers. The production rate from 1908 to 1916 was about $3,000 per year, and, since 1908, a total of $25,000 has been recorded (see page 89). Assuming this rate from 1884 to 1908, the yield from these placers for that period would amount to between $75,000 and $100,000.

FLORA TEMPLE CLAIM

The Flora Temple claim, owned by Mrs. Eliza De Luce, is S. 33° W. from Castle Dome Peak. It was surveyed for patent in 1871, for Messrs. Polhamus and Gunther, and has the distinction of being the second claim patented in Arizona. As permitted by the mining laws of that time, it is 2,000 feet long by 200 feet wide.

As stated on page 86, the Flora Temple produced 400 tons of ore in 1871. For a long period, this claim was one of the most important producers in the district, but, during recent years, has yielded little. Its total output is unknown.

The surface of this claim is mantled by several feet of gravels which, at their base, contain placer nuggets of galena altering to anglesite, cerussite, and reddish lead oxides. The ore veins were originally found by trenching through these gravels and following the placer lead minerals to their source. The principal vein found by this method strikes N. 18° W. and dips from 45° to 55° E. Blake [112] states that a vertical vein, striking a few degrees more northwesterly, branches from this vein near the southern boundary of the claim.

Workings on the Flora Temple claim are probably the most extensive of any in the district. Some eleven shafts, more or less conected by irregular, partially filled stopes, have been sunk at intervals along the length of the claim. A large portion of these workings are half a century old and inaccessible. For this reason, the writer did not see the western vein, but Blake [113] shows it in a vertical section more than 100 feet deep, and states that its character is similar to that of the eastern vein.

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[112] Blake, Wm. P., Castle Dome Mining and Smelting Company (private report), p. 21. July, 1880. Published by Tuttle, Morehouse, and Taylor, New Haven, Conn.

[113] Work cited, p. 21.

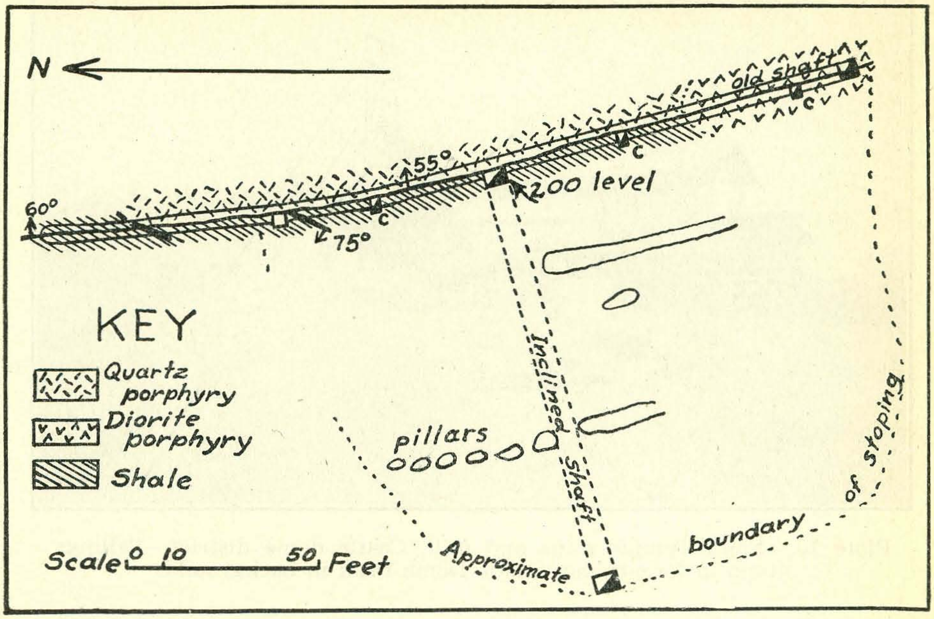

Fig. 4.—Plan of part of Flora Temple workings—C, chute.

The main Flora Temple shaft, situated about 1,000 feet from the southern boundary of the claim, is 225 feet deep on a 45° to 55° E. incline. From the surface, it passes through some 25 feet of cemented gravels which contain, at their base, numerous nuggets of the lead minerals already mentioned. Downward, the footwall is mainly dense gray slate, and the hanging wall quartz porphyry. From the base of the gravels downward for a depth of approximately 190 feet on the incline, the vein has been stoped out for a width of one to ten feet, or an average of about 4½ feet, and along a length, as shown in Figure 4, of 100 to 160 feet.

Other stopes, connected with the older shafts, extend at intervals along the vein, but most of them are inaccessible. Some of them were worked and abandoned prior to 1880.[114]

A sketch of the geology visible on the 200-foot level is given in Figure 4. The drift follows a well-defined fault that dips from 55° to 60° E. and cuts some minor cross faults. This fault appears to be the locus of the main vein. On this level, a narrow vein of galena, with the usual gangue minerals, is exposed for a length of a few feet north of the main shaft. At the northern end of the drift, a little iron oxide, but no ore, occurs adjacent to the fault. The vein is very narrow to absent for some thirty feet south of the main shaft, but widens somewhat in the diorite-porphyry area towards the old shaft.

[114] Blake, Wm. P., work cited, p. 21.

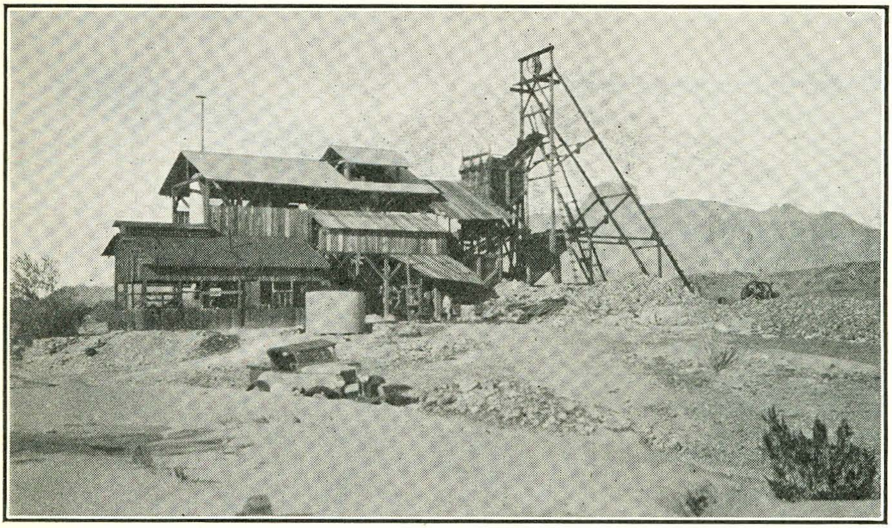

Plate 10.—Flora Temple mine and mill, Castle dome district—Tailings dump in foreground, Castle Dome Peak in background.

On the 200-foot level, all of the wall rocks are appreciably sericitized and silicified, and locally iron stained. Vugs lined with crystalline calcite are common. The quartz porphyry hanging wall shows abundant small pseudomorphs of limonite after pyrite, and the ferromagnesian minerals of the diorite-porphyry are partly altered to limonitic minerals.

Surface equipment on the Flora Temple includes a head frame (see Plate 10), hoist, blacksmith shop, and a Stebbins concentrator.

SENORA CLAIM

The Señora claim, now held by Mr. Arthur Haak, is in the southwestern portion of the area mapped on Plate 9, about 1,500 feet south of the Flora Temple. It was located many years ago and has produced a large, but unknown, amount of ore. According to Mr. Haak, the galena from this claim averaged about 29 ounces in silver per ton.

Local geology: Here, narrow bands of steeply dipping dense gray shales alternate with dikes of diorite-porphyry and quartz porphyry. The diorite-porphyry predominates, and, southeast of the main shaft, forms a mass more than 100 feet wide. Fully half of the Señora claim is covered by surface gravels. In the vicinity of the vein, they contain, at their base, abundant nuggets of placer lead minerals.

The mine workings seen above the 250-foot level do not show much of the shale, but are mainly in diorite-porphyry, cut in places by dikes of quartz porphyry. Below that level, the rock is quartz prophyry.

Main vein: The Señora vein strikes N. 20° to 40° W. and dips from 50° to 70° E. In the northern portion of the claim, it traverses dense gray slate that shows some cherty bands and effervesces only slightly in cold acid. Here, the vein has a gangue of gray blocky calcite crystals up to an inch in diameter, intermingled with smaller crystals of fluorite. This gangue contains masses of galena, up to two inches in diameter, and cubical pseudomorphs of black anglesite after galena. Both the galena and anglesite are coated with a film of rusty-red lead oxide.

As shown in the mine workings, the dip of the vein is approximately 70° E. for the first 140 feet of depth, below which it flattens to 50° for 100 feet, and, from there to the 300-foot level, it ranges between 55° and 65° E. Apparently, it follows a well-defined fault, the plane of which is wavy on a broad scale. As indicated by stopes, the width of the vein ranges between a few inches and five or more feet. Below the 250-foot level in the shaft, in quartz porphyry, the vein becomes only a few inches thick.

The gangue of the vein consists mainly of pale green, purple, and rose-colored fluorite, in crystals from less than an inch up to several inches in diameter. Along with the fluorite, occur crystalline calcite, bladed to massive barite, and minor amounts of fine-grained quartz. This barite is clearly later than the fluorite.

The ore mineral, galena, occurs as irregular veins and masses in gangue, and is superficially altered to anglesite, cerussite, and oxides. The northern face of the drift in the 200-foot level shows the following section of the vein from west to east: adjacent to the western wall, a six-inch strip with more than half galena and the remainder mostly crystalline fluorite, and, next, an eight-inch strip of fluorite with a little galena and oxidized lead and iron minerals. The fluorite is traversed by barite veinlets.

The northern face of the stope on this same level shows the following section from west to east: Six inches of fluorite, containing considerable galena; two to four inches of bladed and banded barite, apparently later than the fluorite and carrying no galena except on the edges; beyond a wavy fracture-surface, six inches of fluorite, barite, crystalline calcite, and brecciated porphyry, together with a little galena.

In portions of the upper levels on all the veins, hydrozincite, accompanied by minor gypsum, occurs, mainly in certain fissures that have become solution channels. These channels are also partly filled by various other secondary minerals, such as calcite, quartz, lead and zinc carbonates, and wulfenite.

Other veins: On the 100-foot level, three other veins have been found east of the main vein, as indicated by the drifts sketched in Figure 5. They strike about S. 30° E. and follow steeply eastward-dipping fault zones. Mineralogically, they are very similar to the main vein, and the easternmost one contains large lumps of galena, in places more than one foot thick.

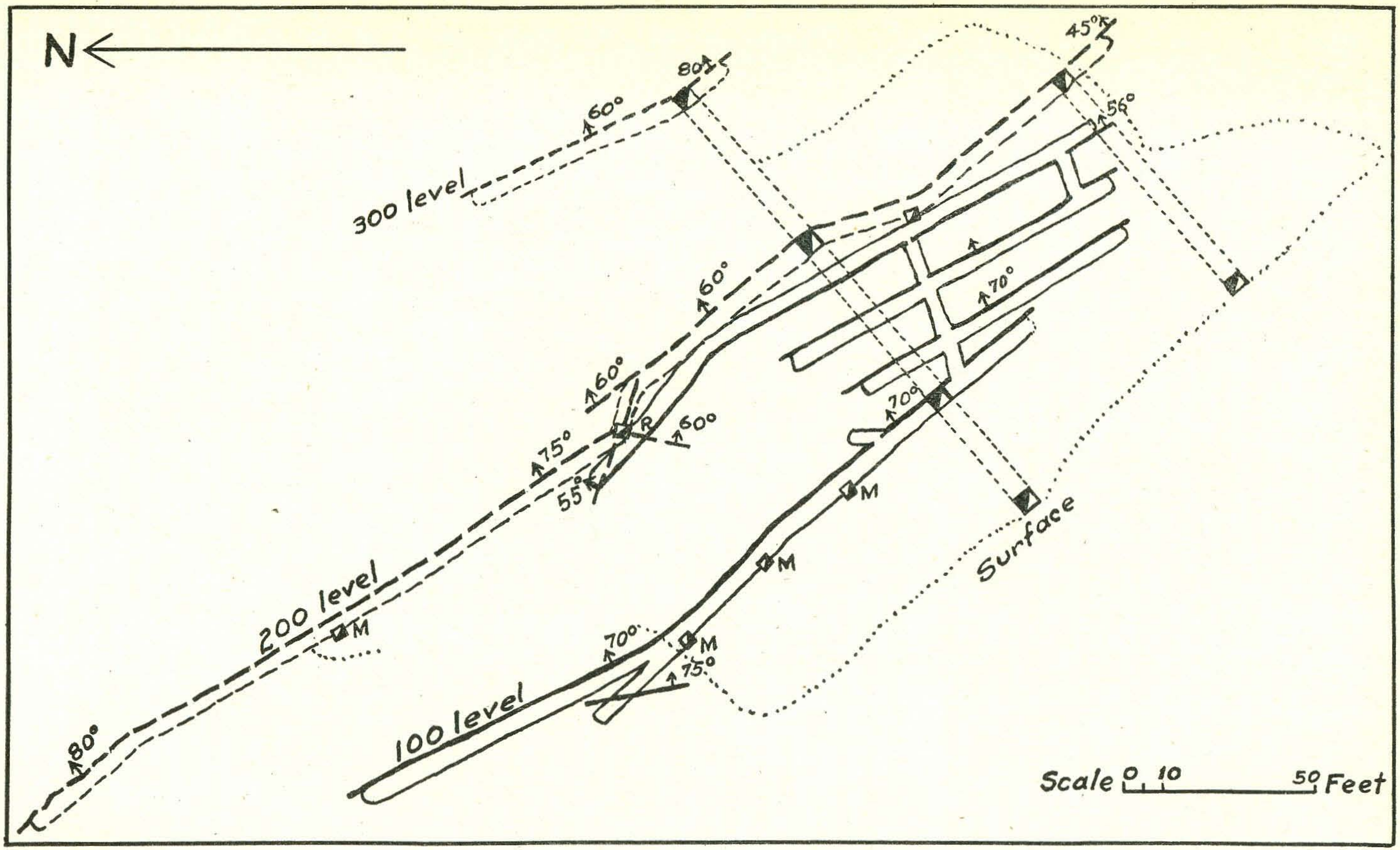

Fig. 5.—Plan of principal workings in Señora mine—M. manway; R, raise; dotted line indicates approximate outer limit of stoping; heavy lines indicate faults.

Wall-rock alteration: The vein walls show marked silicification, carbonatization, and sericitization. Small pyrite metacrysts, more or less altered to limonite, are abundant in the wall rocks.

A sample of the diorite-porphyry from the northern drift on the 100-foot level is seen, in thin section under the microscope, to consist of phenocrysts of plagioclase feldspar and quartz, together with flakes of chloritized biotite, set in a microcrystalline groundmass of quartz and feldspar. The feldspar phenocrysts, which are albite and up to 0.2 inch in diameter, show deep sericitization and carbonatization. The quartz phenocrysts show corrosion by the groundmass which is also sericitized. The whole rock is traversed by quartz and calcite veinlets.

Workings: Workings on the Señora claim include three shafts in the south-central portion. The southernmost two shafts, 250 and 300 feet deep on the dip of the vein, are some 200 feet apart and more or less connected by stopes. Figure 5 is a sketch of the principal workings. From the base of the gravels down to the 200-foot level, the vein has been largely stoped out over a length of 100 to 250 feet and an average width of about three feet. Below the 200-foot level, the stoping extends for a depth of fifty feet over a length of 125 to 150 feet, all south of the deeper shaft. Portions of these stopes, particularly in the vicinity of the southernmost shaft, are filled. Mr. Haak states that a test run on 1,000 pounds of screened material, under one inch in diameter, from this fill yielded ten percent lead.

The 300-foot level was run in 1914, but the upper workings are considerably older.

Surface equipment and concentrator: Surface equipment on the Señora claim consists of a headframe, hoist, and Stebbins dry concentrator.

After hand-sorting out the best fluorspar, the lead ore passes through a jaw-crusher onto a 1/16-inch stationary screen. The oversize passes through friction rolls, and back to the screen, while the fines are fed to a Stebbins dry table with a capacity of ten tons per shift. The tails are said by Mr. Haak to contain only one percent lead.

CLAIMS ON THE BUCKEYE VEIN

Beginning on the Castle Dome claim, which joins the northeast corner of the Flora Temple, the Buckeye vein is traceable in a S. 25° E. direction more or less continuously for 5,000 feet, on the New Dil, Lady Edith, Yuma, and Big Dome claims.

These claims are now held by Mrs. Eliza De Luce. The Castle Dome claim is patented, but the others have been relocated, at various times, with names and dimensions different from the present arrangement. According to Blake's[115] map of 1880, the claims on this vein, successively southward from the Castle Dome

[115] Blake, Wm. P., Castle Dome Mining and Smelting Company (private report). July, 1880.

claim, were the Hopkins, Norma, Caledona, William Penn, and Miller.

The Buckeye vein has furnished a large portion of the district's production since before 1870. As stated on page 86, it yielded 850 tons of ore during 1871. In 1930, the mines upon this vein were all idle and their surface equipment mostly dismantled. None of the workings were studied by the writer. As seen on the surface, the Buckeye vein prevailingly dips 70° W. and is from a few inches to several feet wide. Mineralogically and texturally, it is similar to the other veins of the district.

Castle Dome claim: The Castle Dome claim, held by Mrs. Eliza De Luce, was surveyed for patent in 1876, for Mr. I. M. Barney. Its surface, which is 2,000 feet long by 200 feet wide, is mantled by gravels. This claim was an important producer in 1870, but has been idle for many years, and its total output is unknown. The patent-survey plat of 1876 shows seven shafts, from forty to 191 feet deep, in the southern half of this claim.

New Dil, Lady Edith, and Yuma claims: These claims are held by Mrs. Eliza De Luce. As shown by the geologic map (Plate 9), their surface is largely mantled by gravels, but small areas of slate, cut by large dikes of diorite-porphyry and smaller dikes of quartz porphyry, outcrop. In these exposures, the vein is near the contact between the two kinds of dikes.

Workings on these claims include five shafts on the New Dil and Lady Edith, and several shallow cuts. The shafts are from 75 to 600 feet deep on the incline and some of them connect with extensive stopes above the 300-foot level. The deepest shaft is 200 feet from the northern end of the New Dil, and a 400-foot shaft is 950 feet farther south. Prior to 1880, according to Blake,[116] the Hopkins and Norma ground (now the New Dil and Lady Edith) was stoped out continuously for a distance of 1,000 feet and to a depth of 200 to 250 feet (see Figure 6).

Big Dome claim: The Big Dome, held by Mrs. Eliza De Luce, is one of the principal claims towards the southern end of the Buckeye vein. As shown by the geologic map (Plate 9), the rocks outcropping here consist of steeply westward-dipping shales, cut by large dikes of diorite-porphyry. Workings on this claim include four old shafts, sunk in the shales near the diorite-porphyry contact. No recent information upon these workings is available, but Blake,[117] in 1880, stated that the four shafts were from 180 to 225 feet deep, and that good ore had been extracted from stopes connecting the northernmost three of them above the 200-foot level.

LITTLE DOME CLAIM

The Little Dome claim, adjoining the Señora on the northeast, is held by Mrs. Eliza De Luce. It was worked to a considerable

[116] Work cited, p. 17.

[117] Work cited, p. 23.

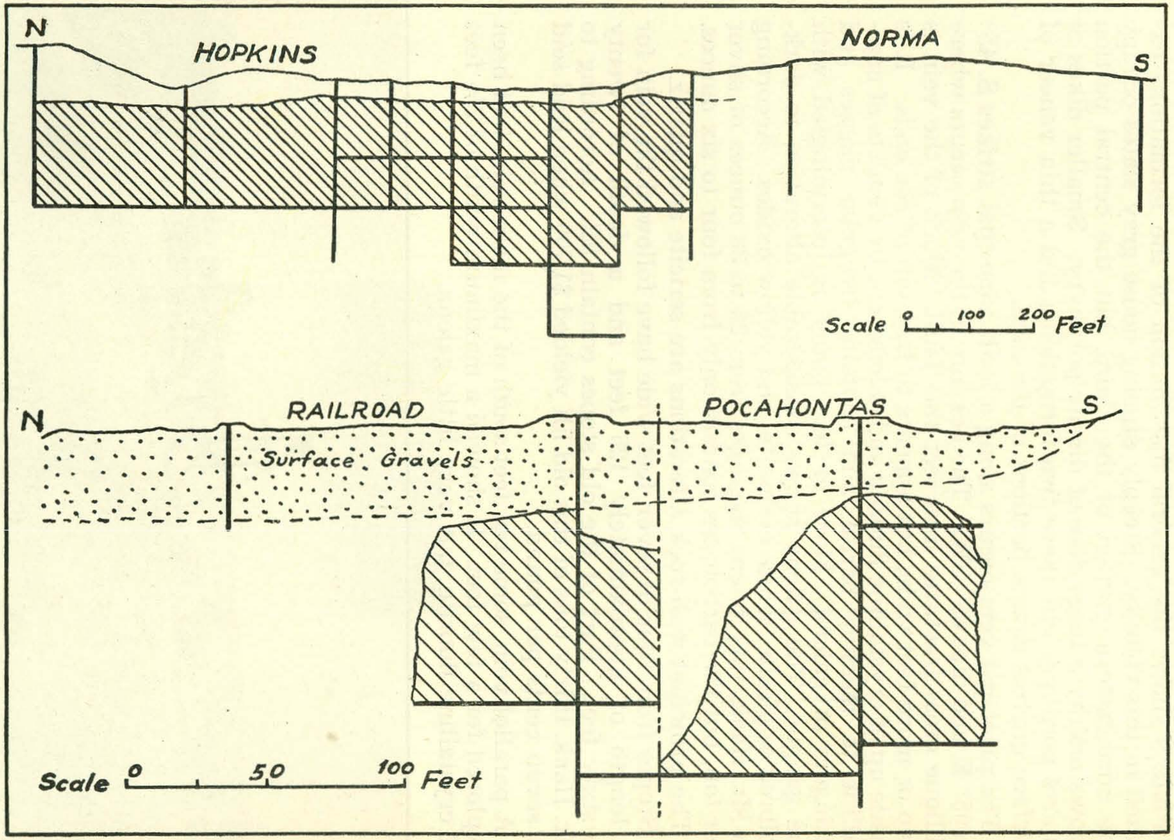

Fig. 6.—Section through Hopkins, Norma, Railroad, and Pocahontas claims in 1880, after Wm. P. Blake—Shaded areas indicate stopes.

extent many years ago, and, in 1930, had been reopened by Mr. Arthur Haak.

Plate 9 shows the general distribution of the formations exposed in this vicinity. Steeply dipping dense gray slates occupy the northeastern portion of the claim, but the central portion shows mainly a large dike of diorite-porphyry. Smaller dikes of quartz porphyry cut these two formations, and a thin veneer of surface gravels covers portions of the area.

The principal vein occurs along a fault zone that strikes S. 45° to 55° E. and dips 85° SW. The best ore in the vein occurs where oblique cross fractures intersect this fault. Much of the vein is two or more feet wide, but appears to fray out at the ends. It is made up of crystalline fluorite and calcite, cut by veinlets of crystalline to massive barite, and contains irregular masses and stringers of galena. More or less gouge is intermingled with the gangue. The galena shows considerable alteration to dark-colored anglesite, white cerussite, and yellow oxides. According to Mr. Haak, this galena averages from 28 to 30 ounces of silver per ton, but the carbonates contain only from four to six ounces.

The principal wall-rock alterations are sericite and quartz.

Stopes from four to seven feet wide have followed the vein for a length of approximately 125 feet and a depth of twenty to sixty feet. Part of the old stopes contain fill. According to Mr. Haak, thirty tons of this old fill yielded $1,700 when lead sold at seven cents per pound.

A parallel vein, some ten feet south of the main vein, had been explored for a few feet. It showed a maximum width of 2½ feet of crystalline fluorite, but very little galena.

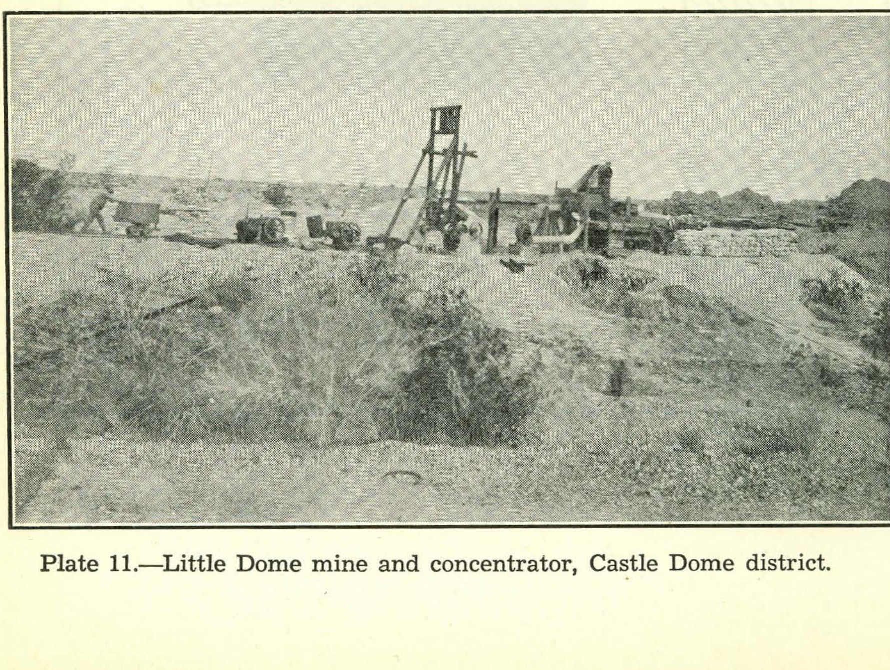

Plate 11.—Little Dome mine and concentrator, Castle Dome district.

Surface equipment on the Little Dome claim consists of a portable hoist and a small concentrator, as shown in Plate 11. This concentrator consists of a one-inch screen, a 1/16-inch screen, a hand jig, and a Stebbins type of table. All of the material larger than one inch is hand sorted, while everything between one inch and 1/16 inch in size passes to a hand jig that separates galena, barite, fluorspar, and tails. The screenings under 1/16-inch size pass to the Stebbins-type table.

HULL OR RIALTO GROUP

The Hull or Rialto group, held by Dr. A. G. Hull, includes sixteen claims in the northwestern portion of the area shown on Plate 9. One of these claims, the Diana, was surveyed for patent in 1899, as the Lola, for Mr. Wm. De Luce.

History: Little is known of the early history of these claims. During the eighties of the past century, part of the ground was worked by the Castle Dome Mining and Smelting Company. The Chief of Dome, Diana, and Surprise ground, in 1880, known as the Douglas, Railroad, and Pocahontas claims, yielded a large production of shipping ore. According to Mr. Arthur Haak, a thirty-ton mill was run during 1902 or 1903 with water from the 300-foot level of the Lola claim. Mr. Sam Ashe,[118] Manager of the Rialto Company, states that a mill worked part of the dump during 1915. This mill was equipped with a crusher, two sets of rolls, plunger jigs, and two Wilfley tables. The Hull or Rialto Company which has held this ground since 1916, has attempted only intermittent development work.

Local geology: As shown by Plate 9, most of the Hull group is mantled by surface gravels, but outcropping through them are a few low hills of well-bedded dense gray shale, limestone, and sandstone, cut by dikes of diorite-porphyry.

Vein and workings: The principal vein, which folllows a fault zone in dense gray slate, strikes approximately N. 30° W. and dips 65° to 75° NE. Where outcropping on the Diana and Surprise claims, the vein is traceable as a gray streak of weathered fluorite and calcite, with local masses of partly oxidized galena. Microscopic study of the slate wall rock reveals an intense development of sericite and less secondary quartz and chlorite.

Underground workings have explored the vein for a length of more than 2,000 feet. From northwest to southeast on the Chief of Dome and Diana claims, the principal shafts shown on Plate 9 are as follows: Old mill shaft, 380 feet deep; present operating shaft, 300 feet deep; and five shafts on the Diana claim, with depths of 300, 470, 85, 60, and 45 feet. Between these shafts, the richer portions of the vein have been largely stoped out and refilled with gob. Some of these workings are very old, and those earlier than 1880 on the Diana and Surprise (then the Rail-

[118] Oral communication.

road and Pocahontas) were described by Blake[119] as follows: "On the Railroad claim, which has furnished a large amount of ore, the extraction has been above a depth of 165 feet. The Railroad vein near the main shaft is twelve feet thick, and well filled with ore. The ore ground appears to be strongest towards the north end and to plunge downwards there to a greater depth.... The wash gravel at this point is very deep.

"The stopes of the old workings are partly filled with refuse ore and waste containing a large amount of galena."

The 265-foot level of the present vertical, operating shaft shows the vein to have been stoped for a distance of more than 400 feet southeastward, or to a point 115 feet beyond the 470-foot shaft. This stope, which in places has a width of eighteen feet, is partly filled with gob, but is said by Mr. Ashe to extend in places to the water level, which is at a depth of 225 to 275 feet. Exposed, unmined portions of the veins contain rotund masses of partly oxidized galena in a fluorite-calcite gangue. Northwestward, towards the old mill shaft, the vein for about 100 feet carries only some small bunches of ore along fractures, but an intersecting, nearly vertical fault with four feet of gouge contains a two-foot, galena-bearing streak.

Northward from a point some 175 feet north of the old mill shaft, the vein widens and contains chunks of galena, up to fifty pounds in weight, within a gangue of crushed fluorite and calcite. The 380-foot level of the old Mill shaft extends for some distance northwestward on a barren, wet fracture zone.

The 470-foot vertical shaft, situated immediately south of the road, is timbered for 135 feet, to the top of the old stope already mentioned. Within open cavities of the vein here, a little wulfenite appears. Blake[120] states that considerable amounts of vanadinite and a vanadiferous mimetite were found associated with wulfenite on the Railroad claim (now the Diana).

Equipment: Surface equipment on the Hull claims includes a small hoist, a blacksmith shop with a portable compressor, and some old concentrating machinery.

Water is removed from the workings by a Cameron air pump. According to Mr. Ashe, the water being raised in May, 1930, amounted to 6,000 or 7,000 gallons each 24 hours, but, in certain seasons, has reached a total of more than three times that amount.

CLEVELAND-CHICAGO VEIN

The Cleveland-Chicago vein, 3,600 feet northeast of the Flora Temple, was located many years ago and is now held by Messrs. Felix Mayhew and Fred Timmons, of Yuma. In the early days,

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[119] Blake, Wm. P., Castle Dome Mining and Smelting Company (private report), p. 17. July, 1880.

[120] Blake, Wm. P., On the occurrence of vanadates of lead at the Castle Dome mines in Arizona: Am. Jour. Sci., 3d ser., vol. 22, pp. 410-411. 1881.

it was worked by Mr. Pete Hodge, and later, at different times, by Messrs. De Luce, Haak, and Timmons. Since 1913, it has been practically idle, except for a little reworking of the dumps.

The local geology is indicated on Plate 9. Well-bedded, steeply southwestward-dipping slates and impure limestones are intruded by several dikes of diorite and quartz porphyry. Surface gravels mantle part of the Cleveland claim.

The vein is traceable for some 1,400 feet in a S. 30° E. direction, along a fissure that dips about 80° W. At the northwestern end, it is in slate, with a dike of quartz porphyry near the footwall, but, farther southeast, it cuts or lies near a dike of diorite-porphyry. As seen at the surface, this vein has a maximum width of three feet, but most of it is narrower. The principal gangue consists of clear, crystalline calcite, together with fluorite and less barite. According to Mr. Haak, the galena content was rich.

Workings on this vein include two shafts, 170 and 130 feet deep, on the Cleveland claim, a 100-foot shaft on the Chicago claim, and several shallower holes. A considerable portion of the vein, above the hundred-foot level, appears to have been stoped. When visited in 1930, the surface equipment had long been dismantled, and the workings were not entered.

ADAMS CLAIMS

In the southeastern portion of the area shown on Plate 9, twenty claims are held by Mr. G. B. Adams. During the last twelve years, about 125 tons of galena ore have been shipped from this ground.

Here, the slates are cut by dikes of diorite-porphyry and a few small masses of quartz porphyry. Much of the area is covered by surface gravels.

Workings on these claims include four shafts, each about 200 feet deep. The principal shaft, which is on the Puzzler claim, struck water at about 192 feet vertical depth, and shows tree roots following rock fractures to a depth of 165 feet. On the 55-foot level of this shaft, some 100 feet of drift shows the vein to occupy a fault zone that strikes S. 23° E., dips 70° NE., and in places is seven or eight feet wide. The vein material here consists of fluorite, brownish-black calcite, and galena in reddish-brown gouge and brecciated slate. The fluorite forms greenish crystals up to an inch in diameter, and the gouge is spotted by black iron oxide. The galena masses are coarsely crystalline and generally coated with black anglesite, grayish-white cerussite, and a little yellow lead oxide. In certain vug holes, vanadinite and wulfenite occur. On the 110- and 175-foot levels, respectively, about 230 and 290 feet of drifts show the vein to be much the same as on the level just described. In general, the best ore occurs where the fault zone contains the reddish gouge.

Very little drifting has been done from the other shafts on these claims. One of them yielded, at seventy feet, a chunk of galena eighteen inches long, sixteen inches wide, and from two to four inches thick.

MABEL CLAIMS

The Mabel group of fifteen claims, held by Mr. J. A. McCaddon, is in the hilly country between the Chicago and the Adams claims.

Part of this ground has been worked intermittently since the early days. It was formerly known as the Puckett property, and has produced considerable amounts of galena ore. Three different concerns have operated a small concentrator on this ore.

Here, as shown by Plate 9, the shales strike southeastward, dip 50° SW., and are intruded by dikes of diorite and quartz porphyry. Surface gravels mantle part of the area.

The writer did not study this deposit, but the following information was furnished by Mr. W. E. Smith, who was in charge of the property in 1930: The workings include five shafts that are 324, 380, 60, 50, and 49 feet deep. Some ten feet of water is in the 324-foot Mabel shaft. Most of the stoping has been south of this shaft, on an eleven-inch streak of galena that feathered out in depth.

LINCOLN OR COLORADO CLAIMS

Several claims, held by Mr. E. Lincoln, extend southward from the Union shaft, beyond the limits of the area shown by Plate 9. These claims were formerly known as the Colorado group. Subsequent to 1900, they were held by Mr. A. P. Modesti, and produced several thousand dollars worth of argentiferous galena.

Part of this ground is covered by surface gravels, but the rock and vein outcrops visible are similar to those of the northern portion of the district. Some of the veins are marked by copper stain. The wall rocks show strong silicification and sericitization.

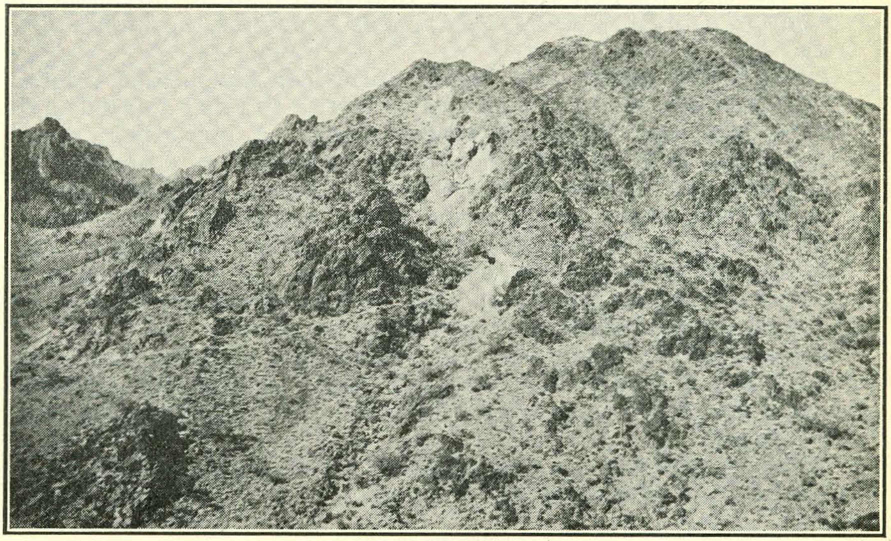
The surface equipment of these mines had been dismantled prior to 1930.

BIG EYE MINE

The Big Eye Mine, on the eastern slope of the Castle Dome Mountains, is held by Mr. A. K. Ketcherside, of Yuma. It is accessible by some ten miles of road that leads northeastward across the range from Thumb Butte settlement.

As recorded by the U. S. Geological Survey Mineral Resources, this mine from 1912 to 1917 produced $33,185 in gold.

In this region, deep, steep-sided, eastward-trending canyon systems have carved very rugged topography. The mine is on the northeastern slope of a spur that consists mainly of steeply dipping, brownish-pink, andesitic flows, intruded by dikes of rhyolite-porphyry and, apparently, faulted against brownish Cretaceous (?) quartzites. These quartzites form the crest of the ridge west of the mine, where they strike southwestward, dip steeply southeastward, and are badly shattered. About ¼ mile south of the mine is an outcrop, ¾ mile long by ½ mile wide, of fine-grained, greenish, granitic rock that apparently underlies the Cretaceous (?) rocks. Microscopic examination shows it to be a syenite, consisting of an aggregate of well-developed crystals, up to 0.05 inch in diameter, of orthoclase and sodic plagioclase, together with considerable chlorite and epidote and a little secondary quartz.



—Photograph by W. G. Reese.

Plate 12.—Looking southwestward at Big Eye workings, Castle Dome Mountains.

The vein occurs in a brecciated zone that, at its northern end, strikes south-southwestward and dips steeply eastward, but, within 150 feet farther south, curves to S. 25° W. and dips steeply westward. This zone is several feet wide. As revealed by surface stopes (see Plate 12), the vein is traceable for some 400 feet where it feathers out into breccia. The stopes do not appear to have been in commercial ore below a depth of thirty feet, and they indicate that the ore shoot was narrow and lenticular. The vein material consists of brecciated, dense, yellowish quartz, intermingled with veinlets of abundant white crystalline calcite. In one place, an eight-inch vein of manganiferous calcite occurs, but it tapers out within a vertical distance of eight feet. Microscopic examination of a sample of the vein wall rock shows it to consist of phenocrysts of kaolinized plagioclase in a chloritized groundmass. Many calcite veinlets, bordered by combs of quartz crystals, traverse the rock.

Workings here include, besides the stopes already mentioned, some 800 feet of tunnel that explored the brecciated zone below the stopes.

A mill, equipped with a crusher, five stamps, and cyanide tanks, is situated about 1/4 mile southeast of the mine.

SHEEP CLAIM

The Sheep claim, in the southeastern portion of the Castle Dome Mountains, is held by Messrs. H. Kurtz and G. T. Richardson, of San Diego, Calif. It is accessible by 4 1/4 miles of road that branches westward from the Roll-Kofa road in the northern portion of T. 6 S. Locally, this area is known as the Mofitt district.

Here, schist, gneiss, and granite form low, steep-sided ridges. In the vicinity of the Sheep claim, biotite granite, jointed and sheared in several directions, predominates. A quartz vein, from a few inches to three feet wide, strikes southward and dips 45° W. The quartz, which is white and vitreous, contains irregular masses of slightly greenish adularia, and small, sericitized, schist inclusions. In places, it is coated by slightly yellow lead oxide, and, near the surface, contains much iron oxide. A little secondary carbonate occupies fractures. This vein has been explored by a fifty-foot inclined shaft, with some lateral stoping.

From a cut higher up the hill, westward, a little ore has been mined from a similar, but narrower, vein. A few tons of gold-bearing quartz has been mined from this claim, but its grade was not learned.

Some prospecting has been done on other similar veins within the schist and granite of this vicinity.

KEYSTONE CLAIM

The Keystone claim, formerly located as the Goat, is in the southeastern portion of the Castle Dome Mountains. It may be reached by about five miles of road that branches westward from the Roll-Kofa road in T. 4 S.

Here, a northeastward-trending canyon has made an alluvial-floored re-entrant in the range. The claim is on the southeastern slope of a bold ridge of quartz-sericite schist that is capped by eastward-dipping Tertiary rhyolite flows. As shown by Plate 13, quartz porphyry dikes, up to fifteen or more feet wide, cut these rocks in various directions, but predominantly strike southwest.

The principal vein, outcropping with a width of one to three feet, in a brecciated zone in the rhyolite, strikes N. 15° W. and dips 56° W. It is traceable northward for some 750 feet, beyond which it narrows to one foot or less and swings northwestward, continuing for a long distance as a dark-gray quartz-carbonate streak. The vein material consists mainly of manganiferous calcite, intermingled with brecciated quartz and rhyolite. It contains some manganese dioxide near the walls. The quartz is fine grained and cellular, and shows a few spots of malachite. This vein has been prospected by a few shallow workings which, according to Mr. Arthur Haak, revealed pockets of rich silver ore close to the surface.

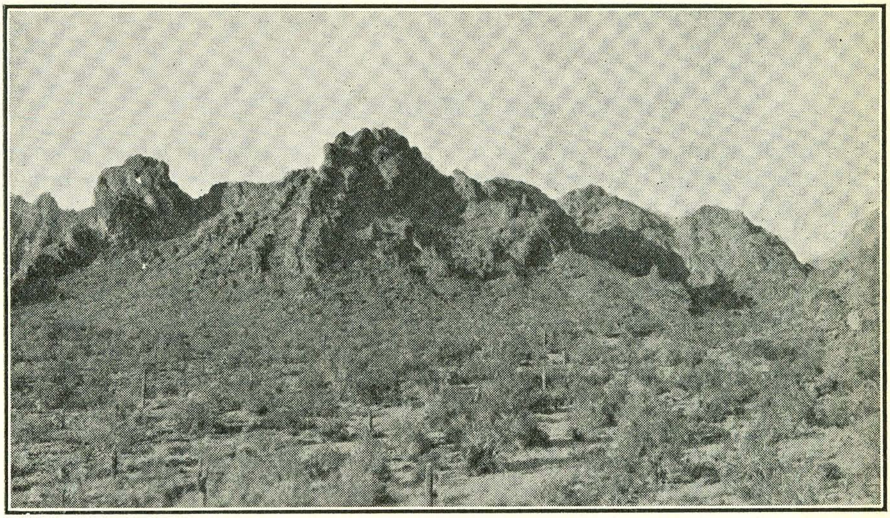


Plate 13.—Dikes cutting schist near Keystone claim, Castle Dome Mountains.

About ½ mile farther northwest, in the schist area, a vein, up to six feet wide, outcrops with a N. 25° W. strike and nearly vertical dip. The walls of this vein are mainly sericitized, iron-stained quartz porphyry. Its filling consists of banded manganiferous calcite and dense, honey-combed quartz. Some of the cavities contain fine crystals of smithsonite, and others are filled with red iron oxide.

This vein has been prospected by a long tunnel, but, according to Mr. Haak, it was poor in silver content.

CHAPTER V—S. H. OR KOFA MOUNTAINS

SITUATION AND ACCESSIBILITY

The S. H. or Kofa Mountains are northeast of the Castle Dome Mountains from the low, northern end of which they are separated by a narrow, alluvium-floored gap. The S. H. Mountains, which include an area of approximately 200 square miles, extend eastward from the middle of R. 18 W. to the Little Horn Mountains, a distance of twenty miles, and southward from T. 2 N. to the Tank Mountains, a distance of eighteen miles. On recent maps, they are shown as the Kofa Mountains, after the King of Arizona mine, but their original name, which Darton[121] says stands for Stone House, is much better known.

Less than a dozen people live at the mines and prospects of the S. H. Mountains, but a few prospectors and cowboys frequent the range during favorable seasons. As shown by Plate 1, a road from Yuma unites with several other roads from the south and leads to the King of Arizona and North Star mines, at the southern edge of the range. With the same destination, an old road from Quartzsite leads around the western end. A branch from it extends to Tunnel Springs, in the western part of the range. The Palomas-Vicksburg road, via Sheep Tanks, ascends through a pass three miles east of the S. H. Mountains. A road through New Water Pass skirts the northern edge of the range, and a branch from this road extends southward, past Alamo Spring, to Ocotillo.

TOPOGRAPHY

The bulk of the S. H. Mountains consists of a gently northward-dipping block that rises to more than 4,000 feet above sea level, or 2,500 feet above the adjacent plains. Portions of its crest represent a sloping mesa, modified in many places by extensive dissection into pinnacles and deep, groove-like canyon systems. Cliff-like slopes are rather common. The western and southern fronts are wall-like, but the northern side, as shown by Plate 14, is very ruggedly dissected.

Drainage from the southwestern and eastern portions of the S. H. Mountains flows towards the Gila River, but that from the northern side joins northwestward-flowing tributaries of the Colorado River.

GEOLOGY

The S. H. Mountains are made up largely of lava flows, but minor areas of schist, granite, and shales are exposed at their base.

[121] Darton, N. H., A resumé of Arizona geology: Univ. of Ariz., Ariz. Bureau of Mines Bul. 119, pp. 224-225. 1925.

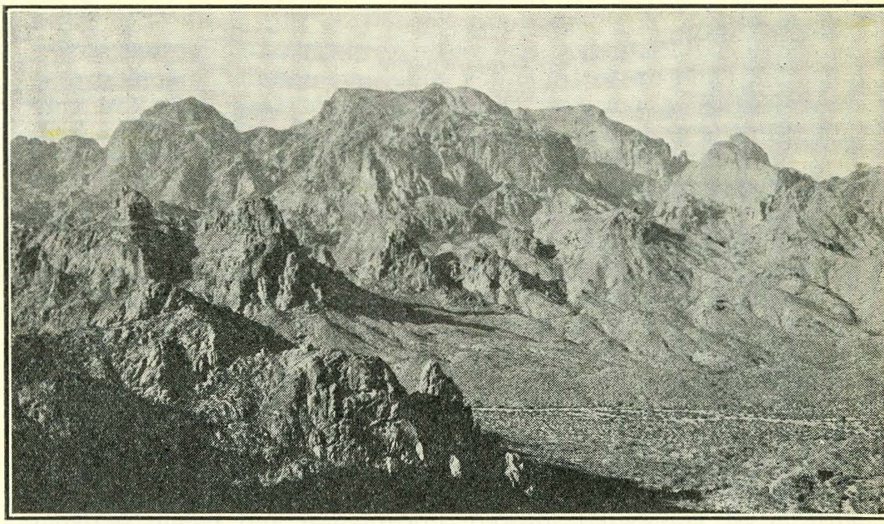


Plate 14.—Looking southward from Tunnel Springs at northern portion of S. H. Mountains.

Schist: A small area of gray fissile quartz-biotite schist outcrops at the southern margin of the range, where it forms a low, sharp ridge south of the North Star mine. So far as known, the the only mineral deposits within this schist are a few narrow, galena-bearing veins.

Granite: A granite area, about three miles long and up to 1½ miles wide, outcrops in a southeastward trending canyon 2¼ miles northeast of Alamo Spring. Jones[122] says: "The granite is fine grained and is composed of quartz, feldspar, hornblende, and alteration products and a few accessory minerals. The feldspars consist of orthoclase and a perthitic intergrowth of orthoclase and albite. In some of the sections the feldspars are largely altered to sericite. Hornblende is a variable constituent of the rock, though nowhere abundant, and is commonly altered to epidote and chlorite. Magnetite was noted as a secondary mineral in one of the sections." Because of its lack of dynamic metamorphism, he believed this granite to be of Mesozoic age and intrusive into the sedimentary rocks, although it was nowhere found in contact with them. In the Castle Dome Mountains, however, a similar granite appears to be older than the sedimentary beds.

This granite is of economic interest in the S. H. Mountains because of the copper deposits that it contains (see page 120).

Cretaceous (?) sedimentary rocks: Gray to buff shales, sandstones, conglomerates, and limestones outcrop along the southern

[122] Jones, E. L., Jr., A reconnaissance in the Kofa Mountains, Arizona: U. S. Geol. Survey Bul. 620, p. 155. 1915.

margin of the range, southeastward from the North Star mine. As shown by Plate 1, these rocks form an irregular belt seven miles long and up to 1¾ miles wide, but detailed mapping may show further exposures. Numerous shale fragments are contained in the andesites at the King of Arizona mine. These beds have been tilted, faulted, fractured, and extensively intruded by dikes, but show very little metamorphism.

Jones,[123] who saw a small exposure of these rocks in the footwall of the North Star vein, regarded them as pre-Cambrian. In the present report, however, they are correlated with the post-Carboniferous (probable Cretaceous) sedimentary rocks of the Castle Dome and New Water mountains, to which they bear a very strong lithologic resemblance.

These beds are of economic interest in the S. H. Mountains only because of forming the footwall of the North Star vein.

Dike rocks: Mesozoic or Tertiary dikes of diorite, pegmatite, and monzonite-porphyry intrude the schist, sedimentary rocks, and granite. Jones [124] describes the diorite as coarsely granular, with large, somewhat altered, hornblende and calcic feldspar crystals, and he states that its dikes are up to 100 feet wide.

Volcanic rocks: The volcanic rocks of this range have been described by Jones [125] as follows:

"Rhyolites and andesites with accompanying tuffs, breccias, and local thin beds of grit are overlain by olivine basalts which cap the mesas. The thickness of these volcanic rocks exposed in the Kofa Mountains is probably 2,000 feet. A light-colored, thin, fragmental rhyolite on the eroded surface of the older intrusive rocks was noted near the Cemitosa Tanks. Overlying it are thick flows of maroon to brownish andesites and associated tuffs and breccias. For the most part, the flows are horizontal, but, on some of the peaks, light-colored tuff beds between layers of darker material dip at steep angles. Near the North Star mine, flow bands in the andesite are well developed, but over most of the area examined the lavas give little indication of flow structure. The rhyolite tuff, of general light color, contains sparsely disseminated crystals of orthoclase, quartz, and biotite.

"Andesites of gray, red, brown, and intermediate shades constitute a large part of the lava series. They vary in texture from fine-grained, dense rocks with few phenocrysts to those having abundant phenocrysts. The phenocrysts are predominantly feldspar, mostly altered to calcite, but locally biotite is an abundant constituent of the rock. Tests on some of the unaltered feldspars indicate that they have the composition of labradorite. The groundmass is a microcrystalline feldspar aggregate, colored with iron oxide. Olivine is a sparse though variable constituent of the andesites, becoming more abundant toward the top of the series. The occurrence of this mineral indicates a close relation,

[123] Jones, E. L., Jr., work cited, p. 156.
[124] Jones, E. L., Jr., work cited.
[125] Jones, E. L., Jr., work cited, pp. 154-155.

and possibly a gradation in composition, between the andesite and the overlying basalt.

"The basalt flows are 300 feet or more thick in places. Although, as suggested, the lower flows appear to be closely related to the underlying andesites, the upper flows are made up of typical black vesicular basalt. It consists of a groundmass of calcic feldspar laths and augite grains which enclose large crystals of olivine, some of which show alteration to serpentine, enclosed by rims of iron oxide."

Structure: When viewed from the west, the lavas of the main mass of the S. H. Mountains are seen to dip about 20° northward. Farther east, along the Ocotillo road, the volcanic rocks in some places lie flat and elsewhere dip in various directions.

In all of the formations older than the basalt, considerable faulting and fracturing and very minor amounts of local folding occur.

MINERAL DEPOSITS

Deposits of gold, copper, and lead occur within certain fault zones in the S. H .Mountains, and gold placers have been formed south of the North Star mine. Jones [126] regarded the gold-bearing veins as Tertiary, and the lead and copper deposits as probably Mesozoic, but they all may belong to the same period of Tertiary mineralization. The placers are probably of Quaternary age.

GOLD-BEARING VEINS

Numerous gold-bearing veins, all of which appear to have been deposited in the epithermal zone, occur in the S. H. Mountains. Only the King of Arizona and North Star veins have produced much ore.

KING OF ARIZONA MINE

Situation and accessibility: The King of Arizona mine is at the southwestern edge of the S. H. Mountains, at an elevation of approximately 1,700 feet above sea level. It is accessible from Yuma by a semi-improved road that branches eastward from the Quartzsite highway at the Stone Cabin. Unimproved roads lead from the Southern Pacific Railway at Wellton and Mohawk to the mine, and many confusing trails, made by wood haulers more than twenty years ago, radiate southward over the plain. The nearest railway point, Growler, on the Phoenix loop of the Southern Pacific, is about 35 miles distant.

History:[127] The King of Arizona mine was discovered during the winter of 1896 by Mr. Chas. E. Eichelberger, who, with Messrs. H. B. Gleason and Epes Randolph, shortly afterwards organized the King of Arizona Mining Company.

In June, 1897, a five-stamp amalgamation mill was completed

[126] Jones, E. L., Jr., work cited, p. 156.

[127] Data compiled by J. B. Tenney.

near Mohawk, on the Gila River, 35 miles south of the mine. In 1898, a cyanide plant for treating the tails was added. This first mill, to which the cost of delivering ore amounted to $8 per ton, was operated until January, 1899.

During the latter part of 1897, after several unsuccessful attempts, an adequate water supply was located at a depth of 1,000 feet in a well five miles south of the property. Water was also struck at a depth of 465 feet in a well seventeen miles south of the mine. In January, 1899, the mine was temporarily closed, and a 100-ton cyanide plant was started at the mine. This mill and pipe line were built by a Tucson organization called the King of Arizona Construction Company. In August, the plant was completed, and the mine was reopened with a force of sixty men. Later, the mill was enlarged to a capacity of 250 tons, and about 125 men were employed on the property.

From August, 1899, to July, 1910, the mine and mill were run continuously with an average production of 200 tons a day. The total production, as shown on page 122, amounted to $3,500,000.

Topography: The King of Arizona mine is at the northeastern margin of a plain, here ten miles wide, that separates the S. H. from the Castle Dome mountains and slopes south-southeastward to the Gila River. Erosion has indented this margin of the faulted, fractured lava mass of the range with many deep, rugged canyons that, for some distance headward, are floored by detrital gravels and separated by ragged to blocky spurs. The King of Arizona vein outcrops at the foot of one of these spurs. Only narrow pediments (rock floors) are exposed here, probably because of the relatively rapid accumulation of alluvial fans.

Mineral deposit: Blake,[128] in 1898, wrote the following notes regarding the King of Arizona mine: "This gold-bearing property, known for a time as the 'Gleason,' has been transferred to the King of Arizona Mining and Milling Company, a corporation organized under the laws of the Territory of Arizona, with a capitalization of 5,000,000 shares of a par value of $1.00 each.

"This company owns four full claims — the Homestake, the King of Arizona, the Last Hope, and the Mucho Bueno.

"This district is north of the Gila River, and about 42 miles from Texas Hill station, on the Southern Pacific Railroad. This is the nearest station on the railway. There are several other locations besides those conveyed to the King of Arizona.

"The Homestake location covers the chief workings up to this date. There is on this claim a strong vein of gold-bearing quartz. This lode or vein has three well-marked divisions or layers. On the hanging wall there is a soft layer from 3 to 3½ inches wide, which averages about $800 per ton in value. Next below this there is a middle layer or body of quartz about twenty inches thick, which will average about $190 to $200 per ton in value. The

[128] Blake, Wm. P., Report of the Terr. Geol., in report of Gov. of Ariz., 1898: Misc. Repts., Washington, pp. 255-256. 1898.

remainder of the vein, so far as it is exposed by the shaft, averages about $24 per ton. Test holes have been drilled three feet deep into the foot wall, and all are in ore.

"The shaft by which the exposure of the nature of the vein has been made was fifty feet deep in July last, and followed the dip of the vein. From this shaft at the bottom drifts have been run along the vein under the hanging wall a distance of about forty feet westerly, and easterly about twenty feet, making, including the length of the shaft, about seventy feet of drivage on the lode and showing a continuity of vein having the same characters and values developed by sinking the shaft.

"The hill rises rapidly on the western side of the shaft, so that the heights of backs on the lode above the drift is greater on the west than on the east. At a point about thirty feet west of the shaft and on a level with the collar of the shaft the vein has been crosscut from wall to wall and is shown to be eighteen feet wide. The ore in this crosscut has about the same grade as that at the collar of the shaft. The value of the vein at the shaft has been estimated at $3,500 per lineal foot, longitudinally. The vein is exposed for eighteen feet or more above the shaft. The croppings of the vein may be followed for some 750 feet up to a second opening known as the King of Arizona shaft. This was thirteen feet deep in July. By means of drill holes the vein was shown to be over eleven feet wide and to average $12.00 per ton in value. A tunnel has been started in to tap the vein about ninety feet below the croppings.

"There are several large croppings of quartz near the workings on the 'Homestake,' and probably a dozen or more other locations in the vicinity.

"Wood is sufficiently abundant at the mine and at the mill on the Gila. It is chiefly mesquite and iron wood, and costs from $3.00 to $3.25 per cord, delivered.

"The contract price for hauling ore from the mine to the mill on the Gila is $8.00 per ton of 2,000 pounds. Contracts have been made for the erection at the mill of a plant to treat the tailings by the cyanide process."

Jones,[129] who visited this property in 1914, states: "At the time of the writer's visit the mine had been closed for four years and the workings were in part inaccessible and generally in a bad state of repair below the 100-foot level. Mr. Eugene S. Ives, of Tucson, Arizona, kindly supplied notes regarding the value of ore and cost of treatment and other data. . . .

"The mineralized zone or lode trends between N. 60° W. and west and dips at an angle of 60° S. This zone can not be traced beyond the limits of the detached hill area. Its identity is lost a few hundred feet east of the mine shaft, but west of the shaft the vein is covered by two claims of the King of Arizona group, and it probably extends for a considerable distance beyond them.

[129] Work cited, pp. 157-158.

On the King of Arizona claims the vein is stoped out to the surface for 1,500 feet along its strike. The stoped areas are from a few feet to thirty feet wide and the ore body is said to average twelve feet in width. There is no mine dump, as all the material was run through the mill. The footwall of the vein is generally a well-defined slickensided plane, but the hanging wall is more indefinite. The ore body contained many small fissures and small slip planes, and most of them are parallel to the trend of the ore body, but several lie at angles with the vein, generally coming in from the hanging-wall side, and make horses of barren material. About 200 feet east of the shaft strong cross fissures filled with calcite apparently limit the ore, for development has not proceeded beyond this point.

"The lode matter is a brecciated, generally brown to maroon andesite-porphyry. The dense fine-grained groundmass contains altered white plagioclase feldspars and small, sparsely distributed, highly altered ferromagnesian minerals. The andesite is partly silicified, particularly where the fissuring is closely spaced. Stringers of quartz and calcite traverse the lode in all directions. They vary from those of knife-blade thickness to those several feet thick. The small veinlets are composed of quartz crystals, but in those one inch or more thick the walls are commonly lined with small quartz crystals and calcite occupies the middle. The calcite is brown to black in color and is highly manganiferous. The lode matter is stained with iron and manganese oxides. The gold is said to occur free but in a very finely divided state. None was noted in the specimens collected from the vein and dump. The disintegration of the lode has produced no placer deposits.

"The ore is valuable chiefly for its gold, but it also contains silver, the two metals being present in the ratio of approximately 58 to 1 in value. The ore at the surface was very rich, and many tons of it valued at $2,000 a ton were mined. The average tenor was $40 a ton. The metal content of the ore body steadily decreased with increasing depth until at the deepest workings, 750 feet below the surface, the gold and silver content averaged less than $3 a ton. At this figure the ore could not be treated profitably and the mine was closed. The walls of the ore body diverge with increasing depth, and Mr. Ives states that at the bottom of the shaft they are eighty feet apart."

Mill: The original 100-ton plant used at the King of Arizona mine, as described in the *Engineering and Mining Journal,*[130] made a very high extraction with less than 35,000 gallons of water per 100 tons of ore. Jones[131] describes the later, 250-ton plant as follows: "The ore treatment was extremely simple, no complicated or expensive methods being necessary. After being dry-crushed through jaw crushers and rolls, to pass a twenty by sixteen mesh, the ore was loaded into vats of 250-ton capacity and

[130] Vol. 68, p. 556. 1899.

[131] Jones, E. L., Jr., work cited, p. 158.

there leached with cyanide solution for a period of nine days. The strength of the solution was 4½ pounds of cyanide to the ton of water. The gold and silver were precipitated in zinc boxes and the precipitate smelted into bars. The sands and slimes were not separated, as in ordinary cyanide practice, but notwithstanding this, the average extraction was reported to be 93 percent. It is said that the cost of development work, stoping, and milling, including general expenses and taxes, amounted during the last few years of operations to about $2.80 a ton, and therefore material below $3 in assay value could not be treated profitably. The mill treated an average of 200 tons a day.

Development and present operations: "The mine is developed by an inclined shaft 750 feet deep, drifts at the 100-foot level, and an adit at the level of the collar of the shaft. The shaft is driven on the hanging-wall side a short distance south of the outcrop of the vein and approximately 100 feet lower. The drifts extend east and west and follow the vein; some of those to the west are over 2,000 feet long, but the drifts east of the shaft are not longer than 200 feet. A steam hoist in good condition is still in position at the shaft, but the cyanide mill is now dismantled."

In 1931, the property was owned by Mrs. Mary Huffman. Little work, beyond surface prospecting and road maintenance, has been done here since 1910. Its settlement, Kofa, is inhabited only by one or two families.

NORTH STAR MINE

Situation and accessibility: The North Star mine is about 1¾ miles north of the King of Arizona, and is accessible over the same roads.

History: The North Star vein was discovered in 1906 by Felix Mayhew,[132] who sold it in 1907 to the Golden Star Mining Company for $350,000. In 1908, this company erected a fifty-ton cyanide plant at the mine, and later doubled its capacity. Water for this plant was obtained from the King of Arizona wells. Operations continued until August, 1911, when the ore reached an unprofitable grade.

As shown on page 122, the production from this property amounted to $1,100,000. In addition, a considerable amount of rich ore was stolen by "highgraders."

Topography: The North Star mine is at the foot of the precipitous southern wall of the main mountain mass. A detrital-floored re-entrant separates it from the spur that contains the King of Arizona vein. Certain general topographic features of this area are described on page 110.

Mineral deposit: This mine has been closed since 1911, but Jones[133] has given the following description:

[132] Oral communication from Mr. Mayhew.
[133] Work cited, pp. 159-160.

"The ore body of the North Star mine is in a lode or vein of silicified andesite breccia and quartz which strikes east and dips about 60° N. The lode is ten feet in average width at the North Star. It crops out several feet above the country rock, and from the mine it can plainly be seen extending for a considerable distance to the east and west. It is said that it can be traced for several miles and marks in a general way the base of the southern hills of the Kofa Mountains. At the mine the hanging wall is a pink flow-banded biotite andesite, and the footwall a dark calcareous shale or slate. . . . The shale in places contains finely disseminated pyrite. The lode probably occurs along a fault.

"The vein matter is of striking appearance. Near the surface angular fragments of the pink andesite, in places altered to green and gray tints, are cemented to an extremely hard rock by banded chalcedonic quartz, the bands being well shown by the deposition of minute crystals of sulphides, most if not all of which are pyrite. Pyrite also occurs disseminated sparingly through the altered andesite. Small vugs in this material are lined with sparkling quartz crystals. Under the microscope the chalcedonic quartz is seen to be accompanied by adularia in variable amounts, but nowhere in the slides examined is this mineral as abundant as the quartz. A green, micaceous mineral is developed in the altered andesite, as well as a little chlorite and epidote.

"The ore is valuable chiefly for its gold content, but it also contains small amounts of silver in about the ratio of its occurrence in the King of Arizona ore. The gold is said to occur free and very finely divided, associated with the fine sulphides in the chalcedonic quartz.

"As interpreted from the assay chart of the mine, the high-grade ore bodies occur in shoots or chimneys which pitch to the east. They are of variable width, and the gold content deteriorates rapidly with increasing depth until at the fifth level the average tenor of the ore is below that required for its profitable treatment — $14 a ton. Assays in the drifts beyond the enriched parts of the lode show gold and silver in variable amounts, with a probable average value of $2 a ton. The surface ore of the North Star mine was of exceptionally high grade. One streak of ore on the footwall was said to have been worth from $6 to $20 a pound, and ore to the value of thousands of dollars was stolen. The stoped-out parts of the ore bodies averaged ten feet in width. No. 2 shaft was sunk on the lode in the approximate center of a shoot of high-grade ore over 500 feet long, the tenor of which exceeded $50 a ton. On the second level the high-grade ore occurs in several small shoots separated by ledge matter of relatively low grade. On the third, fourth, and fifth levels these shoots appear to have joined to form a shoot which is comparable in length to that of the first level, but which shows a rapidly decreasing metal content.

"The ore of the North Star mine differs markedly from that of the King of Arizona mine in the absence of calcite and in the abundance of chalcedonic quartz and pyrite, factors which make it far less amenable to cyanidation. Several processes are necessary in order to reduce the ore to sufficient fineness to release the gold content. The cost of mining and milling is said to be $14 a ton. The disintegration of the North Star lode has produced no placer deposits.

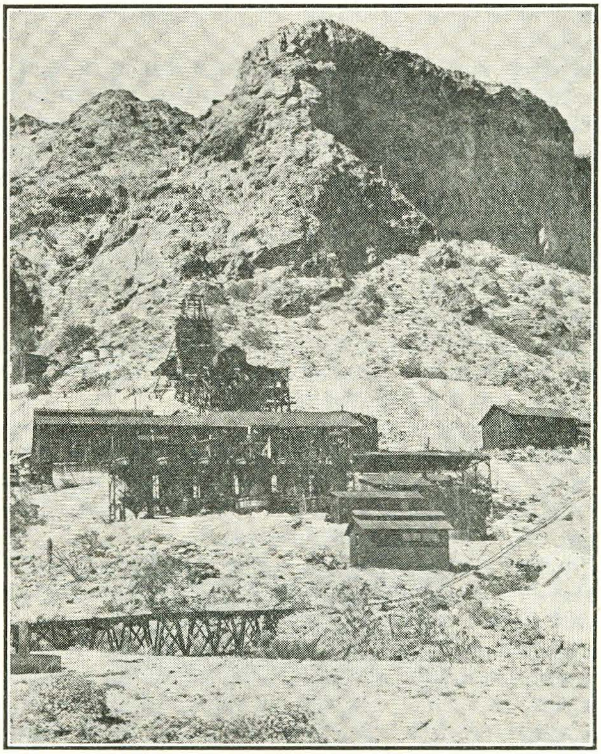


Plate 15—North Star mine and mill, Kofa district—Rock in background is andesite.

Development and present operations: "The mine is developed by two inclined shafts, No. 1 and No. 2, 90 and 500 feet deep, respectively, and by drifts and crosscuts on the vein at each 100-foot level. An adit from the footwall side connects with the first level from No. 2 shaft. The total length of development work is about 3,500 feet. The shaft is equipped with a steam hoist. The ore is treated in the combination amalgamation and cyanide mill after being reduced to sufficient fineness through crushers and rolls and finally in tube mills."

In 1931, the property was said to be owned by the Golden Star

Mining Company, but little work, beyond assessment on outlying claims and road maintenance, has been done here since the mine closed in 1911. Its settlement, Polaris, which had a population of 339 in 1910, is inhabited only by one or two families.

GOLD PROSPECTS IN ALAMO REGION

The Alamo region, as here considered, embraces a small mineralized district in the vicinity of Alamo Spring, Cemitosa Tanks, Red Raven Wash, and Ocotillo, in the northern portion of the S. H. Mountains.

Alamo Spring, which is approximately thirty miles from Vicksburg, is accessible by about thirteen miles of unimproved road that branches westward from the Sheep Tanks road at the eastern entrance to New Water Pass. The Cemitosa Tanks, which are 4½ miles northeast of Alamo Spring, are accessible by about twelve miles of desert road that branches westward from the Sheep Tanks road at a point some eight miles south of Sheep Tanks. Red Raven Wash is about two miles by road southwest of Alamo Spring. The road leads westward, beside this wash, for two miles, to Ocotillo.

Many claims were located in this region about 25 years ago, and have been considerably prospected from time to time. So far as known, they have produced no ore.

Here, the mountains are somewhat less cliffy and rugged than in the vicinity of Kofa. Sharp ridges and flat-topped mesas prevail, but they are separated by canyons that are rather broad, especially in the tuffaceous rocks. Nearer the northern margin of the range the canyons are narrower.

Alamo Spring issues from near the southern edge of an area of nearly flat-lying basalt. When seen in March, 1931, it had only a very small flow.

Regarding the gold prospects of the Alamo region, Jones[134] says: "As yet, no large, rich ore shoot has been developed in any of these zones, but one prospect shows a high-grade ore streak, and encouraging results have been obtained from several others.

"*Geyser Prospect:* The Geyser prospect, formerly known as the Silent King, is on one of several claims on a ledge of brecciated andesite-porphyry near Ocotillo. The developments consist of an inclined shaft about 300 feet deep with short drifts and crosscuts on the 140-foot and 200-foot levels. The shaft is sunk at an angle of 45° on the hanging wall of the lode. The country rock in the vicinity of Ocotillo is predominantly a reddish andesite-porphyry, with smaller masses of rhyolites and andesite tuffs and thin grit beds. The lode or brecciated zone in the andesite porphyry trends about N. 80° W. and dips 45° S. It can be traced for about 1½ miles, the I. X. L. prospect being located near its eastern extremity and the Rand near its western extremity. The lode ranges in width from a few feet to sixty

[134] Work cited, pp. 160-163.

feet on the Geyser claims, where for 2,000 feet it forms a prominent ledge, in places thirty feet high. The brecciated andesite-porphyry is replaced by silica in varying amounts. In some places, angular fragments one foot or more in diameter are replaced to form banded greenish rocks; in others, small porphyry fragments are little altered. White, coarsely crystalline calcite occurs abundantly in the lode, particularly on the footwall, where there are many stringers and veinlets as much as one foot wide. The lode near the hanging wall contains iron-stained kaolinized material in the numerous slips and seams and as the cementing substance of the breccia. Pseudomorphic quartz after lamellar calcite occurs in the hanging wall, and it indicates a deposition of calcite earlier than that deposited in the footwall.

The gold occurs free. It is more abundant along the hanging wall than along the footwall and is particularly associated with the iron-stained kaolinized material. A high-grade ore band of iron-stained breccia is several feet wide at the surface, but it gradually thins out to a seam about one foot wide along a small fault plane at a depth of ninety feet, and it was not observed below the 140-foot level. A specimen of ore from the hanging wall on the 200-foot level shows abundant small particles of gold contained in a thin film of iron-stained kaolinized material enveloping a lamellar crystalline aggregate of pseudomorphic quartz after calcite. The average value of the ore from this prospect was not learned, but a small quantity of sorted ore is said to have assayed $140 a ton. No ore shipments have been made from the property.

"*Rand Prospect:* The Rand prospect is near the west end of the Geyser lode. It is about five feet wide and is prospected by a shallow shaft and a drift. The ore is a brecciated biotite andesite cemented principally by calcite, with some iron-stained material from which gold can be panned. The andesite fragments are dense and more or less silicified. They contain small nodules and veinlets of chalcedonic quartz, and small rust-stained cavities apparently result from the weathering of pyrite.

"*I. X. L. Prospect:* The I. X. L. prospect is near the east end of the Geyser lode. The developments consist of an inclined shaft 35 feet deep, driven on iron-stained breccia that is said to contain fine gold. Much of the lode matter is a breccia of small andesite fragments cemented by fine-grained secondary quartz. Calcite veins of later age, some of them six inches wide, cut this breccia. Under the microscope a thin section of the breccia shows a few adularia crystals in the secondary quartz.

"*Regal Group:* The Regal claims are about a mile southeast of Ocotillo, and the workings are in a small hill on the south side of Red Raven Wash. Several brecciated zones and veins with east-west trend cross these claims and are developed by shallow shafts and tunnels. On the Regal No. 1 an inclined shaft about 35 feet deep is driven in iron-stained brecciated andesite-porphyry. The zone is about six feet wide, trends N. 80° W., and dips 45° S. The zone is said to assay $8 a ton in gold. On the Regal claim a 70-foot tunnel driven N. 10° E. into the hill, a winze 35 feet deep, and two short drifts constitute the development work. The country rock is andesite-porphyry and gray tuff, cut by numerous veins and stringers of quartz and calcite, most of which have vertical dips. The largest calcite veins are six to eight inches wide, and the winze was sunk on one of these veins. A short drift from the bottom of the winze intersects and follows for twenty feet a quartz vein about one foot wide. The quartz is porous and in places shows distinctly a pseudomorphic replacement of calcite. It is coated with an abundant manganese oxide residue, probably originally contained in the calcite. This material is said to yield gold on panning.

"*C. O. D. Group:* The C. O. D. group consists of several claims on a zone of brecciated red andesite-porphyry which trends about N. 70° W. and crops out in several places along the course of Red Raven Wash. The brecciated zone is from ten to forty feet wide, is partly silicified, and in one place contains a calcite vein three feet wide. A shaft on one of the claims is probably 100 feet deep. The material on the dump consists of silicified andesite fragments, calcite, and gouge, but the tenor of the ore was not learned. Development on other claims of this group consists merely of shallow discovery holes.

"*Claims Southeast of Ocotillo:* On the south and west sides of Red Raven Wash, about seven miles southeast of Ocotillo, are twenty or more claims covering low hills that lie between high mesas to the west and the broad desert plain to the east. These claims are on the outcrops of numerous small brecciated zones and calcite and quartz veins in andesite and associated tuffs. The development work on most of them consists simply of shallow discovery holes and short tunnels, so that little could be learned of the continuity or character of these mineralized zones. The veins trend from northwest to west, and all have southerly dips. Mr. A. R. Gibson has submitted a sketch map of many of the claims surrounding the Big Horn and has indicated localities from which free gold can be panned, but no assays are available.

"*Big Horn Prospect:* The workings of the Big Horn prospect consist of a tunnel 120 feet long which connects with a shaft 35 feet below the collar. The tunnel is driven N. 25° E. and cuts several small shear zones in the andesite porphyry stained with iron and manganese oxides. A shear zone several feet wide, with two inches of slickensided gouge, is exposed in the shaft. The country rock of andesite-porphyry is gray, brown, or purple and contains abundant altered calcic feldspars in a dense groundmass. Fine flake gold is said to have been found in the gouge material from these fissures.

"*Cemitosa Prospect:* The Cemitosa prospect is in Cemitosa Wash, a short distance west of the Cemitosa Tanks. The workings consist of small discovery holes in a brecciated zone of andesite-porphyry ten feet wide. This zone trends N. 50° W., has a vertical dip, and can be traced for 1,500 feet along the westerly slope of a basalt-capped mesa north of the Cemitosa Tanks. The country rock is a reddish to brown andesite-porphyry which apparently grades into the basalt capping of the mesa. The andesite at this point is probably a thin flow overlying granite which is exposed at about the same elevation a short distance west and southwest of the tanks. The brecciated zone is iron-stained and contains numerous stringers of calcite, some of which are one foot wide. Part of the calcite is dark colored and it probably contains manganese. Fine colors of gold may be obtained from parts of this lode by careful panning, but the highest assay in gold reported from this prospect is $3 a ton."

TUNNEL SPRINGS GROUP

The Tunnel Springs or Ramshorn group of two unpatented claims is about ¾ mile west of Tunnel Springs, in the northwestern portion of the S. H. Mountains. It is accessible by 12¾ miles of desert road that branches southeastward from the Quartzsite-Yuma road at a point thirteen miles south of Quartzsite. The principal workings are at an elevation of approximately 3,400 feet above sea level, at the head of a long, broad, westward-trending canyon that is floored by alluvium with a steep gradient. In many places, the sides and head of this canyon are cliffs.

Here, a mass of dark gray andesite-porphyry, intrusive into light-colored tuffs and brown andesites, outcrops with a width of ⅛ to ½ mile and a considerable eastward extent. Above is the cliff-forming, red-brown andesite flow, perhaps 250 feet thick, that caps this part of the range.

As may be suspected from the topography (see Plate 14), considerable fracturing and minor faulting have taken place. The principal jointing strikes N. 35° W. and dips 60° SW., but another system strikes a little north of east and dips 45° S.

These claims are held by Messrs. Beeler, Chapin, and J. V. Smale. In April, 1931, development consisted of several tunnels, winzes, shafts, and shallow cuts. The principal tunnel extends southeastward along a narrow brecciated zone, near the andesite-porphyry, and yields a steady, small flow of water. According to Mr. Smale, this tunnel is 180 feet long, and has a ten-foot winze near its end. Its dump shows some iron-stained calcite. Some 200 feet eastward and about 80 feet higher is a shaft, inclining 45° southward, in the andesite-porphyry. According to Mr. Smale, it is 58 feet deep and has a 54-foot crosscut extending southward. Still farther east is another shallow shaft and several small cuts. A short distance northeast of the main tunnel are two short tunnels.

According to Mr. Smale, the main brecciated zone, marked by the iron-stained calcite, in places pans visible colors of gold and assays a few dollars per ton.

COPPER DEPOSITS IN GRANITE

Copper mineralization occurs in the granite north of Alamo Spring. Jones[135] describes it as follows: "The granite is exposed in an area of low relief in a zone over one mile wide west of the Cemitosa Tanks. Small knolls and mesas on the eroded surface of the granite are composed of quartzose breccias and tuffs and andesites. North of Cemitosa Wash, the mesas are numerous and the area of granite is restricted to narrow belts in the arroyos, and, to the south, the granite is largely concealed by outwash deposits. The shear zone, which trends northwest, marks in a general way the western limit of the granite and probably represents a fault. Along this zone, the granite is hydrothermally altered, and sericite, chlorite, epidote, and a greenish talcose mineral are prominently developed. A sheared basic dike that consists chifly of altered pyroxene occurs in this zone and is associated with the copper mineralization of the Alamo group.

"*Alamo Group:* The Alamo group consists of several claims along the western base of mesas north of a low divide at the head of Cemitosa Wash. The workings are all shallow holes or short drifts which explore the outcrop of the shear zone. Nearly all these workings show copper-stained rock and in some there are small irregular veins and seams of oxidized copper ores containing chrysocolla, malachite, and earthy oxides. The country rock of granite and basic dike rock is highly altered and numerous slip planes are exposed in the workings. The development is insufficient to indicate fully the character of the deposit, and no ore body has yet been found.

"*Alonah Group:* The Alonah group comprises several claims south of the road between the Cemitosa Tanks and Alamo Spring. The relief is low, and the outwash from the mesas to the west conceals much of the granite. The developments consist of shallow holes sunk in the sheared and altered granite, apparently along the same shear zone or fault on which the Alamo group is located. Along this zone, the feldspar of the granite is in places completely sericitized and the ferromagnesian minerals are altered to chlorite and epidote. The mineralization has produced small seams and replacements of the sheared granite by oxidized copper minerals and disseminated magnetite, but the copper content is low. The development is entirely too superficial to show whether an ore body is present."

LEAD DEPOSITS IN MONZONITE-PORPHYRY

A few narrow galena-bearing veins occur in the schist of the southern portion of the S. H. Mountains. Unfortunately, the

[135] Work cited, pp. 163-164.

writer's reconnaissance had to be terminated without investigating these deposits. According to all reports, comparatively little prospecting has been done upon them. Jones[136] mentions one of the occurrences as follows: "A dike of monzonite-porphyry which cuts the pre-Cambrian metamorphic rocks crops out on a small ridge about a mile north of the King of Arizona mine. A short tunnel has been driven along a vein in the intrusive rock near the contact. No work was being done at the time of the writer's visit, and the tunnel could not be entered. The ore consists of a galena disseminated in a gangue of coarse fluorspar and calcite crystals. The tenor of the ore was not learned."

GOLD PLACERS

Many gulches in the southern and northeastern portions of the S. H. Mountains carry placer gold in their gravels, but only one, near Kofa, has been of notable importance. Of these placers, Jones[137] says:

"The known placer deposits of the Kofa Mountains occur in a gulch draining westward north of the detached hills in which the King of Arizona mine is located. These placers have been worked for many years, and the production is reported to be about $40,000 in gold nuggets. At present (1914) the placers are being worked in a small way, and a yearly production of several hundred dollars is reported. The gold occurs in outwash deposits which consist of boulders and fragments from the metamorphic and volcanic rocks. The gold-bearing debris is said to be from a few feet to seventy feet deep over an area of approximately sixty acres. The gold is coarse and occurs near bedrock. It has evidently been derived from the disintegration of auriferous veins in the metamorphic rocks, as it is much coarser than that contained in the North Star and King of Arizona veins."

The reported yearly production of these placers since 1914 is listed on page 122.

[136] Work cited, p. 164

[137] Jones, E. L., Jr., work cited, p. 164. 1916.

PRODUCTION, KOFA DISTRICT
(Data compiled by J. B. Tenney)

Date	Price silver	Ounces silver	Ounces gold	Total value	Remarks
1897-1906	$0.59	66,382	132,764	$2,784,063	Estimated by difference King of Arizona to 1901 King of Arizona and North Star, 1902 to 1906
1907	0.66	4,774 232	12,022 464	251,622 9,774	King of Arizona Golden Star Mining & Milling Co. (North Star)
1908	0.53	6,177	16,151	337,115	King of Arizona Golden Star Mining & Milling Co. (North Star)
1909	0.52	4,700 9,937	11,735 24,491	245,017 511,305	King of Arizona Golden Star Mining & Milling Co. (North Star)
1910	0.54	7,492	15,945	333,590	Golden Star Mining & Milling Co. (North Star)
1911	0.53	2,731	6,099	127,514	Golden Star Mining & Milling Co. (North Star) (Closed August)
Total, 1896-1911		102,425	219,671	$4,600,000	Grand total from Jones Report. Bul. 620, U. S. G. S.
1912	0.615	4,523	9,046	18,996	Lessees and small mines
1913	0.604	54	108	2,274	Placers and small mines
1914	0.553	48	96	2,000	$709 placers. Balance bullion from Independence Mine
1915	0.507	177	354	7,433	Placers and Quartette mine
1916	0.658	166	333	7,000	Lessees on North Star, Quartette, Independence and placers (estimated)
1917	0.824	47	95	2,000	Lessees on North Star (estimated)
1918	1.000	48	95	2,000	Placers and Lessees on North Star (estimated)
1924	0.670	23	47	1,000	Ironwood mine (estimated)
1925	0.694	48	95	2,000	Lessee on North Star (estimated)
1928	0.585	12	24	500	Placers (estimated)
Total		107,571	229,964	$4,645,243	

CHAPTER VI — TANK MOUNTAINS

SITUATION AND ACCESSIBILITY

Separated from the southeastern end of the S. H. Mountains by a low saddle in T. 2 S., R. 15-16 W., the Tank Mountains extend southward to T. 4 S., and eastward into R. 13 W. They are about twenty miles long, from three to seven miles wide, and include an area of approximately 102 square miles. Their name alludes to the several natural rock tanks that they contain. Many local people, however, know the northwestern half of the range as the Frenchman Mountains, and the eastern portion as the Puzzles Mountains.

No one lives in the Tank Mountains, but a few prospectors work in them every year. They depend for their water supply upon artificial cisterns or rather inaccessible rock tanks. As shown by Plate 1, the western and southern margins of this range may be reached by unimproved roads from Palomas and from Middle Well, but the eastern side is accessible only over a few car trails that branch westward from the Palomas-Sheep Tanks road.

TOPOGRAPHY

In their northern portion, the Tank Mountains attain a maximum altitude of approximately 3,200 feet above sea level, or 1,700 feet above the adjacent plains, but most of the range is several hundred feet lower. For the most part, these mountains are steep-sided, flat-topped, and deeply carved by canyon systems, but, in a few places, notably near their ends, they are of gentler contour.

Surface drainage from the Tank Mountains is by numerous arroyos that join axial channels on the adjacent plains and lead to the Gila River.

GEOLOGY

Schists: The oldest rocks exposed in the Tank Mountains are schists that outcrop over a few square miles in the southeastern portion of the range, as shown by Plate 1. These schists strike between west and northwest, dip steeply northward or northeastward, and form low ridges that generally trend with the strike. More than one kind of schist is present, but the most common variety resembles fine-grained, banded arkose. In places, dikes and irregular intrusive masses of dioritic and granitic character are present.

Granite: A narrow mass of coarse biotite granite intrudes the schist near its southeastern margin. In several places where erosion has been sufficiently deep, additional, but comparatively small, granitic masses outcrop from beneath the lavas of the mountains. These granitic rocks range in texture from fine grained to coarse, but have lost many of their original features through alteration.

Mesozoic rocks: The belt of shales, sandstones, and impure limestones that outcrops, as described on pages 107-108, along the southwestern base of the S. H. Mountains, continues for about three miles into the Tank Mountains. On the northeast, it appears to terminate, with relations that were not determined, against the granite of the Engesser area. Elsewhere in the range, it disappears beneath the lavas or is limited by the plains. Its southeasternmost observed outcrop occupies a small, narrow area at the western edge of the range, about a mile south of the Engesser prospect. Detailed mapping may reveal other such areas in these mountains.

These strata are tilted, faulted, and extensively intruded by dikes of diorite-porphyry and rhyolitic porphyry, but show comparatively little metamorphism. Lithologically, they closely resemble the Cretaceous (?) strata of the New Water and Castle Dome mountains.

Tertiary and Quaternary volcanic rocks: Lavas, resting in places upon a moderately rough erosion surface of schist, granite, and Mesozoic rocks, constitute the bulk of the Tank Mountains. No study of these volcanic rocks has been made, but, in general, they appear to correspond to the Tertiary rhyolites, andesites, tuffs, and breccias of the S. H. Mountains, described on pages 108-109.

Basalt, probably of Quaternary age, forms an area of about four square miles at the eastern end of the range. Several smaller areas, as shown by Plate 1, occur both on top of the range and on the neighboring plains, and suggest Quaternary uplift of the mountain mass.

MINERAL DEPOSITS

Some minor gold-bearing, quartz-carbonate veins occur within the granites and schists of the Tank Mountains, and a little copper has been produced from one deposit within the andesites.

The quartz-carbonate veins commonly contain sulphides or oxidized minerals derived from them. In general, they are narrow and lenticular with walls that typically show pronounced sericitization, silicification, and carbonatization. Such mineralogy and wall-rock alteration suggests deposition in the mesothermal zone.

JOHNNIE OR ENGESSER PROSPECT

The Johnnie, or Engesser, prospect, in the northwestern part of the Tank Mountains, is accessible from the railway at Clanton siding by approximately thirty miles of unimproved road. It may also be reached from Kofa by some eight or ten miles of desert trail, but the route is rather difficult to follow.

This ground was located about forty years ago by Mr. Max Engesser who milled, with an arrastre, a little gold from its surface outcrops. Mr. J. F. Nottbusch, of Palomas, has carried on occasional prospecting in the vicinity for the past fifteen years and now holds six claims here.

The principal workings are on a lenticular vein near the southern outcrop of a long mineralized fissure at an elevation of approximately 1,800 feet above sea level. This portion of the range, although of relatively moderate relief, is extensively dissected by shallow steep-sided canyons that drain southward onto the plain. The country rock is granite which shows coarse pinkish phenocrysts of orthoclase, and dark minerals that are largely chloritized. It is cut by dikes of diorite-porphyry and rhyolitic porphyry and, adjacent to veins, is rather intensely altered to sericite and carbonate.

The Engesser vein strikes N. 20° E. and dips 45° W. Its outcrop consists of a few inches to three feet of rather pulverent to solid iron oxide together with some angular quartz, flanked by a like thickness of yellowish jarosite mixed with limonitic material. This quartz pans a little gold. The vein is lenticular along the strike, but the sericitized, silicified fissure zone that it occupies is traceable along the surface northward to several similar, but smaller, lenses of iron oxides and minor quartz. In places, the siliceous portions of the vein-outcrops show numerous bladelike impressions that originally may have been filled with calcite.

When visited in March, 1931, the Engesser workings, according to Mr. J. Ryan, consisted of an old, irregular shaft, which extended for about 300 feet down the dip of the vein, and a few short, irregular drifts. The dump showed large aggregates of granular hematite and magnetite together with small bunches of pyrite and minor chalcopyrite, traversed by radiating threads of quartz and calcite. This magnetite is of the lodestone variety. It and the sulphides are said by Mr. Ryan to have come from depths of ninety to 200 feet.

BLODGETT PROSPECT

The Blodgett prospect, about two miles east of the Engesser, is accessible from there by some four miles of road.

Here, a small area of fissured granitic rock emerges from beneath the lavas that make up the surrounding, rugged mass of the range. This granitic rock, which is rather fine grained, has suffered deep decay so that its exposures now consist of quartz, chlorite, and kaolinized feldspar.

In this vicinity, a little work has been done.upon certain quartz-carbonate veins that show, on panning, a few colors of gold. A shallow cut has been sunk on a narrow quartz-carbonate stringer that is traceable for a short distance in a north-south direction. The quartz, which is of yellowish-white color, is locally honeycombed and contains many small bunches of brown to black iron oxide. Its wall rock, which is somewhat sericitized and silicified, contains numerous small bunches of hematite, chrysocolla, and malachite.

About ⅛ mile farther east, two shafts, fifteen and thirty feet deep, have been sunk on a quartz vein in the granitic rock. This vein, which ranges from a few inches to 1½ feet in width, shows much iron stain and contains a little calcite. Carbonate veins, as much as four feet thick, occur in the vicinity.

GOLDEN HARP CLAIM

The Golden Harp claim, in the eastern foothills of the Tank Mountains, is accessible from Palomas by some sixteen miles of unimproved road.

This ground was located some 35 years ago by a Mr. Morris who milled some of the surface ore with an arrastre. In 1929, it was relocated by Messrs. O. Newbrough and T. Bryden. For a short time during 1930, according to Mr. John Collins, quartz from this vein was run through a small crusher and table, and amalgamated.

Here, low, rounded hills and ridges of schist rise above Palomas Plain. Westward, they give way to rougher topography and, northward, disappear beneath a basalt mesa. In general, these schists are striped and of a brownish color, and they resemble fine-grained arkose. They strike N. 30° W. and dip 80° NE. Several diorite-porphyry dikes up to a few feet in width cut them.

The quartz vein, which appears to have been generally less than two feet wide, strikes N. 25° E. and dips about 80° N. It is lenticular along the strike and is not traceable for more than 75 feet. Some of the quartz is of yellowish color, and in places, it contains abundant iron oxide and chrysocolla.

In March, 1931, workings on this vein consisted of two vertical shafts, about twenty and sixty feet deep, and a short open cut.

RAMEY CLAIM AND PUZZLES AREA

The old Ramey claim is about ¼ mile south of the Golden Harp, at the northeastern edge of the low ridge locally known as the Puzzles Mountains. Exposed on a pediment several feet below a gravel bench is a quartz vein within somewhat foliated chlorite schist and schistose diorite. This vein strikes N. 30° W. and dips 45° NE. It is heavily shattered, and, as exposed in a shallow shaft and open cut, apparently has been cut off by a fault. Its quartz, which is white in color, is heavily stained in places by yellowish limonitic material. Veinlets of ferruginous calcite traverse it along parallel fractures.

Several years ago, according to Mr. John Collins, Mr. Ramey recovered about $500 worth of gold by horning the upper few feet of this vein.

A short distance farther southwest in the Puzzles area, the schists contain several iron-stained quartz stringers that, in the early days, yielded a few small, rich pockets of gold ore, but did not encourage more than shallow workings. Some of the iron-stained outcrops southwest of the Regal contain a little gold.

REGAL PROSPECT

The Regal prospect is about a mile west of the Golden Harp. It was located in the nineties by Mr. E. Becher, who sank an eighty-foot shaft. In 1921, it was relocated by Messrs. E. Becher and John Collins, who formed a corporation and sank another shaft. They also dug a 130-foot well in a near-by sand wash, but found no water.

Banded, silicified, biotite schist is the prevailing rock of this region. It strikes east-northeast, dips steeply north, and, a short distance farther west, passes beneath tuffs and overlying basalts.

The vein at this place consists of the silicified, iron-stained fault breccia that strikes northwestward and dips 45° SW. In places, this silicified material is rather cellular, but it generally forms only thin, lenticular masses. A little gold is said by Mr. Collins to have been produced during the early days from the surface croppings of this vein. The old vertical shaft, approximately eighty feet deep, found no ore. According to Mr. Collins, the newer shaft, sunk in 1922 to a depth of 75 feet, followed the vein for 55 feet and found it to be more than two feet wide in places but to contain only from $2 to $10 in gold per ton.

GOLD PLACERS

Some placer gold has been recovered in the Tank Mountains at various times since the seventies, but no production record or estimate exists.

Probably the earliest and most profitable activity was in the main gulch below the Engesser prospect and, to some extent, in the smaller neighboring gulches. This placer gold doubtless was of local derivation.

Some thirty years ago, active dry washing was carried on in certain shallow gravels of the Puzzles area and also near the Golden Harp, Ramey, and Regal prospects. The gold from the Puzzles region is said by Mr. Collins to have been coarser than that of the localities farther north. Recent production from all these areas has been practically negligible.

CHAPTER VII — NEVERSWEAT RIDGE

SITUATION AND ACCESSIBILITY

A small range, locally known as Neversweat Ridge, is separated from the Tank Mountains by a narrow, alluvium-floored gap in T. 4 S., R. 15 W. It extends southward for five miles, with a width of less than two miles, and includes an area of approximately six square miles.

As shown by Plate 1, the Palomas-Engesser road leads through the northern tip of the range, and several desert trails, from Middle Well and elsewhere, pass near it.

TOPOGRAPHY AND GEOLOGY

Neversweat Ridge rises sharply for several hundred feet from a plain that stands approximately 900 feet above sea level. In general, the slopes of this range are steep and angular, but not very rugged. Northward, it terminates in several low, flat-topped hills.

The prevailing rocks are fine-grained, well-laminated schist and irregular dikes of acid to intermediate composition. Tertiary lavas, similar to those of the Tank Mountains, form the low hills at the northern end.

MINERAL DEPOSITS

NOTTBUSCH OR SILVER PRINCE MINE

Several narrow veins of barite, some of which contain argentiferous galena, outcrop in Neversweat Ridge. The vein at the old Nottbusch or Silver Prince mine, in the schist near the northern tip of the range, occurs within a brecciated fault zone that dips 45° W. Workings on this vein consist of an inclined shaft which, according to Mr. J. F. Nottbusch, is 200 feet deep and connects with a few short drifts and small stopes. The dump shows irregular bunches of medium-grained galena, up to several inches in diameter, within an abundant gangue of crystalline barite and massive gypsum. A little anglesite, cerussite, and red and yellow lead oxide accompany the galena. Mr. Nottbusch states that, in 1912, two cars of sorted ore, which contained approximately 35 percent lead and 35 ounces of silver per ton, were shipped from this mine.

CHAPTER VIII — PALOMAS MOUNTAINS

SITUATION AND ACCESSIBILITY

The Palomas Mountains are from 1½ to 5 miles south of the Tank Mountains and three miles north of the Southern Pacific Railway. Their crescent-shaped area is twelve miles long from east to west, by five miles in maximum width, and includes approximately 42 square miles.

As shown by Plate 1, the Palomas-Engesser route skirts the southwestern margin of the range, and a prospector's road enters it from the southeast. An old route, which is rather difficult to follow, leads around the northern margin. All of these roads are sandy and rough.

TOPOGRAPHY

The Stoval topographic sheet, issued by the U. S. Geological Survey in 1930, includes the southern 2½ miles of the Palomas Mountains. In the southwestern portion of the range, sharp, pinnacled, northwestward-trending ridges rise steeply to a maximum elevation of more than 1,900 feet above sea level, or 1,300 feet above the adjacent plain. The northern and eastern portions consist of deeply dissected, gently northwestward-dipping mesas. A hilly pediment, up to 2¼ miles wide, borders the southern margin.

This range contains no watering places.

GEOLOGY

The Palomas Mountains are made up principally of schist, granite, and volcanic rocks, which outcrop as indicated on Plate 1.

Fine-grained, well-laminated schist forms a small area at the southern base of the range. Examined microscopically in thin section, it is seen to consist of abundant, irregular, elongated grains of quartz, together with smaller, irregular grains of quartz, orthoclase, and albite, and parallel shreds of biotite. This schist dips steeply but, due to faulting, has no constant direction of strike.

Medium-grained, grayish-white granite makes up the rugged southwestern portion of the range. Microscopic examination shows it to be an aggregate of quartz, orthoclase, albite, and semi-chloritized biotite, in crystals up to 0.1 inch in diameter. This albite constitutes approximately half of the feldspars.

Long, thin dikes of intermediate composition intrude the schist and granite.

As shown on Plate 1, a small area of Tertiary lavas, similar to those of the Tank Mountains, occurs near the southwestern corner of the range.

Resting upon the granite and the Tertiary volcanic rocks are a few hundred feet of white tuffs that appear to be younger than the unconsolidated silts of the plain. Several hundred feet of probable Quaternary basalt overlies these tuffs and forms extensive black mesas.

MINERALIZATION

In the south-central portion of the Palomas Mountains, several narrow, silicified, brecciated fault zones in the granite locally contain abundant limonite together with minor amounts of chrysocolla and malachite. In places, this limonite is pseudomorphic after pyrite.

Workings on these mineralized zones include, besides several short tunnels, two thirty-foot shafts on the Charles Engles claims, and two shafts, 50 and 100 feet deep, on the Henry Adams group.

CHAPTER IX — LITTLE HORN MOUNTAINS

SITUATION AND ACCESSIBILITY

Separated from the S. H. or Kofa Mountains by a low, broad saddle in the western part of T. 1 N., R. 15 W., the Little Horn Mountains, as here considered, extend east-southeastward for fourteen miles, with a width of six to ten miles, and comprise an area of approximately 77 square miles.

The Little Horn Mountains contain one small settlement, at the Sheep Tanks mine, in their southwestern portion. As shown by Plate 1, the Palomas-Vicksburg road crosses the western portion of these mountains, by way of Sheep Tanks, and a poor car trail branches southeastward from this road into the north-central section. A desert trail, from Clanton's Well to Ocotillo, skirts their southern edge and the Palomas-Harquahala road lies within two or three miles of their eastern base.

TOPOGRAPHY

The Little Horn Mountains reach a maximum elevation of approximately 3,200 feet above sea level. They consist of mesas surrounding a few smaller areas of more rugged character. The mass as a whole is deeply cut by steep-sided canyons which are generally V-shaped, but, in places, are flat bottomed.

Run-off from the northern side of the Little Horn Mountains joins the axial drainage channel of Ranegras plain which drains northwestward, via Bouse Wash, to the Colorado River. On the southern and eastern sides of the range, many arroyos, from five to ten feet deep, lead southward to the Gila River.

GEOLOGY

Tertiary volcanic rocks: The oldest rocks exposed in the Little Horn Mountains are flows of rhyolite, dacite, and andesite together with intrusive masses of diorite-porphyry. As a rule, their ridge topography and brown, gray, or locally maroon color distinguishes them from the black mesas and white tuffs of the Quaternary volcanic series.

Rocks of this earlier group outcrop, as shown by Plate 1, in the southwestern, central, and southeastern portions of the range, but have been studied only in the southwestern, or Sheep Tanks, district. There (see pages 134-135), these flows make up an apparent thickness of more than 1,000 feet, and outcrop in an area 6½ miles long by 2½ miles wide.

These older volcanic rocks, which are probably of Tertiary age, contain all the known mineral deposits of the Little Horn Mountains.

ner of T. 1 N., R. 15 W. As shown by Plate 1, the Palomas-Vicksburg road leads past the mine. By way of this road, which is rather rough in places, the Santa Fe Railway at Vicksburg is thirty miles north and the Southern Pacific at Hyder is about 35 miles south-southeast.

MINING HISTORY AND PRODUCTION

The first mineral discovery in this vicinity was an argentiferous galena vein upon which Mr. J. G. Wetterhall located the Resolution claim in 1909. During the same year, he located the Resolution No. 1 claim upon the Resolution vein. Other locations were made during succeeding years, but very little work was done until 1926 or 1927 when the Sheep Tanks Mines Company of Nevada opened up part of the Resolution vein. Between late 1928 and October, 1929, the Ibex Mines Company, with Mr. C. M. d'Autremont as manager, operated the mined. Production for 1929[139] amounted to 801 tons of siliceous gold ore of smelting grade which contained 1,303.27 ounces of gold, 12,525 ounces of silver, and a little copper, worth in all about $33,514. This ore was hauled by truck to Vicksburg and Hyder and was shipped by rail to the Hayden smelter. During that year, the property ranked fourteenth in the production of gold in Arizona.

In 1931, the Anozira Mining Company, which later became the Sheep Tanks Consolidated Mining Company, obtained the twelve original claims. This corporation, with Mr. E. Mills as manager, located 115 additional claims, and, during part of 1932, carried on extensive prospecting and development work. Water for all purposes is hauled from wells several miles distant.

TOPOGRAPHY

Here, the mesas of the Little Horn Mountains are interrupted by a northwestward-trending belt, up to about two miles wide, of rough, narrow ridges and peaks that rise to a maximum of about 2,800 feet above sea level, or 1,200 feet above the adjacent plains. The elevation at the camp is approximately 2,000 feet above sea level. From a divide near the mine, canyon systems trend towards the north, east, and south. These canyons, because of their low gradient and open bottoms, are relatively easy routes of access. Most of the mountain slopes here lie from 25° to 35° from horizontal, but many steeper and a few flatter ones obtain. They hold very little talus or soil, and, except along canyon bottoms, are nearly bare of vegetation. These bare slopes are extensively pitted by irregular, shallow caverns.

GEOLOGY

The rocks in the vicinity of the Sheep Tanks mine consist of volcanic flows, breccias, tuffs, and intrusive rocks. As already

[139] U. S. Bureau of Mines, Mineral resources of the United States, part I, p. 827. 1929.

stated on page 131, they are divisible into two distinct series of which only the older, or Tertiary, contains mineral deposits.

TERTIARY VOLCANIC ROCKS

The Tertiary volcanic rocks of this area include rhyolite, dacite, breccia, agglomerate, and diorite-porphyry. This series outcrops, as shown by Plate 1, in a belt that extends, with a width of 2½ miles and a length of 6½ miles, southeastward from the southeastern section of T. 1 N., R. 15 W. The total thickness of these volcanic flows has not been measured or estimated, but it probably amounts to more than 2,000 feet.

Rhyolite: The oldest rocks exposed in the Sheep Tanks district are rhyolite flows that outcrop, as shown by Plate 16, in several neighboring areas, of which the largest is 2,400 feet long by 300 to 1,200 feet wide. These flows have probably been duplicated by faults. Their base has not been found, and the rocks upon which they rest are unknown.

The rhyolite is typically reddish brown on weathered surfaces and light gray on fresh fractures. Locally, hydrothermal solutions have changed its color to dull white or pinkish red. The rock is further distinguished by dense, granular texture, angular fracture, and fine flow-lines. In most exposures, its constituent minerals are too fine grained for identification by unaided eyes. Viewed microscopically in thin section, it is seen to consist of a few small phenocrysts of orthoclase in a dense, microcrystalline, groundmass.

Dacite: Resting unconformably upon the rhyolite is a thick series of pinkish-gray, slabby, dacite flows. They make up the high ridge west of Sheep Tanks camp, and also outcrop, as shown by Plate 16, as a few smaller masses north and south of camp. The stratigraphic relationships of this formation have not been fully worked out. On the Resolution No. 4 claim, it is separated from the underlying rhyolite by one to ten feet of breccia which consists of rhyolite and dacite fragments in a firmly cemented, iron-stained matrix.

Weathered surfaces of the dacite have a pinkish-gray to brown color, locally stained darker by desert varnish. They are marked by conspicuous flow-bands along which the rock tends to split into thin slabs. Freshly broken material shows small, closely spaced crystals of clear feldspar and abundant small flakes of dark minerals, oriented parallel to the flow lines, in a pinkish-gray matrix. Examined microscopically in thin section, the rock is seen to be a dacite. It consists of phenocrysts, up to about 0.05 inch in diameter, of feldspar, quartz, hornblende, and biotite, set in a turbid groundmass containing a few grains of accessory magnetite. Its feldspar is about one-fifth orthoclase and four-fifths andesine-labradorite. The latter commonly forms zoned crystals that are more calcic inward. The orthoclase is generally broken by curved cracks.

Economically, the dacite has been of no importance.

Diorite-porphyry: Intruding the rhyolite and dacite are extensive bodies of diorite-porphyry. As indicated by Plate 16, it forms large, irregular, cross-cutting masses together with sills and a few small dikes.

This rock typically weathers to moderately steep slopes of dull-gray, reddish-brown, or black color. On fresh fracture, it shows phenocrysts of dull-white feldspar, up to 0.25 inch in diameter, embedded in a dense, brownish-gray groundmass, locally stained by iron and manganese oxides. Examined microscopically in thin section, the feldspar phenocrysts are found to be andesine-labradorite, surrounded by a matrix of tiny, lath-like, feldspar crystals and interstitial chlorite derived from original ferromagnesian minerals.

Breccia: Unconformably overlying the rhyolite and diorite-porphyry, and apparently in fault contact with the dacite, are irregular areas of breccia that outcrop as shown on Plate 16. Its maximum thickness is difficult to determine, but probably amounts to less than 200 feet. Throughout, this breccia is rather intensely silicified and stained by iron and manganese oxides. Its basal portion consists largely of angular fragments of rhyolite, from small size to several inches in diameter, cemented by vuggy, fine-grained silica. Upward, the fragments consist largely of shattered, locally silicified material of andesitic composition resembling the diorite-porphyry. Whether this breccia, prior to its cementation, originated from fault movement or from volcanic activity has not been determined. It is the host-rock for the Sheep Tanks gold deposit.

Agglomerate: The next younger formation in this district is an agglomerate that lies unconformably upon the rhyolite, dacite, and diorite-porphyry. This agglomerate outcrops, as shown by Plate 16, in a triangular mass about 1,000 feet wide on the Mongolian claims and in two small masses on the Diplomate claim. Its total thickness is not exposed, but apparently exceeds 100 feet. The rock is made up of generally angular fragments, from a fraction of an inch up to more than a foot in diameter, of dacite, porphyry, and rhyolite, set in a fine, tuffaceous matrix. It is considerably younger than the other Tertiary rocks of this region, but is more indurated and structurally disturbed than are the Quaternary tuffs.

Economically, this agglomerate is of no importance.

QUATERNARY FORMATIONS

As stated on page 132, the Sheep Tanks area are Tertiary formations is surrounded by basalt and tuff of probable Quaternary age. The tuff, which appears within the limits of Plate 16 on the

Red Top and Black Eagle claims, northward passes beneath mesas of olivine basalt. Its contact with the older rocks is an erosion surface that has a relief of 75 or 100 feet.

Except under basalt cliffs, where its slopes may be steep and somewhat mantled by talus, the tuff tends to weather into low dark-gray ridges. It consists of moderately coarse volcanic ash with a considerable percentage of fragments of dacite and diorite-porphyry up to a foot or more in diameter.

The canyon bottoms of this region are mantled by gravel, sand, and talus of local origin.

STRUCTURE

The geologic structure of the Sheep Tanks region could not be analyzed adequately during the short field study made by the writer in 1932. Evidences of complex faulting, regional fracturing, and brecciation are abundant, but are within rocks that generally lack the horizon-markers necessary for a reconstruction of the original framework. No folds, except on a small scale, are recognizable here.

The rhyolite flows generally strike eastward and dip steeply or nearly vertically. Likewise, the flows in the largest mass of dacite strike eastward and dip steeply, but, as shown by Plate 16, this attitude is not constant throughout all exposures of the formation. The attitude of the breccia is not everywhere clear, but it generally strikes eastward and dips from 20° to 75° N. All of the formations have been fractured in several directions, the principal one of which is parallel to the prevailing strike, and at right angles to the dip, of the flows.

The Sheep Tanks region has been affected by faults belonging to at least four different periods of which one preceded the formation of the breccia, one preceded and one accompanied the deposition of the veins, and one was later than the veins. The last faults may belong to the rather late period of block-faulting that affected the whole range.

A fault zone that dips northward at low angles contains the main ore body of the Sheep Tanks mine, but most of the faults and fracture zones that preceded the mineralization strike towards the northwest and dip steeply northeast. Such a zone follows the base of the diorite-porphyry cliff that extends northwestward from camp and lies immediately west of the Sheep Tanks-Vicksburg road. This fault zone is marked by a belt of brecciation, up to fifty feet wide, that is locally cemented and filled by quartz-carbonate veins.

The post-mineral faults of major importance strike eastward and dip northward.

SHEEP TANKS PROPERTY

Resolution vein: The principal gold-bearing vein so far discovered on the Sheep Tanks property occurs on the Resolution claims and outcrops, as indicated by Plate 17, near the top of a ridge immediately south of the camp. This vein occupies a fault zone that dips northward at a low angle and has been offset by later faults.

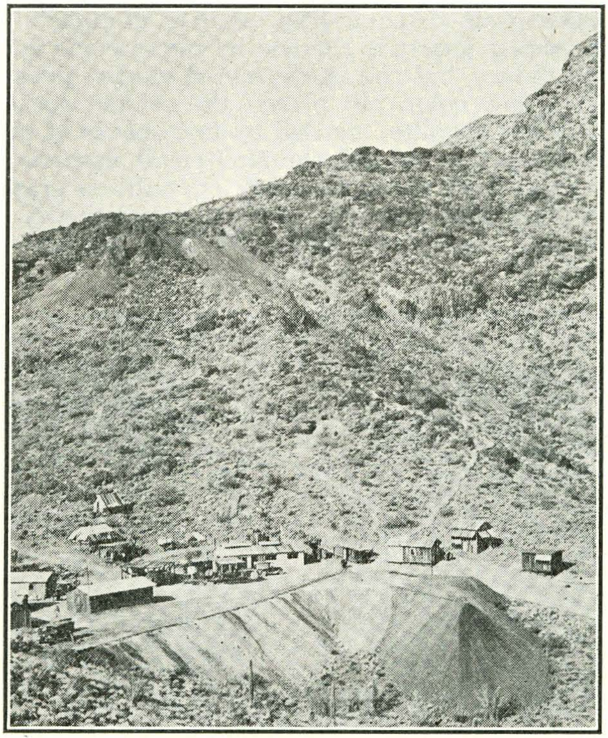


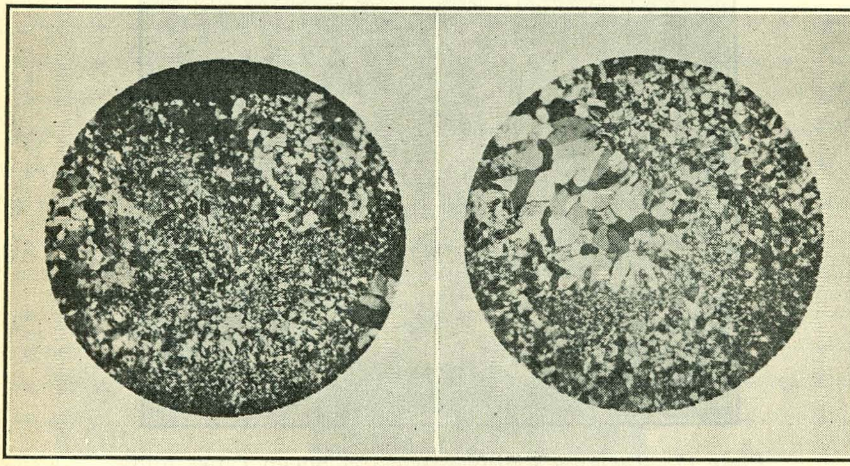
Plate 17.—Looking southwestward at Sheep Tanks mine.

As indicated by surface outcrops and mine workings, the maximum known dimensions of this low-dipping vein are approximately 800 feet from north to south, by 700 feet from east to west. It ranges in thickness from a few inches to about forty feet.

The vein-filling consists of irregular masses and streaks of limonite, pyrolusite, quartz of two periods of deposition, and calcite together with more or less silicified porphyry. In places, irregular, vein-like masses of crystalline barite cut the earlier quartz. All of the Resolution vein contains gold and silver, but the shoot from which the ore shipped was stoped is near the top of its western portion. In the Resolution tunnel, this ore shoot consists mainly of brown and yellow limonitic material, from two to five or more feet thick, together with vein-like masses of pyrolusite and brecciated fragments, up to two feet in diameter, of greenish-yellow quartz. It also contains irregular masses of later dense, grayish-white quartz and crystalline calcite within vugs and fissures. Locally, small veinlets and blebs of chrysocolla and an unknown green copper-lead mineral are present.

Examined microscopically in thin section, the greenish-yellow quartz is seen to consist of a mosaic of microcrystalline quartz, cut by coarser-grained, comb-like veinlets of quartz and adularia. This coarser quartz is clouded by microscopic dendrites of an unknown nature, but the finer-grained quartz gives the mass its greenish-yellow color. In places, the section contains fragments of silicified rhyolite, mottled by fine specks of hematite.

The greenish-yellow quartz contains small fissures and vugs which are lined with dense to finely crystalline, grayish-white quartz, and filled with limonite, pyrolusite, and calcite. Some of the fissures and vugs carry chrysocolla and the green copper-lead mineral.



—Photograph by Robt. E. Heineman.

Plate 18-A—Photomicrograph of thin section of high-grade quartz with adularia—Resolution vein, Sheep Tanks district—Magnified twenty diameters.

B—Photomicrograph of thin section of low-grade quartz from lower tunnel vein, Sheep Tanks district—Magnified twenty diameters.

Part of the gold of the Resolution vein occurs within the massive limonitic material, and some is probably contained in the solid portions of the greenish-yellow quartz, but most of the visible gold forms small, thin flakes in iron-stained fractures and vugs within the later, dense, grayish-white quartz.

Wall-rock alteration along the Resoluton vein consists of intense silicification of the breccia fragments. Some tens of feet away from the vein, the diorite-porphyry has been extensively chloritized and sericitized, but less silicified. This sericite is very fine grained.

Several post-mineral faults, with dips of 35° to 60° N., have cut the Resolution vein. Two of them have stepped its northeastern portion downward for vertical distances of approximately seventy and ninety feet, respectively.

Lower Tunnel vein: Some 345 feet in from the northern portal of the long, lower tunnel, a fault zone in the breccia strikes S. 55° E. and dips 50° NE. As exposed in this drift, it is about four feet thick, but, in the 160-foot raise above, it thickens somewhat. This fault zone shows from a few inches to one foot of rather coarse-grained gouge along its walls, but its brecciated interior has been largely replaced by pyrolusite and limonite together with lenticular and rounded masses of yellowish-green quartz up to a few inches in diameter. Crystalline white calcite occurs in vug-like cavities. Microscopic examination of a thin section of this quartz shows it to be similar to the yellowish-green quartz of the Resolution vein (described on page 138), except that much of it is coarser grained and free of adularia. According to Mr. E. Mills, manager of the property, the vein, as exposed in this raise, contains good gold ore in its upper portion and low-grade material in its lower 82 feet above the drift.

The breccia wall rock adjacent to this vein shows some silicification. Examined microscopically in thin section, the diorite-porphyry of the breccia is seen to have its groundmass largely replaced by yellowish-brown chlorite and its feldspars deeply altered to fine-grained sericite. For some distance along the drift, away from the vein, the breccia contains pyrolusite in fractures and shows abundant voids partly filled with calcite and limonite.

The rhyolite exposed still farther south in this tunnel shows extensive alteration to fine-grained sericite and in places is stained pink or red by limonite.

Smyrna vein: On the Smyrna claim, some 2,500 feet south of camp, a gold-bearing vein occupies a brecciated zone in diorite-porphyry. This zone strikes northeastward, dips from 30° to 40° SE., and has a maximum exposed thickness of four feet. The hanging wall of this vein is marked by a thin streak of coarse-grained gouge. As exposed by a few shallow pits, the vein material consists largely of brecciated porphyry, intermingled with limonite, pyrolusite, and angular to slightly rounded fragments, up to several inches in diameter, of fine-grained, yellowish-green and white quartz, cemented by calcite, manganiferous calcite, and limonite. Some of the quartz is intermingled with fragments of silicified rhyolite that are cemented by silica. According to Mr. Mills, this vein, as exposed, assays a few dollars in gold per ton.

Black Eagle vein: On the Black Eagle claim, some 1,600 feet north of camp, a manganiferous vein occurs along a fault in the breccia. This vein, which is somewhat curved, strikes N. 65° W., dips 45° NE. and is from a few inches to about two feet wide. Near the surface, it consists mainly of fine, silicified breccia, cemented by abundant pyrolusite. Fractures in the breccia, for ten or more feet on both sides of the vein, are marked by limonite and manganese stain. As shown by a tunnel, certain cross-fractures are similarly mineralized. At a distance of about 175 feet in from the mouth of the tunnel, the vein is only a few inches wide and consists mainly of black, manganiferous calcite altering to pyrolusite.

No quartz was seen in this vein, but, according to Mr. Mills, the wall rock in places carries a little gold.

Lead vein: On the Resolution claim, some 800 feet southwest of camp, an argentiferous lead-bearing vein occurs within a minor fault zone in the breccia. As exposed in a short tunnel, this zone strikes S. 15° E. and dips 70° NE., but it flattens downward. The vein, which is two feet wide in places, consists largely of breccia which has been partly replaced by iron and manganese oxides and contains streaks and bunches of calcite, manganiferous calcite, barite, and lead minerals that consist of relatively small kernels of galena partly altered to anglesite, cerussite, and yellowish oxide.

Workings: Workings on the Sheep Tanks property include a tunnel (LT on Plate 16), some 1,450 feet long, that penetrates the ridge south of camp; several hundred feet of branch tunnels and raises from this level; a few hundred feet of workings on levels 170 (T170), 183 (T183), 200 (T200), 237 (T237), and 243 (T243) feet above the long tunnel; some 225 feet of tunnels on the Black Eagle claim; and many short tunnels and shallow pits.

DAVIS PROSPECT

The Davis prospect is five miles east of the Sheep Tanks mine and a short distance north of the road to Palomas. Here, a wide pediment, mantled by surface gravels, shows a few weathered rock outcrops of andesitic composition. During the winter of 1931-1932, prospecting of these outcrops revealed a brecciated zone that contained a few narrow, lenticular, quartz-carbonate stringers that carried some gold, and small limonite-filled pockets that were fairly rich in gold. This quartz, which is of dense texture and pinkish-gray color, contains vugs and cavities lined with white calcite and cut by veinlets of dark, ferruginous calcite.

A shallow inclined shaft, sunk upon this brecciated zone in April, 1932, by the United Verde Extension Mining Company, revealed a few small pockets of rich ore very near the surface. According a Mr. George B. Church, the first twenty feet of depth assayed several dollars in gold per ton, but the lower portion of the shaft ran less than $2 per ton. At the bottom of the shaft, a short crosscut and an inclined winze on the zone failed to find ore. These workings indicate that the brecciated zone strikes about N. 55° W. and dips from 30° to 50° N. Except for a few thin, lenticular, quartz-carbonate stringers at irregular intervals, this zone is marked only by a thin, wavy, gouge streak and local iron stain. Its brecciated andesite walls have been extensively chloritized and carbonatized and show local sericitization.

The discovery of this gold occurrence promoted a mild rush to the vicinity. Many claims were located here during the spring of 1932, but very little work has been done upon them.

ALLISON CLAIMS

About four miles east of the Sheep Tanks mine and about ⅛ mile south of the road to Palomas are some shallow workings upon claims held by Mr. J. V. Allison. Here, a mass of locally shattered and brecciated diorite-porphyry forms low ridges of eastward trend. A lenticular area of silicified breccia contains prominent, nearly vertical fractures that strike eastward and are marked by considerable amounts of limonitic stain.

An old shaft and a few shallow cuts have prospected this brecciated zone. According to Mr. Church, certain portions of the iron-stained, silicified breccia carry a little gold.

PROBABLE ORIGIN OF THE ORES

The veins of this region were originally deposited by hydrothermal solutions which rose along permeable fault zones. Where these solutions reached the breccia on the Resolution claim, they encountered a flat-dipping fault zone with a relatively impervious cover that apparently caused them to spread outward. They deposited chiefly manganiferous calcite, gold-bearing quartz of two generations, certain iron and copper minerals, and minor galena and barite. The iron and copper minerals were probably sulphides and may have been auriferous. More or less brecciation of the veins occurred before this deposition was completed. The mineralogy, texture, and wall-rock alteration of these veins clearly indicate that they belong to the epithermal type of deposits.

Subsequent uplift and erosion removed parts of the veins, and oxidized the portions now exposed. The large amount of manganese present in the outcrops, the richness of the ore near the surface, and the mineralogical features of the visible free gold (described on page 138) suggest that some supergene enrichment of the gold may have taken place within the brecciated zones.

CHAPTER X — CEMETERY RIDGE

SITUATION AND ACCESSIBILITY

The low range known as Cemetery Ridge is in Ts. 1 N. and 1 S., Rs. 11 and 12 W., near the northeastern corner of the area mapped on Plate 1. This mass trends northwestward for an interrupted length of sixteen miles, with a breadth of less than two miles, and includes about 25 square miles.

As shown by Plate 1, the Palomas-Harquahala road is near the western margin of the range, and the Phoenix-Clanton's Well road leads past its southeastern tip.

TOPOGRAPHY

Most of Cemetery Ridge rises with rather gentle slopes to less than 200 feet above the plain, but Nottbusch Butte, in the southeastern portion, is several hundred feet higher. The northern portion of the range is sharp-crested and contains a few short, rugged canyons.

The only watering place in this vicinity is Clanton's Well, three miles south of Cemetery Ridge. Deadman Tank, a shallow pothole in agglomerate at the western foot of the ridge and just west of the road at a point ten miles north of this well, contains water during wet seasons.

GEOLOGY

The principal formations of Cemetery Ridge, as seen during the brief visit that was made by the writer in 1931, are schist, granite, rhyolite-porphyry, hornblendite, and volcanic flows.

The schist, which outcrops prominently along the western margin of the range, is mainly a fine-grained, laminated aggregate of quartz, biotite, and sericite. Its strike, although somewhat irregular, is mainly northwest, and its dip steep. Medium-grained, gray granite intrudes the schist and forms a few small, weathered outcrops of low relief. Intruding both the schist and granite are numerous dikes of gray rhyolite porphyry and granite porphyry, and fewer dikes of hornblendite. Thick, extensive, rhyolitic to basaltic flows and tuffs, such as those of Nottbusch Butte, overlie these formations.

MINERAL DEPOSITS

Cemetery Ridge contains a few low-grade deposits of copper, gold, manganese, and actinolite asbestos, which have received a little attention from prospectors.

Collins copper prospect: These six claims, held by Messrs. J. J. Collins and C. Johnson, are four miles north of Clanton's Well. Here, a small area of schist is intruded by rhyolite porphyry and an irregular dike of hornblendite. This dike, which ranges up to about sixty feet wide but pinches out in several places along its irregular strike, consists mainly of coarsely crystalline hornblende, marked by numerous spots and irregular veinlets of secondary quartz. Many fractures and minor faults cut the rock. In places, they contain a few thin veinlets of chalcopyrite which, near the surface, has been largely altered to chrysocolla, malachite, and iron oxide. According to Mr. Collins, a little gold accompanies these oxidized minerals. Near these veinlets, the dike has been rather strongly epidotized.

Workings on this prospect consist of two shallow shafts, approximately 1,200 feet apart, and a few surface cuts.

Red Bird gold prospect: On the Red Bird claim, about two miles west of the Collins prospect, a fault that strikes N. 60° W., and dips 45° W. separates granite, with included schist masses, from rhyolite porphyry. In places, it is marked by iron-stained gouge and breccia, up to ten feet wide. In 1909, Messrs. J. J. Collins and F. E. Walker sank a 100-foot shaft on this brecciated zone, and found it to contain less than $4 in gold per ton.[140]

Adams gold prospect: The Adams prospect is near the crest of the ridge, east of Deadman Tank. Here, a northwestward-trending dike of fine-grained granite porphyry, about eighty feet wide, is cut by a fault that strikes northeast, and dips steeply northwest. An iron-stained, brecciated zone, four feet thick, accompanies this fault and contains abundant brecciated, coarse-grained, vitreous quartz together with earthy hematite. In places, the granite porphyry is silicified and marked by copper stain.

Workings on this vein consist of a shallow shaft which, according to Mr. Collins, showed it to contain a little gold.

Manganese prospects: On the flat west of Cemetery Ridge and southeast of Deadman Tank, several short, flat-dipping, manganiferous veins in volcanic breccia outcrop from beneath a mantle of gravels. These veins range from nearly pure pyrolusite to about one-half brecciated, chalcedonic quartz. The purest veins range from a few inches to about one foot thick, but the more siliceous ones in places are ten feet thick and form outcrops 100 feet long by fifty feet wide.

Only a few shallow cuts have been made on these veins.

Actinolite asbestos: East of Deadman Tank, asbestiform actinolite occurs where the schist has been intruded by irregular greenish-black, mottled dikes. Microscopic examination of these dikes shows them to consist largely of coarsely crystalline actinolite, partly altered to chlorite, and numerous veinlets and small irregular masses of magnetite.

The asbestiform actinolite occurs near these dikes, in veins that, as exposed by shallow cuts, are from a few inches up to one foot wide. The fiber, which is long, fine, and very brittle, has no present commercial value.

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[140] Oral communication from Mr. Collins.

CHAPTER XI — GILA BEND MOUNTAINS

SITUATION AND ACCESSIBILITY

The Gila Bend Mountains constitute a large range that lies mostly in Maricopa County but also extends, within T. 2 S., for a distance of 6¼ miles into Yuma County, to the pass that separates it from the Clanton Hills. In this county, the range has a maximum width of four miles and an area of approximately 28 square miles. Many people know this mass as the Nottbusch Mountains.

During 1931, several prospectors were working in the Gila Bend Mountains, but the only permanent inhabitant of the vicinity is the cattle man who stays at Clanton Well, near the northwestern tip of the range.

As shown by Plate 1, the Phoenix-Clanton Well road skirts the northern edge of these mountains, and joins the Palomas-Harquahala road.

TOPOGRAPHY

The Gila Bend Mountains rise gradually eastward to approximately 2,000 feet above sea level, or 800 feet above the adjacent plains. On the south, their slopes are steep, but, towards the north, become gentle. The central portion of the range is characterized by massive, blocky, topographic forms. Run-off from this portion of the Gila Bend Mountains is towards the Gila River.

GEOLOGY

The oldest rocks exposed in the Gila Bend Mountains of Yuma County are schists that outcrop as a strip from one to two miles wide along the northern margin of the range. Where seen by the writer, these schists are characterized by strong lamination, steep dip, and variable strike which tends to parallel the principal ridges. Over much of the area, they consist essentially of fine-grained quartz, sericite, and chlorite, but, in places, chert-banded, gray limestone predominates. Wherever prospect holes penetrate, this schist is seen to be extensively sheared and faulted. From the evidence now available, its age can not be told, but it is tentatively regarded as pre-Cambrian.

Many dikes, of andesitic to granitic composition, and a few large masses of granite cut the schists. Most of these dikes are believed to be of Mesozoic and Tertiary ages.

Overlying the schist is cherty gray limestone, with minor gray to buff sandstone, which outcrops near the western end of the range. This limestone, which is particularly marked by round concretions, less than an inch wide, doubtless represents a continuation of like material occurring in the Clanton Hills. Ross[141] regarded the latter as Tertiary. These beds have been faulted and tilted to a minor extent. In places, they are cut by andesitic dikes. ?

Resting upon these sedimentary rocks is a thick series of Tertiary lavas which contain abundant yellowish-brown tuffs and andesites and forms the main mass of the range.

MINERAL DEPOSITS

The Gila Bend Mountains of Yuma County contain several gold-bearing quartz veins and minor lead and copper mineralization.

BILL TAFT GROUP

The Bill Taft prospect, on a group of about twelve claims held by Mr. A. B. Moore, is in the north-central part of this range. It is accessible by about two miles of road that branches southward from the Clanton Well-Phoenix road at a point some four miles east of Clanton Well. Hanley Tank, about ¾ mile south of the property, furnishes its domestic water supply.

One of these claims was located in 1909 and the remainder of the group about twenty years later. Only a little surface gold ore has been mined from this vicinity.

A short distance west of this prospect, the moderately rounded schist hills of this portion of the range pass under steep-sloped volcanic rocks. In general, the schist stands nearly vertical and strikes approximately N. 60° E., but considerable local irregularity of structure is evident. Andesitic dikes, ten to fifty or more feet wide, strike S. 80° E. and southeast. Several brecciated zones, up to a few feet wide and traceable for as much as 200 feet, strike parallel to the dikes.

In March, 1931, the Bill Taft shaft, which inclines about 20° W., was 150 feet deep and had about 25 feet of drifting at the bottom. These workings show many iron-stained fractures along the larger of which a little gold occurs. The schist is deeply oxidized and marked by a few spots of copper stain. According to Mr. J. A. Moore, the gold-bearing material was richest within fifteen feet of the surface, but lower down, did not horn more than a few dollars per ton.

About 300 feet N. 20° W. from the Bill Taft workings, a small tongue of weathered, greenish, granitic rock cuts the schist. It contains a small lense of quartz that trends southeastward and shows considerable staining by limonite and some by copper carbonate. Mr. H. H. Hanley is reported by Mr. Moore to have shipped several sacks of rich gold ore from this vein in 1910.

A short distance farther southwest, an eighteen-foot shaft fol-

[141] Ross, C. P., The lower Gila region, Arizona: U. S. Geol. Survey Water-Supply Paper 498, p. 23. 1923.

lows a small quartz lense that dips southwestward. The dump shows abundant iron oxide.

On the Little Jane claim, about 3/8 mile east of the Bill Taft workings, a quartz vein strikes east and dips 20° S. Its wall rock is heavily stained with sericitic, brown hematite. The vein, which is one foot or so thick, consists of white quartz, shattered in somewhat parallel directions. Many streaks of iron oxide and thin veinlets of gray calcite traverse this quartz. It is said by Mr. Moore to have contained visible, coarse gold near the surface.

The Lucky Strike claim is about two miles N. 60° E. from the Bill Taft, near a prominent wash. Here, a large tongue of fine-grained, granitic rock has invaded the schist. It shows very marked alteration of its feldspar and mica and, near the vein, contains considerable amounts of specularite in disseminations, streaks, and bunches. The vein is about two feet wide, strikes northeast, and, at the surface, dips 80° NW. At a depth of 25 feet in a vertical shaft, the vein steepens and thickens for a short distance. It is said by Mr. Moore to have shown good gold values only at that depth. About 200 feet west of this shaft, a little copper stain appears in the granite.

BELLE MACKEEVER GROUP

The Belle MacKeever group of five claims is less than 1/2 mile northwest of the Bill Taft shaft. This group, which was located early in 1931 by Messrs. Chas. Davis, C. LaMar, and H. Ammeter, is on the southern slope of a ridge that marks the outcrop of a thick, andesitic dike. This slope, which is somewhat mantled by talus, appears to be underlain by rather foliated schist. Through careful prospecting of the talus, Mr. Davis found a silicified, gold-bearing zone that, as exposed by a few shallow cuts in March, 1931, strikes slightly north of east, dips 50° N., and is about 2 1/2 feet wide. It is made up of bunches or lenses of quartz alternating with streaks, up to a few inches thick, of brown and black iron oxide. Its wall rock contains considerable sericite, quartz, and chlorite. Some of the vein quartz shows banding, but much of it is cellular and abundantly stained with iron oxide. Horning of a small sample of this quartz revealed several coarse colors of gold, and according to Mr. Davis, portions of it assayed from $40 to $139 per ton. At the time of the writer's visit, the length of this vein beneath the talus had not been explored.

YELLOW BREAST PROSPECT

The Yellow Breast prospect is about 3/4 mile northeast of the Bill Taft workings. Here, a gravel-mantled pediment locally exposes calcareous schist that strikes S. 30° W., dips nearly 90°, and is marked with chert bands up to 1/4 inch wide. A fault zone that strikes and dips with the schist contains a vein, about five feet wide, of brecciated, iron-stained, dull-brown quartz. Two vertical shafts, about 45 feet deep, show that this vein contains a few irregular bunches of galena, partly altered to anglesite and cerussite, in a gangue of pale-green crystalline fluorite. A little wulfenite and yellow lead oxide occur within fractures and small cavities in the quartz.

CAMP CREEK PROSPECT

The Camp Creek prospect, held by Mr. J. M. Owens, is on the King of the West claim, beside the Phoenix-Clanton Well road at a point one mile west of the Maricopa County boundary. In this vicinity, a rolling, dissected pediment that extends north from the Gila Bend Mountains exposes a small area of gray silicified schist, intruded by many irregular dikes of granite-porphyry. This schist is cut by numerous fractures that strike eastward and dip nearly 90°. At the surface, one of the fracture zones has a width of fifteen feet and contains abundant siliceous hematite and limonite together with small veinlets and specks of chrysocolla and malachite. According to Mr. J. A. Moore, it also contains a little free gold.

Workings on this group consist of two 100-foot vertical shafts, about fifty feet apart, with drifts on the thirty and ninety-foot levels. The thirty-foot level shows two fracture zones, each about one foot thick, which contain chiefly limonite and a little copper stain.

CHAPTER XII — MOHAWK MOUNTAINS

SITUATION AND ACCESSIBILITY

Beginning at a point near the Gila River in R. 15 W., the Mohawk Mountains extend southeastward for a length of 29 miles, with a width of ½ to 3 miles, and include an area of approximately 45 square miles. In the early days, they were known as the Big Horn Mountains.

As shown by Plate 1, the Southern Pacific Railway and U. S. Highway 80 lead through a pass at Mohawk Station, in the northern portion of the range. A rough, sandy road to Papago Well skirts the western margin of the mountains, and a branch from it, leading through a gap near their southern end, connects with the Stoval-San Cristobal Valley road.

The sole population of the Mohawk Mountains centers about Mohawk station. Water is hauled to this place by the railroad because the mountains themselves contain no wells and almost no rock tanks or water holes.

TOPOGRAPHY

The Mohawk, Norton, and Kim topographic sheets, issued by the U. S. Geological Survey in 1928, 1929, and 1931, respectively, show in detail the topography of the northern and southern portions of the Mohawk Mountains, but no detailed topographic maps of their middle segment exist.

This range rises steeply to elevations of more than 2,000 feet above sea level, or 1,500 feet above the adjacent plains. Its crest is sharp and jagged, particularly in the northern portion (see Plate 19). Its slopes, which are generally steeper on the western side, are dissected by deep, rugged canyons that commonly trend northeastward and southwestward. An alluvium-floored pass, 1½ miles wide, separates the southern one-third of the range from the northern portion. Further topographic details are summarized by Bryan,[142] as follows:

"A narrow mountain pediment surrounds the mountains. During its formation, a number of hills were detached from the main mass, and these now fringe the mountain border. Such isolated hills are the one just south of Mohawk station (on the west side) and one near the Red Cross mine, on the east side of the mountains. The mountain pediment, like others of the region, is dissected, as is well shown by the pass at Mohawk where steep-walled trenches cut twenty to thirty feet deep along the streams are in marked contrast to the smooth curves of the old valleys that connect with and form part of this pediment. Along the

[142] Bryan, Kirk, The Papago country, Arizona: U. S. Geol. Survey Water-Supply Paper 499, p. 193. 1925.