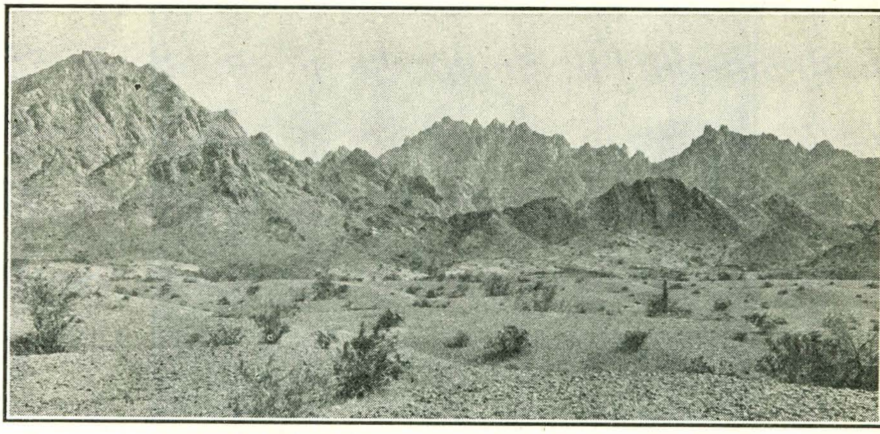

Plate 19—Northern end of Mohawk Mountains—Rock is Tertiary (?) sandstone, conglomerate, and shale—Pebble-mantled plain in foreground.

west side of the Mohawk Mountains, erosion and dissection of the mountain pediment is retarded by drifting sand. The sand, swept forward by westerly winds, mantles the east side of the valley and reaches up to the very foot of the mountains."

GEOLOGY

The Mohawk Mountains are composed largely of schist, gneiss, and granite, tentatively regarded as pre-Cambrian to Mesozoic in age, and sedimentary rocks of probable Tertiary age.

Schists: The schists, which make up a large portion of the range, bear a strong field resemblance to the schists of the Gila Mountains. Most of their exposures consist of coarsely laminated, medium to fine-grained aggregates of quartz, feldspar, hornblende, and biotite with locally sericitic phases and appear to be, in large part, of sedimentary origin. In the southern portion of the range, an exceptional, but prominent, phase of the schist is fine-grained arkose that shows faint stratification. Examined microscopically in thin section, it is seen to consist of an interlocking mosaic of microcline, orthoclase, and elongated quartz grains with a little interstitial limonite.

In general, the schists strike parallel to the trend of the range and dip from 30° to 45° NE., but locally they have been considerably displaced by faults.

Gneiss: In places, particularly in the vicinity of Mohawk and northward, the schists give way to dark-gray gneiss of granitic texture. It consists largely of quartz, feldspar, biotite, and hornblende and apparently represents a metamorphosed granite. On Plate 1, this formation is not distinguished from the schists.

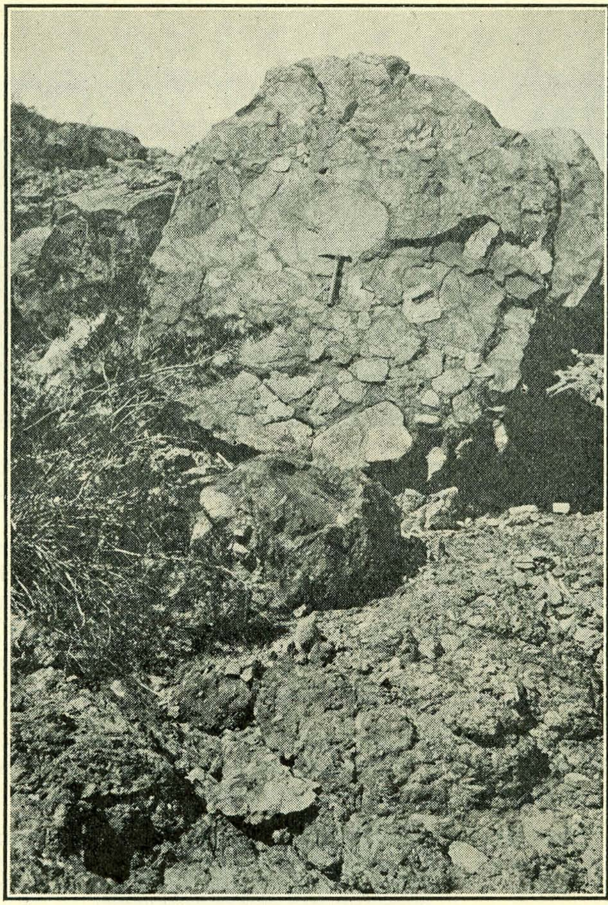

Plate 20.—Tertiary (?) conglomerate in northern portion of Mohawk Mountains.

Granite: Intruding the schists in the southern portion of the range are large masses of well-jointed, medium-grained, light-gray granite that resembles the granites of the Copper and Pinta Mountains.

Dike rocks: In places, dikes of granite porphyry, aplite, and pegmatite intrude the schist, gneiss, and granite. A prominent dike of the granite porphyry cuts southward across the pass east of Mohawk.

Sedimentary rocks: Capping the northwestern portion of the Mohawk Mountains and forming very sharp pinnacles and ridges is a thick series of unmetamorphosed reddish-brown sedimentary rocks that are lithologically identical with the probable Tertiary strata of the Baker Peaks, Antelope Hill, and Northern Copper Mountains. This series is made up of poorly stratified conglomerate which grades upward into well-stratified sandstone and shale. Its bedding, in general, strikes with the trend of the range and dips from 45° to nearly 90° SW.

The conglomeratic member consists mainly of rounded to subangular boulders of gneiss and granite, from a few inches to two feet in diameter, in a firmly cemented, arkosic matrix (see Plate 20). It has an apparent thickness of well over 1,000 feet, but some duplication by faulting is probable.

At the northern end of the range, the conglomerate rather abruptly gives way to thin-bedded shale and sandstone in which the following section was measured:

Section at northern end of Mohawk Mountains

Conglomerate

	Thickness in feet
1. Sandy red shale containing a few pebbles	5
2. Sandy gray shale	10
3. Coarse-grained grayish-red sandstone	2
4. Like 3 but more conglomeratic	8
5. Coarse-grained dull-brown sandstone, containing several conglomerate lenses	25
6. Hard gray arkose with conglomerate pebbles less than one foot in diameter	6
7. Like 5, but redder and containing finer pebbles	25
8. Gray arkose	3
9. Like 7	2
10. Like 8	3
11. Thin-bedded maroon shale	45
12. Gray arkose	55
13. Thin-bedded red shale	10
14. Thin-bedded red shale, alternating with a few bands of gray arkose	225
15. Fine-grained gray arkose	8
16. Like 14	175
17. Fine-grained conglomerate	20
18. Like 14	50
19. Fine-grained reddish-brown arkose	15

Section continues essentially like 14 for approximately 400 feet, to where it is cut by a fault.

MINERAL DEPOSITS

Silver and barite veins of economic importance, and minor mineralization of gold, copper, lead, and molybdenum have been found in the Mohawk Mountains. The barite and the silver-bearing veins appear to be of epithermal character. The copper occurs as malachite and chrysocolla at the Red Cross mine and also stains quartz veins that locally carry a little gold. Small amounts of wulfenite have been found within vuggy quartz veins in the southeastern portion of the range.

RED CROSS OR NORTON MINE

The Red Cross or Norton mine is at the eastern foot of the Mohawk Mountains, about 5½ miles from Mohawk station. In 1930, the road to the mine could be reached by passing under a railway trestle 1½ miles west of Stoval and continuing for some 3½ miles southwestward.

This mine was formerly held by Mr. G. W. Norton. In 1910, according to local press reports, it produced one car of silver ore worth $10,000. In 1913, it yielded a small tonnage of sulphide lead ore and siliceous silver ore.

Here, a hill, rising about 150 feet above the dissected pediment, is made up of schist that prevailingly strikes N. 25° E. and dips 20° SE., but has been locally displaced by faulting. It is cut by an irregular dike of white, fine-grained granite porphyry that has a maximum width of three feet and shows many small spots of iron stain.

A curving fault zone that, near its northwestern end, strikes N. 65° W. and dips from 60° to 80° SW., contains the vein. The richest portion of this vein was limited to the northwestern 150 feet of its length, beyond which it passes beneath surface gravels. Unmined remnants of this part of the vein consist of limonite, breccia, and gouge, cut by veinlets of malachite, chrysocolla, and calcite, and containing irregular bodies of gypsum and copper-stained, crystalline calcite. No silver minerals were seen. The vein is traceable for several hundred feet farther east as a silicified, iron-stained, brecciated zone up to three feet wide. Its schist walls show abundant sericitization and silicification together with iron-staining along fractures.

Workings on the Red Cross vein consist of five or six shallow shafts and several surface cuts.

BARITE MINE

A group of nine claims, held by Messrs. Jas. Renner and Chas. Sam, is located on baritic veins that outcrop a short distance northwest of Mohawk. According to Mr. Renner, these claims were located in 1902 by Mr. G. W. Norton, but little work was done on them until 1929 and 1930 when the present owners and their lessees mined and shipped about eighteen carloads of barite from one of the veins. The costs per ton, as reported by Mr. Renner, amounted to about $1.25 for mining and $3.85 for shipping to Los Angeles.

In this vicinity, low, rounded hills of dark-gray, granitic gneiss rise above the gravel-mantled pediment at the western base of the Mohawk Mountains. This gneiss is cut by a few narrow, branching dikes of granite porphyry, many thin brown veins of ankerite, and a few veins of barite.

The principal barite vein occurs within a fault zone that strikes S. 70° E. and dips 80° SW. This vein, which is traceable for a length of several thousand feet, is mostly less than two feet thick, but in one place it swells to a thickness of seven feet. All of the barite shipped was mined from an open cut on the widest portion. In this cut, which was 25 feet long by twenty feet deep, the vein widened from a maximum of four feet at the surface to seven feet at the bottom. The barite occurs as white to pink radiating crystals, up to several inches in diameter, within masses of crystalline manganiferous calcite and white calcite of a later generation. The walls are bordered by irregular layers, up to several inches thick, of pale-blue chlorite and intermingled calcite. According to Mr. Renner, this chlorite carries a little silver.

A few narrow veins branch from the main vein. About 200 feet south of the open cut, one of these branch veins attains a width of ten inches.

RUBY PROSPECT

The Ruby claim, held in 1930 by Mr. W. G. Reed, is about four miles north of Mohawk, near the eastern foot of the range.

Here, eastward-trending arroyos have cut through a detrital mantle and exposed a pediment of granitic gneiss with lamination which strikes northwestward and dips about 45° E. A vertical shaft sunk through the gravel and into the gneiss contained water at a depth of approximately seventy feet. Its dump contains a minor amount of granular, vitreous, gray quartz, with fractures lined with sericite, limonite, and small amounts of malachite.

Some 300 feet farther northeast, a quartz vein that strikes northwestward and is seventy feet thick in places, outcrops as a low, sharp ridge. This quartz, which is similar to that on the shaft dump, is extensively shattered. Some of the fractures contain a little iron stain and traces of malachite.

TAVASCI OR VICTORIA PROSPECT

A prospect owned by Mr. G. E. Tavasci is on the western slope of the Mohawk Mountains, about six miles by road south of Mohawk.

Here, coarse-grained biotite schist strikes southeast, dips 30° NE., and is cut by a few dikes of aplite and pegmatite. More than 300 feet of tunnel, driven by Mr. Tavasci during the past 35 years, extends eastward along a steeply southward-dipping fault zone. This zone contains a vein, up to ten or more feet wide, of limonite, breccia, and scattered bunches of quartz. The quartz, which is dense, vitreous, and brecciated, contains limonite and calcite within fractures and cavities. According to Mr. Tavasci, the quartzose portions of the vein carry a little gold.

LIME QUARRY

An old lime quarry, with two small adobe furnaces is a short distance northwest of Mohawk. According to Mr. Jas. Renner, this quarry was operated for a short time, prior to 1911, to furnish lime for the King of Arizona cyanide plant.

The topography and geology of this locality have been described on page 152. A lenticular mass of fine-grained, arkosic, biotite schist in the gneiss contains a bed of white to gray banded marble that strikes east, dips 30° N., and is about six feet thick. Near the hanging wall, it contains lenticular veinlets of quartz and manganiferous calcite.

CHAPTER XIII — BRYAN MOUNTAINS

SITUATION AND ACCESSIBILITY

This name is applied to Bryan's [143] "unnamed range" that extends southeastward from an alluvium-floored gap at the southeastern termination of the Mohawk Mountains.

As shown by Plate 1, the Bryan Mountains extend southeastward for eighteen miles, to a point near the Pima County boundary, and continue westward, in a hook about four miles long, to within two miles of the Pinta Mountains. They are from one-eighth of a mile to four miles wide and include an area of approximately 45 square miles. As shown by Plate 1, roads from Mohawk and Stoval to Papago Well skirt both margins of the range and are linked by a road through the gap at its northern end.

These mountains are occasionally visited by prospectors and hunters, but are waterless and uninhabited.

TOPOGRAPHY

The eastern margin of the Bryan Mountains is remarkably linear in plan and steep in profile, but the western side is raggedly indented by deep canyons which lie between sharp westward-trending ridges. The northern segment of the range, which is eight miles long by a maximum of four miles wide, rises to an elevation of approximately 2,000 feet above sea level, or 1,400 feet above the adjacent plains. The southern portion consists of several segments, up to 1½ miles wide, separated by narrow, alluvium-floored gaps through which sand-choked arroyos from the Pinta Mountains extend. Southward, these segments decrease in elevation and size. The southwestern hook consists of low hills rising above a well-developed rock floor, or pediment.

The plains bordering the range are mantled with packed, wind-blown sand, and the northward-trending, axial drainage channel east of the Granite Mountains is bordered by a narrow belt of sand dunes.

GEOLOGY

The Bryan Mountains are made up of schist and granite, intruded by dikes of aplite and pegmatite.

The schist, which outcrops only in the southern portion of the range, weathers gray to black in color, and bears a strong field resemblance to the schists of the Mohawk and Gila mountains. In general, it consists of distinctly laminated aggregates of fine-

[143] Bryan, Kirk, The Papago country, Arizona: U. S. Geol. Survey Water-Supply Paper 499, p. 193. 1925.

grained quartz, together with more or less abundant feldspar, hornblende, and biotite. Microscopic examination of a typical specimen from the southwestern portion shows fine-grained layers of quartz and sparse feldspar, separated by scattered shreds of biotite and muscovite in a turbid aggregate of quartz and sericite. In general, the schist strikes parallel to the trend of the range and dips 30° or more northeast, but local variations due to faulting occur.

Medium-grained, grayish-white granite, generally similar to the granites of the Mohawk and Pinta mountains, intrudes the schist and constitutes most of the range. It is sheeted by several systems of joints, the principal one of which strikes S. 10° W. and dips about 45° SE.

Irregular, branching dikes of aplite and pegmatite cut the schist and granite in several directions.

MINERALIZATION

The principal mineralization noted in the Bryan Mountains consists of copper and iron stains in pegmatite dikes and in narrow veins of glassy quartz. The veins locally contain crystalline epidote and blebs of magnetite, and their walls show strong sericitization.

These quartz veins are relatively plentiful in the northeastern portion of the range. At a point some 100 feet above the plain on the eastern side and about 1½ miles from the northwestern end, an irregular, inclined shaft has been sunk for about 75 feet on a vein that strikes northwest and dips 40° SE. This vein consists of shattered, locally vuggy, glassy quartz, together with minor amounts of brown, ferruginous calcite. Malachite and hematite are present in fractures and irregular cavities, but the copper stain becomes notably less at a depth of fifteen feet. Many smaller quartz veins, which cut the granite of this vicinity in various directions, locally show mineralization of similar character.

CHAPTER XIV — SIERRA PINTA

SITUATION AND ACCESSIBILITY

The Sierra Pinta extends N. 40° W. for 27 miles from the narrow, alluvial gap that divides it from the O'Neill Hills. It has a width of generally less than 3½ miles and embraces an area of approximately 51 square miles. The name Pinta alludes to the contrast, strikingly visible for many miles, between the blackish schists of the southern, and the grayish-white granite of the northern, portions of the range.

The uninhabited Sierra Pinta is occasionally entered by hunters and prospectors. As shown by Plate 1, a branch from the Mohawk-Papago Well road leads to the eastern side of the Sierra Pinta. Two dim trails lead northward from the Camino del Diablo to Heart Tank, in the central part of the range. This watering place, which is described on page 158, was used by the early Spanish padres who travelled the Camino del Diablo. From Heart Tank, a road extends westward to the Cabeza Prieta Mountains, and northwestward to Wellton, but much of it was difficult to travel in August, 1931.

Plate 21.—Heart Tank, Sierra Pinta, in August, 1931—Rock is granite.

TOPOGRAPHY

The Sierra Pinta rises very steeply to a maximum elevation of approximately 2,700 feet above sea level, or 2,000 feet above the adjacent plains. Its sharp, rugged crest is highest in the southern and middle portions and generally lowest in the northern half. Its margins are sharply indented by a great many V-shaped canyons that separate sharp, faceted spurs. The lower slopes of the range are steepest, and hanging valleys locally occur about 400 feet above the base.

The only reliable source of water in this range is Heart Tank which lies in a canyon on the western slope of the middle portion of the range, at an elevation of approximately 1,250 feet above sea level, or 250 feet above the plain. This canyon is below the highest peak north of the schist contact. Like many other canyons on the western side of the range, it trends about S. 55° W., but, near its mouth, swerves several degrees southward. The tank, which is a heart-shaped pot hole about seven feet deep by ten feet long (see Plate 21) is fed by water that trickles over a prominent, dark-stained cliff. It is accessible from the plain by about ½ miles of trail that follows up the canyon. Car trails from the Cabeza Prieta Mountains on the west and from the Camino del Diablo on the south lead to the foot of the range at this point, but they are rather difficult to follow.

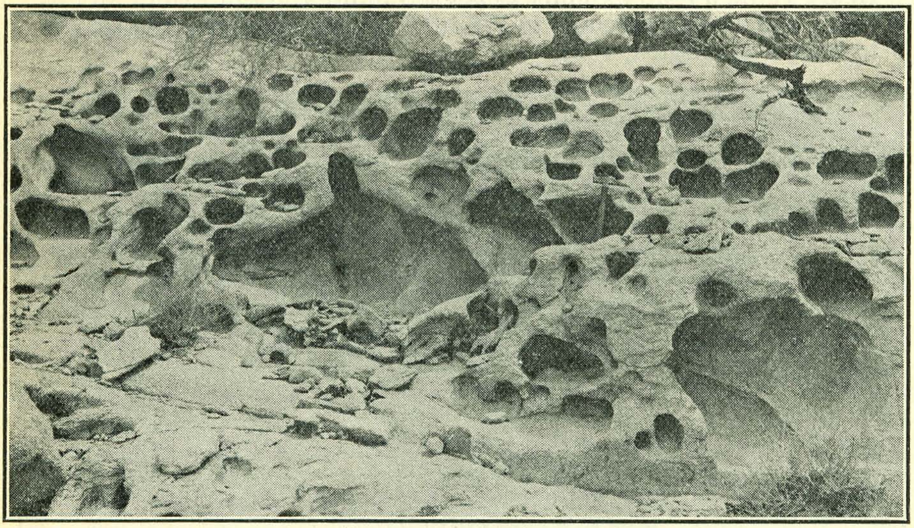

Plate 22.—Niches in granite near Heart Tank, Sierra Pinta.

GEOLOGY

As shown by Plate 1, the Sierra Pinta is made up of schist and granite.

The schist, which forms the southern ten miles of the range, bears a marked resemblance to the schists of the other mountains of this region. In the vicinity of the granite contact, it consists of a finely granular aggregate of quartz, feldspar, and biotite, arranged in layers that are about 0.15 inch thick and alternate with thinner bands of flaky biotite. A few lenses of pink feldspar, up to 0.5 inch long, are present. Examined microscopically in thin section, the finer-grained portion of the rock is seen to be made up of quartz, orthoclase, microcline, albite, and biotite. Some small, irregular masses of magnetite are present. The quartz, which constitutes fully half of the rock, is interlocked with the other minerals. Such phases of the schist might be either of sedimentary or igneous origin.

Uniform white granite intrudes the schist and makes up the northern seventeen miles of the range. Its constituent minerals are generally less than 0.2 inch in diameter, but some of its feldspars are several times that size. Relatively little biotite or other dark minerals are present. Examined microscopically in thin section, this rock is seen to be practically identical with the granite of the Copper Mountains, described on page 165. In places, the granite is marked by a lace-like development of shallow caverns and niches, as shown in Plate 22.

Locally, irregular dikes of pegmatite and aplite cut the granite. Together with dikes of granite porphyry, they are conspicuous in the schist immediately south of the granite contact.

Several systems of joints have extensively sheeted the rocks of the Sierra Pinta. The principal one of these systems strikes parallel to the trend of the range and dips about 40° SW., but another prominent one strikes across the range and dips 40° NW.

MINERALIZATION

Narrow, irregular veins of coarse-grained, vitreous, white quartz occur in the Sierra Pinta, particularly in the vicinity of the schist-granite contact where they are more or less closely associated with pegmatite dikes. Commonly, these veins contain hematite and limonite in fractures and box-work cavities. In places, quartz veinlets that cut pegmatites contain small masses of magnetite and kernels of chalcocite altering to malachite.

CHAPTER XV—TULE MOUNTAINS

SITUATION AND ACCESSIBILITY

The Tule Mountains lie south of the Cabeza Prieta range from which they are separated by the broad, low pass that contains the Camino del Diablo. They are mostly in Mexico, but extend for four miles into Arizona, with a length, between monuments 183 and 188, of fourteen miles, and an area of approximately 29 square miles. Their name was probably derived from Tule Tank, which is near their northern end, in the Cabeza Prieta Mountains. The Mexican portion of the range is called the Sierra de Tuseral. No one lives in the Tule Mountains, but several car trails lead southward from the Camino del Diablo to certain prospects and tanks in the range.

TOPOGRAPHY

The Tule Mountains consist mainly of a series of west-northwestward-trending ridges, dissected by many V-shaped canyons that drain to the Lechuguilla and Tule deserts. Near the international boundary, these ridges rise to more than 3,000 feet above sea level, or 2,000 feet above the adjacent plains, but are higher in Mexico.

The topography of this area has been aptly described in the report of the Boundary Commission as follows:[144]

"The Sierra del Tule, the Sierra Lechuguilla, and the Sierra de las Tinajas Altas present to the eye much the same general appearance. . . . They are bare, desolate, rough, and jagged to an unusual degree, and so steep that in many places it is impossible to climb to the summit, while in most places it is both arduous and dangerous; and, when the jagged, knife-like crest is finally reached, it often proves to be so narrow that it is impossible either to walk along it or set up an instrument there. . . . The scaling of a new ridge or peak sometimes occupied an entire day."

At the northwestern corner of the range, a gently westward-dipping lava mesa, some five miles wide, extends for three miles north of the international boundary.

GEOLOGY

The Tule Mountains are made up of schist and granite intruded by dikes of aplite and pegmatite, and overlain, along the northwestern margin, by flows of basalt.

Very little geologic study of these formations has been made.

[144] Internat. Boundary Comm., report upon the survey and remarking of the boundary between the United States and Mexico west of the Rio Grande, 1891-1896: 55th Cong., 2d sess., S. Doc. 247, pp. 24 and 120. 1898.

In the northern portion of the range, the prevailing rock is granite which resembles that of the Cabeza Prieta Mountains. It intrudes a few relatively small areas of well-laminated schist that consists mainly of quartz and biotite, with phases of nearly pure, flakv biotite.

MINERALIZATION

Certain fissure zones in the schist of the Tule Mountains show minor amounts of copper mineralization.

Venegas prospect: The Venegas prospect is accessible by ½ mile of trail from the end of 2½ miles of road that leads southward from the Camino del Diablo near Tule Tank. Here, the schist strikes southeast, dips steeply northeast, and is intruded by dikes of aplite and pegmatite. The mineralized zone, which outcrops along the crest of a southeastward-trending ridge some 500 feet above the plain, is marked by a belt, several feet wide, of coarse-grained sericite, stained yellow and brown by limonite. It contains a little disseminated pyrite and abundant masses of black to brown limonite. In places, small bunches of gypsum and calcite, surrounded by layers of brochantite, are present. Workings on this prospect consist of several surface cuts, a shallow shaft, and a few short tunnels.

CHAPTER XVI — CABEZA PRIETA MOUNTAINS

SITUATION AND ACCESSIBILITY

The Cabeza Prieta Mountains, which divide the Lechuguilla and Tule deserts, extend northwestward from the Tule Mountains to an alluvial gap, 3½ miles across, that separates them from the Copper Mountains. They are 22 miles long by a maximum of ten miles wide and include approximately 128 square miles. Their name (Spanish for "black head") alludes to a prominent lava-capped peak near the center of the range.

The Cabeza Prieta Mountains are uninhabited. As shown by Plate 1, the Camino del Diablo follows their southern margin, the Wellton-Tule Well road passes through their western fringe, and the Wellton-Heart Tank route leads along their northeastern margin. The two latter roads are connected by a rough, sandy route that extends through the narrow central portion of the range and passes near Cabeza Prieta Tanks. An old road, leading northwestward from Tule Well, was impassable for automobiles in 1931.

TOPOGRAPHY

The Cabeza Prieta Mountains are made up of numerous ridges and peaks together with tilted, dissected mesas. The ridges, which generally trend northwestward, rise very steeply to maximum elevations of about 2,500 feet above sea level, or 1,500 feet above the adjacent plains. Buck Peak, the highest point, is in the northern portion of the range where the topography is particularly rugged. As indicated by Plate 1, several alluvium-floored valleys extend far into the range, isolating many ridges and masses of various sizes.

Except in the driest seasons, water is obtainable at Tule Tank, about ¼ mile north of the Camino del Diablo, and at Cabeza Prieta Tanks, in the northeastern portion of the range. Tule Well, beside the road three miles east of Tule Tank, always contained drinkable, but rather salty, water.

GEOLOGY

As indicated on Plate 1, the Cabeza Prieta Mountains consist of schist, granite, and volcanic rocks.

The schist, which outcrops in the northern portion of the range, resembles in a general way the schists of the Mohawk and Gila mountains. It strikes across the range, dips 60° or more north, and forms steep, rugged, black slopes. Intruding it are large, irregular masses of granite similar to the granite of the Copper Mountains, described on page 165.

Many dikes of aplite and pegmatite cut the granite and schist, particularly in the northern portion of the range.

Resting upon the roughly eroded surface of the granite is a series of volcanic rocks, 1,000 or more feet thick and probably of Tertiary age. Locally, as in the vicinity of Tule Well, a thickness of more than 100 feet of conglomerate and agglomerate is exposed at the base of the series. The flows overlying the agglomerate are dark brown in color and prevailingly of andesitic composition. According to Lord,[145] the andesite from this locality, when examined microscopically in thin section, is seen to consist of phenocrysts of acid labradorite, hornblende, and biotite, in a groundmass of finely felted hornblende and plagioclase.

Basalt flows, up to a few hundred feet in maximum thickness, rest upon the granite and form a few elevated, scattered mesas, as indicated by Plate 1. This basalt, which resembles that of the Tule Mountains, is believed to be of Quaternary age.

STRUCTURE

The elevated basalt mesas indicate that the Cabeza Prieta Mountains are a fault block that underwent a few hundred feet of upheaval in Quaternary time. The andesitic lavas, which generally strike northwest and dip from 25° to 40° NE., have been cut by many strike faults of relatively small throw and by a few transverse faults. Several systems of jointing are apparent in the older rocks, particularly the granite. The most prominent two of these systems strike parallel and transverse, respectively, to the trend of the major ridges and dip nearly vertically. These joints delimit spalls, some of which can be seen forming at the present time, greatly accentuating the steepness of the slopes.

MINERALIZATION

In the northern portion of the Cabeza Prieta Mountains, many long, irregular dikes of aplite and pegmatite cut the granite. Many of them are marked by copper and iron stains derived from chrysocolla, malachite, and limonite which occur in narrow fractures and small cavities. Some of the pegmatites contain small books of black mica. At the McMillan prospect, in the northern tip of the range, several shallow workings have followed narrow fissure zones that occur in or adjacent to such dikes and show the same type of mineralization.

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[145] Lord, E. C., Petrographic report on rocks from the United States-Mexico boundary: U. S. Natl. Museum, Proc., vol. 21, No. 1173, p. 779. 1899.

CHAPTER XVII — COPPER MOUNTAINS

SITUATION AND ACCESSIBILITY

The Copper Mountains extend southward in R. 17 W., from Baker Tanks to the alluvial gap at the northwestern end of the Cabeza Prieta Mountains. They have a length of thirteen miles, a maximum width of six miles, and an area of approximately 49 square miles. The name of these mountains alludes to their numerous showings of copper stain.

The population of the Copper Mountains is limited to one or two prospectors who spend a large part of each year there.

As shown by Plate 1, the Wellton-Tule Well road follows the southwestern margin of these mountains, and a branch road leads eastward to several prospects. The Wellton-Heart Tank route borders their northeastern edge, and various branches lead to prospects in the east-central portion of the range.

TOPOGRAPHY

The Mohawk and Wellton topographic sheets, issued by the U. S. Geological Survey in 1928 and 1929, cover all but the southern six miles of the Copper Mountains.

In the vicinity of Baker Tanks, where a broad, rock-cut pass marks the southern termination of Baker Peaks, the Copper Mountains are three or four miles wide and consist of numerous buttes separated into several ridges by northward-flowing washes. At the pass, these buttes are about 600 feet above sea level, or 150 feet above the adjacent plains, but southward they are increasingly higher. The easternmost, best-defined ridge is separated from its neighbors by an alluvium-floored valley nearly a mile wide. Six miles south of Baker Tanks, the head of this valley joins that of a narrower, but similar, valley of west-northwest trend, as shown on Plate 1. South of this point, the main mass of the Copper Mountains rises steeply for 1,900 feet or to 2,808 feet above sea level. It is mostly single crested, but is deeply and sharply dissected by laterally trending canyon systems. Its topography, although greatly resembling that of the Gila Range, ten miles farther west, is less steeply rugged.

Run-off from the eastern slopes of the Copper Mountains travels in numerous northeastward-trending washes directly to the Gila River. That from the western slopes travels to Coyote Wash and the Gila River.

GEOLOGY

The Copper Mountains are made up of gneiss, granite, pegmatites, and indurated conglomerate. The age of these formations is unknown, but the conglomerate is regarded as Tertiary and the other rocks as pre-Cambrian to Mesozoic.

Granitic biotite gneiss forms a belt about two miles wide across the middle of the range, as shown by Plate 1. In places, schistose, hornblendic phases prevail. The gneiss is intruded by large, irregular bodies of aplite and pegmatite, and contains many stringers and veins of copper-stained quartz.

As indicated on Plate I, granite constitutes the southern half of the Copper Mountains. It weathers light brown, but, on fresh fracture, is grayish white, speckled with abundant, small flakes of biotite. Examined microscopically in thin section, this granite is seen to be of a sodic variety made up of crystals of quartz, orthoclase, microcline, and albite, together with scattered plates of biotite. The individual crystals range up to 0.2 inch in diameter, but are mostly less than 0.1 inch. The albite, which constitutes less than half of the total feldspars, is locally sericitized. Some accessory magnetite is present.

The aplite dikes in places appear to grade into pegmatites. Some of the latter are up to fifteen or more feet thick and many of them contain large books of black biotite mica.

Indurated conglomerate forms the low, hilly ridges at the northern end of the Copper Mountains and continues to the foot of Baker Peaks. This material, which appears to be of local origin, consists mainly of granite and gneiss pebbles or boulders embedded in a minor amount of weakly cemented sand. These fragments range from less than one foot up to twelve or more feet in diameter and are coarsest towards the south, near their contact with the gneiss. Most of the pebbles are slightly rounded, but the boulders have only their corners worn off. The matrix is of arkosic composition and contains abundant dark minerals. In places, it shows some cross bedding. The conglomerate as a whole is poorly stratified and, from a short distance, might easily be mistaken for weathered gneiss.

STRUCTURE

In the Copper Mountains, the strike of the gneiss ranges from S. 65° E. to N., and the dip from 30° NE to 20° E.

The granite shows two prominent systems of jointing, one which strikes southwestward, with nearly vertical dip, and the other southeastward, with a dip of 50° NE.

The conglomerate, where stratified, shows considerable variation in structure. In places, it lies flat, but, towards its southwestern limit, strikes northwestward and dips 30° SW.

MINERAL DEPOSITS

The Copper Mountains contain many quartz veins that, near the surface, are more or less copper and iron stained. They commonly contain irregular bunches of chrysocolla, iron oxide, and limonite, together with minor amounts of malachite, gypsum, and jarosite. A little supergene or secondary chalcocite occurs in the northern portion of the area, but no hypogene or primary sulphides are exposed in the workings. The original presence of hypogene iron and copper sulphides is indicated by the oxidation products. In places, visible free gold occurs in the quartz.

The vein walls are strongly sericitized and silicified, and, in places, lined with biotite. The field association of these veins and the pegmatite dikes suggest the possibility that they are genetically connected with a common magma. The texture, mineralogy, and wall-rock alteration of the veins indicate deposition in the mesothermal zone.

BETTY LEE OR ARIZONA CONSOLIDATED GROUP

The Betty Lee group of twenty claims, now owned by Messrs. Swenson, Copple, and McIntosh, includes part of the old Arizona Consolidated Mining Company's ground. This property, which is nineteen miles from Wellton, is accessible by some seven miles of road that branches southward from the Wellton-Heart Tank road at a point 1⅛ miles south of T. 9 S. According to Mr. G. Swenson, of Wellton, the Arizona Consolidated Mining Company shipped, in 1913, a little gold-copper ore carrying $12.50 in gold per ton.

The principal workings are at an elevation of 1,300 feet above sea level, in the bottom of a steep-sided, northeastward-trending canyon. A quartz vein, up to four feet wide in places, occupies a fissure that strikes S. 52° E., dips nearly 90°, and is traceable on both sides of the canyon nearly to the ridge tops. Near the surface, this vein consists of coarsely crystalline, vitreous, translucent, grayish-white quartz, separated into bands, less than ¼ inch wide, by fractures lined with reddish-brown iron oxide and coarse sericite. The whole contains bunches of admixed sericite, and, in places, masses of hard hematite, up to several inches across, that are veined and coated with massive chrysocolla and subordinate crystalline malachite. A few veinlets, up to 1/10 inch thick, of crystalline calcite cut the quartz. The copper stain fades out into the vein walls which are lined with abundant, dark mica and are considerably silicified and sericitized.

The principal workings on this claim include a shaft that, according to Mr. Swenson, is 700 feet deep and connects with about 2,000 feet of workings on seven levels. Some 100 feet northwest of the shaft and about sixty feet higher, a tunnel follows the vein for approximately 100 feet. A tunnel about 100 feet lower cuts through the shaft, and explores the vein for some distance beyond. Here, the vein widens to about four feet, its copper stain is restricted to spots, and its iron stain is less prominent than in the higher workings.

Surface equipment on this property includes a gasoline hoist, an assay office, and several buildings. A pothole in the canyon was developed into a cistern.

SMITH CLAIMS

The Smith group of eight claims is along the western foot of the Copper Mountains, about eighteen miles from Wellton, by way of the Tule Well road. These claims were formerly worked by Messrs. Pedstel and Everhardy, but are now held by Mr. C. A. Smith, of Wellton. A few tons of gold ore have been shipped from this ground.

Here, the granite is extensively jointed and contains a few small pegmatite dikes. A brecciated zone strikes S. 33° E., dips 60° E., and is up to three feet wide. On the surface, it is traceable northward from the alluvium for about 100 feet. It contains brecciated, coarse-grained, vitreous, grayish quartz, intermingled with coarse sericite. This material contains small, irregular bunches of chrysocolla, copper pitch, and hematite. In places large masses of brown, black, and yellow iron hydroxides, together with some gypsum and jarosite, are abundant. The zone as a whole is marked by iron-stained fractures.

Some short drifts and shallow winzes on this zone have cut several small pockets of quartz that shows finely divided gold.

OTHER PROSPECTS

In the granite-walled canyon about one mile southeast of the Betty Lee mine, several prospects follow narrow quartz veins that are mineralogically similar to the Betty Lee vein. Some of them contain irregular cavities, up to more than an inch across, filled with sericitic iron oxide of black to yellow color. In places, these ferruginous masses are coated with botryoidal chrysocolla, which in turn is crusted with mammillary, transparent, purplish silica of supergene origin.

At the western foot of the gneiss spur about two miles north of the Betty Lee mine, some shallow workings have been made on quartz veins in gneiss. These veins show more or less limonite and copper stain, but have not been found to carry much gold.

Some four miles farther north in the gneiss, immediately east of a sharp bend of the road, a shallow shaft has been sunk on a steeply eastward-dipping pegmatite dike that has a width of about four feet and is cut by irregular veins of vitreous, translucent, white quartz. This quartz is broken by many fractures, some of which are lined with chrysocolla and iron oxide. In places, it contains irregularly rounded kernels, up to an inch in diameter, of chalcocite. Microscopic examination of polished sections of this chalcocite shows it to be weakly anisotropic and locally surrounded by a narrow border of covellite. The copper and iron minerals are more or less altered to malachite and limonite that stain the adjacent rock. Coarse-grained sericite usually lines the walls of the quartz veinlets.

About 1/8 mile east of this shaft, a nearly vertical quartz vein, up to two feet thick, occurs along the upper contact of a pegmatite dike that dips 40° E. and has a width here of fifteen feet. A shallow cut on this vein shows it to contain irregular masses of chrysocolla, iron oxide, and black mica.

CHAPTER XVIII — BAKER PEAKS

9s-17w

SITUATION AND ACCESSIBILITY

The Baker Peaks comprise an area of about five square miles in R. 17 W., four miles south of the Gila River. As shown by Plate 1, a road from Wellton leads through the low pass in the pediment that separates them from the Copper Mountains. A windmill and the series of stream potholes known as Baker Tanks [146] are just north of this road, at the southwestern margin of the range.

TOPOGRAPHY

The Wellton and Mohawk Topographic sheets, issued by the U. S. Geological Survey in 1928 and 1929, include the Baker Peaks. This small range, which rises steeply to a maximum elevation of 1,416 feet above sea level, or 1,000 feet above the adjacent plains, is characterized by angular, pyramid-shaped peaks. A rock-cut pediment, more than one mile wide on the south but rather closely limited by wind-blown sand on the other sides, surrounds the range.

GEOLOGY

The Baker Peaks are made up of well-stratified arkosic sandstone and conglomerate of probable Tertiary age. This sandstone, which grades in texture from fine to coarse, consists mainly of angular to poorly rounded fragments of quartz, feldspar, and biotite. Round to subangular pebbles and boulders of gneiss and granite, from one inch up to four feet in diameter, are erratically distributed within the arkosic sandstone, and, particularly near the southern margin of the area, form beds of conglomerate. In places, thin-bedded, sandy, clay-shale members are present. Bryan [147] has described exposures at Baker Tanks as follows: "The Baker Tanks are a group of potholes and plunge pools in a stream channel along the southwestern flank of Baker Peaks. By headward erosion, the stream is cutting a canyon about thirty feet deep and 100 feet wide in a plain developed on pinkish-red conglomerate. Near the tanks, the conglomerate strikes N. 77° W. and dips 65° SW. The rock is massive but much broken by joints, many of which show slickensides. Along the joints dehydration has taken place, and there is much variation in color. The beds are mostly an aggregate of quartz and feldspar grains from one-eighth to one-half inch in diameter. Where the finer material predominates, the beds show lamination and cross-bedding. Boulders from three inches to three feet in diameter lie scattered in this matrix. Near the lower tanks are two beds made up almost wholly of boulders."

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[146] For a detailed description of Baker Tanks, see Bryan, work cited, pp. 127-129.

[147] Bryan, Kirk, work cited, p. 62.

The freshness of the feldspar and biotite indicates that they were derived from a granitic land mass under arid conditions. The rounded pebbles and boulders point to long transportation by water, but the more angular ones may be of local derivation. This formation is doubtless equivalent to the probable Tertiary beds exposed in the northern portion of the Mohawk Mountains and in Antelope Hill.

These beds have been considerably affected by faulting, which is reflected by changes in strike and dip.

Mineral deposits are unknown in Baker Peaks, but certain portions of the arkosic sandstone could be used for building stone.

CHAPTER XIX — ANTELOPE HILL AREA

Antelope Hill, on the southern bank of the Gila River, north of Baker Peaks, is one mile long by ½ mile wide, and rises steeply to an elevation of 500 feet above the plain. It is composed of gently southward-dipping beds of coarse-grained, gray, arkosic sandstone. This material has been quarried for railway foundation-rock.

Three-fourths mile farther northeast, north of the Gila River, similar material forms a small hill, about fifty feet high, which also has been quarried to some extent.

Some 2¼ miles southwest of Antelope Hill and 1¾ miles west of Tacna, two small hills of this arkosic sandstone rise about 125 feet above the plain. The material of the southern hill, which is just north of the highway and railroad, has been described by Bryan[148] as follows: "The strike is N. 35° W. and the dip 15° SW. The beds of sandstone range from five to twenty feet in thickness and, as exposed in an abandoned quarry on the east side of the hill, are fairly uniform for short distances. Coarse sandstone of quartz, feldspar, and biotite mica, with lenses of small pebbles, is the common rock, but pebbles over three inches in diameter were not found. The color is slightly darker than that of the rocks at Baker Tanks and more uniform. Concentration of iron oxide at the surface forms a dark-red crust. Weathering produces many small pits and miniature caves at the surface." Upon quarrying, this rock breaks well, both along and across the bedding. In places, some thin, lenticular, shaly beds, which show poor resistance to weathering, are present.

Holm, p. 38, correlates with Camelback fm of Maricopa Co. Also Baker Peaks, + Mohawk Mtns.

[148] Work cited, p. 63.

CHAPTER XX — WELLTON HILLS (LA POSA DISTRICT)

SITUATION AND TOPOGRAPHY

Bryan[149] says: "The Wellton Hills, a disconnected group of small mountains, occupy the Lechuguilla Desert at its north end . . . . . . six miles south of the town from which they are named. They divide the Lechuguilla Desert from the valley of Gila River, though the drainage from the desert finds its way through them to the Gila." This run-off flows via Coyote Wash, whose wide, shallow, braided channel, originating south of the international boundary, sometimes carries floods of incredible size.

Two prospectors were living in the Wellton Hills during 1931. As shown by Plate 1, three roads to Wellton lead through, or near, this range.

The Wellton topographic sheet, issued by the U. S. Geological Survey in 1929, includes the Wellton Hills. Regarding the topography of this range, Bryan continues: "The hills occupy an area about six miles in diameter over which they are scattered singly or in groups. Many of them are buttes, but the largest hilly area, which lies west of the road between Tinajas Altas and Wellton, is more than three miles long. The hills rise (to 1195 feet above sea level, or) from fifty to 500 feet above the flat-bottomed valleys that pass between them. . . . . . . The Wellton Hills appear to be the remnants of a complexly faulted elevated area which erosion has reduced to isolated hills. Between the hills are smooth plains cut on rocks which correspond in age to the other mountain pediments of the region. This pediment, however, is largely covered with alluvium brought down by streams from the south."

GEOLOGY

The Wellton Hills are made up of gneiss and minor amounts of schist, cut by scattered dikes of granite porphyry and pegmatite.

This gneiss, aside from a pronounced banding of its constituent minerals, has much the texture of a fine-grained biotite granite. Its principal layering for the most part strikes northwestward, parallel to the general trend of the range, and dips strongly northeastward, but a strong system of jointing dips in the opposite direction, and weaker systems strike transversely. As proclaimed by structural discordances and brecciated zones, a considerable number of faults have affected this formation.

The schist occurs only as small masses included with the gneiss. It is prevailingly dark gray, well laminated, and fine grained. Its major constituents are quartz and biotite, either aggregated or in bands. Feldspathic phases are rare in this rock.

[149] Bryan, Kirk, The Papago country, Arizona: U. S. Geol. Survey Water-Supply Paper 499, pp. 196-197. 1925.

MINERAL DEPOSITS

The Wellton Hills, or La Posa district, contains many low grade gold-quartz veins within brecciated fault zones that predominantly strike between N. 35° W. and W., and dip from 10° to 85° N. or NE. The quartz of these veins is coarsely crystalline, weakly banded, and locally vuggy. It characteristically shows abundant iron oxide together with minor chrysocolla and malachite in irregular bunches or fracture-linings. Brown, crystalline, ferruginous calcite occurs in a like fashion, but more commonly fills the vugs. No sulphides were observed, but the texture and mineralogic composition of the veins indicates that iron and copper sulphides were originally present and have been destroyed by oxidation.

The dominant wall-rock alteration accompanying these veins consists of intense sericitization with less marked silicification and carbonatization. Such alteration along veins of this type indicates deposition in the higher temperature portion of the mesothermal zone.

Certain veins of the Wellton Hills are spectacularly marked with copper stain which extends for a short distance into the wall rock. In places, this copper-stained gneiss carries visible specks of free gold. These features, combined with easy accessibility, have, during the last half century, prompted rather active prospecting throughout the area, but very little commercial ore has thus far been developed. Most of the vein exposures and workings are on slopes or saddles rather than on the pediments.

DOUBLE EAGLE OR GOLD LEAF MINE

The Double Eagle or Gold Leaf prospect, owned by the Arizona Dougle Eagle Corporation, is at the southern end of the Wellton Hills, near the west bank of Coyote Wash. It is accessible from the railway at Wellton by nine miles of desert road. According to Mr. K. B. McMahan, of Yuma, this ground was originally located about fifty years ago by Mr. N. Wanamaker.

Here, the gneiss, which strikes westward and dips at a low angle southward, has been broken by several faults. The most prominent of these faults strikes westward, dips 57° N., and is accompanied by a shattered brecciated zone, six feet across, that locally shows abundant sericitic alteration and marked staining by iron and copper.

The main Double Eagle vein occurs within the footwall portion of this brecciated zone. Near the surface, it consists of 1½ feet of fractured, coarsely crystalline, white quartz, filled with abundant cellular cavities that range from small specks up to an inch or more in size. These fractures and cavities are commonly filled with black or brown iron oxide.

In May, 1931, workings upon the main vein consisted of a shaft, said by Mr. McMahan to be 100 feet deep, and a short adit tunnel. Several hundred feet farther northwest, a fifty-foot tunnel explores a somewhat similar zone that strikes N. 70° W. and dips 30° NE. Here, however, the quartz vein is thinner, the gouge is finer grained, and the walls show less copper stain. Still farther northwest, several shallow shafts and short tunnels have been sunk on small veins that occur within minor brecciated zones.

The U. S. Geological Survey Mineral Resources for 1909 record from La Posa district a 23-ton test shipment containing $1,364 of gold, 23 ounces of silver, and 133 pounds of copper, in all worth $1,393. This ore is stated by local people to have come from the upper forty feet of the Double Eagle vein. In June, 1931, approximately 200 sacks of vein material were in storage on the surface.

POORMAN OR DESERT DWARF PROSPECT

The Poorman, formerly the Desert Dwarf, prospect is at the northeastern end of the Wellton Hills. The Wellton-Tule Well road passes it at a distance of six miles from Wellton. This property consists of two claims that were located in 1897 and are now held by Messrs. J. Ryan and G. Swenson.

Here, the gneiss is rather massive and weathers dark gray. It is intruded by a few narrow aplitic dikes, and has been considerably affected by faulting. A 1½-foot vein, made up of about equal proportions of quartz, gouge, and breccia, occupies a nearly vertical fault zone that strikes N. 56° W. In places, the quartz is banded and streaked by brown and black iron oxide. It is said by Mr. Ryan to carry about $4 or $5 in gold per ton, with a few pockets of higher grade.

Development on this vein includes three old shafts. According to Mr. Ryan, they are 50, 100, and 230 feet deep, and the deepest one, which was sunk in 1902, has about 90 feet of tunnels on its 100-foot level.

DRAGHI PROSPECT

The Draghi prospect is one mile from the southwestern end of the Wellton Hills and ¾ mile north of the Wellton-Tinajas Altas road.

Here, fine-grained, banded, biotite gneiss strikes NW., dips 40° SW., and is cut by a few narrow aplitic dikes. A prominent fault zone, marked by a maximum of about eight feet of breccia and gouge, strikes N. 35 ° W., dips 10° to 40° NE., and contains an irregular quartz vein. This zone has been followed by two tunnels, vertically about fifty feet apart, the upper one of which is 65 feet long. Near the mouth of this tunnel, the quartz vein is 2½ feet wide, but, near the heading, it has narrowed to a few inches. The lower tunnel shows the brecciated zone to be one foot wide and to dip 10° NE. The vein, which here is only two inches thick, contains quartz that is faintly banded and somewhat stained by iron and copper minerals. Near the surface, where this staining is relatively more intense, bunches of chrysocolla and brown cherty hematite are intermingled.

In June, 1931, approximately 100 sacks of material from this vein were in storage on the dump.

DONALDSON CLAIM

The Donaldson claim is about 1¾ miles southeast of the Poorman workings and ¼ mile west of the Wellton-Tule Well road.

Here, the gneiss, which is rather sheared and schistose, dips generally eastward. Cutting across a low saddle is a prominent quartz vein, up to fifteen feet thick, with irregular strike and dip. When visited in May, 1931, this vein had been explored by several short tunnels. The vein quartz is white, somewhat fractured, and marked by iron oxide bands. The vein walls showed abundant sericite, minor chlorite, and sparse copper stain. Whether this chlorite is related to the quartz deposition, or is of regional character, was not determined.

WANAMAKER PROSPECT

The Wanamaker prospect is at the southeastern base of the main mass of the Wellton Hills, immediately west of the Wellton-Tinajas Altas road at a point seven miles from Wellton.

On this pediment, relatively fissile gneiss strikes about N. 60° W. and dips 45° E., but has been somewhat disturbed by minor faults. Several aplitic dikes, from a few inches to more than one foot across, are present. Two narrow quartz veins in the gneiss have been prospected by shallow workings.

The larger of these veins, which is less than one foot wide, strikes and dips with the prevailing lamination of the gneiss. Its quartz is coarsely granular and somewhat stained with iron oxide. Locally, it contains bunches of brown calcite and vugs lined with quartz crystals. A small amount of copper stain is present in this vein.

The smaller vein also strikes and dips with the gneiss, but is only a few inches thick.

McMAHAN PROSPECT

The McMahan prospect is ¾ mile north of the Double Eagle shaft, near the southern tip of a low ridge on the west side of Coyote Wash.

In this immediate vicinity, the gneiss has been faulted sufficiently to show considerable variation in strike and dip. One fault zone, striking southeastward, is from two to three feet wide in places and contains an irregular quartz vein less than a foot thick. Its walls are strongly sericitized. An old sixty-foot shaft, inclining about 55° NE., penetrates this zone. The vein material consists largely of heavily iron-stained, crystalline quartz, locally banded by narrow veinlets of gray and brown calcite. In places, it shows abundant vugs lined with quartz and filled with iron oxide, copper-stained silica, and sericite. A small quantity of wulfenite was seen on the dump.

WELLTONIA PROSPECT

The Welltonia prospect is on the hill slope about ¼ mile southwest from the Wanamaker workings. Here, medium-grained, banded, biotite gneiss, which contains some members of fine-grained, apparently sedimentary schist, strikes N. 35° E. and dips nearly 90°. A thirty-foot shaft has been sunk on a narrow zone that contains a few quartz stringers. This quartz contains small bunches of brown to black iron oxide, and the adjacent schist shows considerable iron staining and sericitic alteration.

NORTHERN PROSPECT

A few shallow cuts have been made in the western slope of the spur that lies one mile south of Sec. 32, T. 9 S., R. 18 W. There, the gneiss strikes nearly west, dips 30° towards the north, and is cut by several aplitic dikes. A narrow, lenticular, white quartz vein near one of these dikes contains some bunches of brown calcite, together with hematite and granular quartz. In places, considerable copper stain is developed. The vein walls are somewhat sericitized.

SHIRLEY MAE PROSPECT

The Shirley Mae prospect is ½ mile east of the Wellton-Tinajas Altas road and about 1¼ miles east of the Draghi workings.

In this locality, fine-grained, banded, biotite gneiss strikes southeastward and dips 65° NE. When visited in May, 1931, the workings on the Shirley Mae claim consisted of a sixty-foot tunnel extending southeastward along a fault zone that was strongly sericitized for a width of about three feet. Some slight iron stain and a very little quartz were apparent.

CHAPTER XXI — TINAJAS ALTAS MOUNTAINS

SITUATION AND ACCESSIBILITY

The Tinajas Altas Mountains extend S. 30° E. from the narrow, alluvium-floored gap, called Cipriano Pass, that separates them from the southeastern end of the Gila Mountains. They extend, beyond monuments 191 and 192, for several miles into Mexico. North of the international boundary, they are fourteen miles long by a maximum of four miles wide and include an area of approximately 35 square miles.

The Tinajas Altas Mountains are uninhabited. As shown by Plate 1, the Camino del Diablo from the east reaches them at Tinajas Altas (High Tanks), which are four miles north of the international boundary. About 1½ miles farther north, a branch road, nearly impassable for automobiles, crosses a low divide in the range and leads to the Fortuna mine. The Wellton-Tinajas Altas road, which lies near the eastern margin of these mountains, continues southward to connect with the San Luis-Nogales road, which is a few miles south of the international boundary.

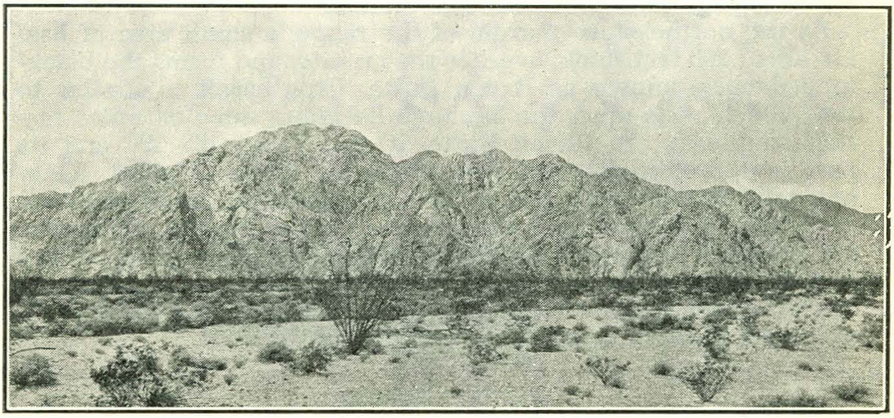

Plate 23.—Eastern side of Tinajas Atlas Mountains south of Tinajas Altas. Rock is granite.

TOPOGRAPHY

At the international boundary, the Tinajas Altas Mountains rise to 2,700 feet above sea level, or 2,000 feet above the adjacent plains, but, northward, their crest diminishes several hundred feet in altitude.

As shown by Plate 23, these mountains are very deeply dissected, but they appear less intricately rugged than the Gila Mountains. Bryan[150] has pointed out that canyons are deeper

[150] Bryan, Kirk, The Papago country, Arizona: U. S. Geol. Survey Water-Supply Paper 499, pp. 189-190. 1925.

here than in the Gila Mountains and that many of them are of the hanging variety. The lower slopes of the range, which are steep to cliffy, sharply give way upward to the gentle inclines of the hanging valleys, which in turn are surmounted by 30° to 45° slopes which continue to the crest of the range.

Run-off from the eastern side of the Tinajas Altas Mountains joins Coyote Wash, which leads northward to the Gila River. That from the western side gathers into southwestward-trending washes, but most of it sinks into the sand of the Yuma Desert before reaching the Colorado River.

The only watering places in these mountains consist of a few stream potholes, such as those at Tinajas Altas, below the hanging valleys. For a description of these tanks, the reader is referred to Bryan's[151] paper.

GEOLOGY

The Tinajas Altas Mountains consist almost entirely of the coarse-grained, grayish-white, sodic granite that is typical of this region. Lord[152] stated that, near monument 191, it contains notable amounts of zoned oligoclase-andesine.

A few pegmatite dikes cut this granite.

At the northeastern margin of the range, a small area of basalt, about 200 feet thick, overlies the granite, and forms the black-topped mesa known as Raven Butte. This basalt is similar to that which rests upon the Lechuguilla plain, some 25 miles farther southeast. In Raven Butte, it dips about 10° W., and its base is approximately 200 feet above the adjacent plain. One-half mile farther south and at the same elevation, small erosional remnants of similar rock are perched on the granite. This basalt probably was poured out before the present hanging valleys and their associated pediment were elevated above the plain. As the age of the flows is believed to be Pleistocene, this uplift probably took place in Quaternary time.[153]

MINERALIZATION

The Tinajas Altas Mountains contain a few quartz veins, locally stained with copper, which have received some attention from prospectors.

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[151] Work cited, pp. 131-135.

[152] Lord, E. C., Petrographic report on rocks from the United States-Mexico boundary: U. S. Nat. Museum, Proc., vol. 21, No. 1173, pp. 773-78 1899.

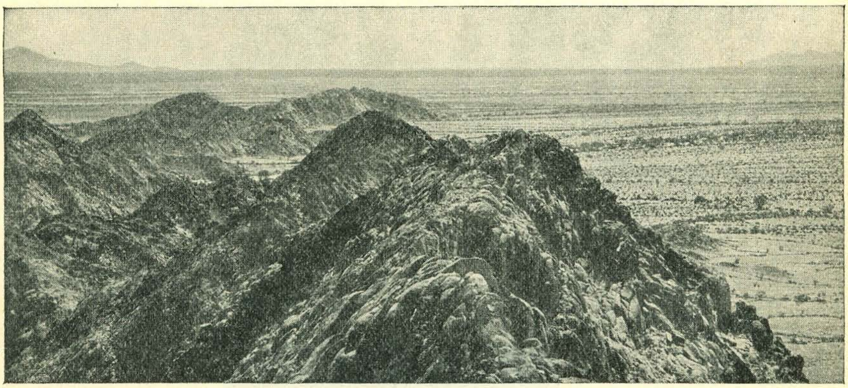
[153] See also Bryan, work cited, pp. 189-190.

CHAPTER XXII — BUTLER MOUNTAINS

SITUATION AND ACCESSIBILITY

The Butler Mountains begin at a point 1¼ miles south of Vöpöki Ridge of the Gila Mountains and extend S. 35° E. for 7½ miles to within two miles of international boundary monument 194. This range was not shown on any published maps until 1930 when it was named for Dean G. M. Butler, of the University of Arizona.[154]

As shown by Plate 1, the western fork of the Camino del Diablo passes between the Butler and Tinajas Altas Mountains. A route, now entirely hidden by drifting sand, formerly crossed the international boundary in the vicinity of Monument 194, and led southwestward to El Capitan and the Laguna Prieta regions in Sonora.



—Courtesy of the Geographical Review, published by the American Geographical Society of New York.

Plate 24.—Looking southward at southern portion of Butler Mountains—Rock is granite.

TOPOGRAPHY

The Butler Mountains rise, with slopes generally steeper than 35° (see Plate 24), to a maximum elevation of about 1,300 feet above sea level. They consist of a group, up to two miles wide, of sharp-crested ridges which are separated by narrow reaches of alluvium and dune sand. Rock pediments, closely limited by wind-blown sand, are visible in a few places. This range appears to represent a stage of erosion similar to that which obtained in the Tinajas Altas Mountains before their cliff-forming uplift.

Run-off from the Butler Mountains joins the braided stream channels that rise in the Gila and Tinajas Altas Mountains and trend southwestward through notches in the range.

[154] See Geographical Review, vol. 21, No. 2, pp. 221-228. April, 1931.

GEOLOGY

This range is composed of medium-grained, gray granite. Microscopic examination shows it to consist of quartz, orthoclase, microline, albite, muscovite, biotite, and hornblende, in grains up to 0.15 inch across, together with scattered grains of accessory magnetite.

Minor faulting and rather intense jointing have affected this granite. A few pegmatite dikes and quartz veins are present, but the only mineralization noted was slight copper stain in some of the quartz veins.

CHAPTER XXIII — GILA MOUNTAINS

SITUATION

The Gila Mountains separate the Yuma Desert on the west from the Lechuguilla Desert on the east. Beginning at the Gila River, twelve miles east of Yuma, they extend S. 30° E. for a distance of 27 miles, with a width of from 2½ to 8 miles and an area of approximately 109 square miles. In the early days, they were known as the Gila City Mountains, after the Gila City gold placers, at their northern end. Subsequent shortening of this name has led to confusion, because another range, in Graham County, eastern Arizona, is also called the Gila Mountains.

ACCESSIBILITY AND POPULATION

As shown by Plate 1, U. S. Highway 80 crosses the northern portion of the Gila Mountains at Telegraph Pass, and an old road, paralleling the Southern Pacific Railway, passes around their northern end, via Dome. One branch of the Camino del Diablo follows the western flank of these mountains, past the Fortuna mine, and its other branch is within a few miles of their eastern edge. Various desert trails lead from these roads to both sides of the range.

A few placer miners and others live at Dome, the railway station that succeeded the early gold placer settlement of Gila City at the northeastern corner of the range. Some farmers till the bottom lands of the Gila River, and a few homesteads are located near the highway. Aside from a service station in Telegraph Pass, the Gila Mountains of Yuma County are uninhabited, but their history and road accessibility have encouraged prospecting.

Water is available at only a few places in these mountains. Near the Fortuna mine, in the western foothills of the range, about fifteen miles south of the Gila River, are a few open prospect shafts that catch rain water. About 1¼ miles farther northeast, in a rather rough canyon, is a small spring. The mountains contain a few stream potholes that serve as natural rock tanks, but they are difficult of access.

TOPOGRAPHY

The Laguna, Fortuna, and Wellton topographic sheets, issued by the U. S. Geological Survey in 1929, cover the northern twenty miles of the Gila Mountains. These maps are on a scale of about one mile to the inch, which is inadequate to express the prevailing ruggedness, angularity, and sharpness of contour, such as is shown in Plate 25.

The peaks of this range are from 1,300 to 3,150 feet above sea level, or from 1,100 to 2,500 feet above the adjacent plains. Many

—Courtesy of Scientific Monthly.

Plate 25.—Looking southeastward in Gila Mountains from top of Red Top peak, southeast of Fortuna mine.

of the higher peaks are separated by saddles that are only a mile or so wide but of 400, 700, or even 1,200 feet lower elevation. In many places, the slopes are 30°, 45°, or even greater, and much of the jagged crest is extremely sharp. Large portions of the mountain slopes tend to be of nearly constant grade and comparatively free from debris, but, along stream courses, they are concave upward and, locally, talus mantled. Also, throughout most of the range, a distinct break appears in the stream gradients and in the intercanyon ridge crests. Although locally irregular, this break in topography follows approximately the 1,200-foot contour through the northern portion of the range, but becomes progressively higher southward. It apparently represents an elevated, dissected pediment. Another break, expressed by steepened spur-ends is generally apparent along the base of the mountains.

Near latitude 32° 30′, or about twenty miles south of its northern end, the Gila range has a width of eight miles. There, however, it abruptly separates into two parallel ridges, three miles apart. The eastern, or main, ridge is seven miles long, from one to three miles wide, and in many places more than 2,000 feet above sea level. The western segment, now called Vöpöki Ridge, was unmapped prior to 1930. It is nearly six miles long and up to two miles wide, but narrows southward. Its zig-zag crest reaches about 2,000 feet above sea level at the north, but gradually declines southward, to the point where its thin end gives way to the narrow plain separating it from the Butler Mountains.[155] Viewed from the west, Vöpöki Ridge is joined to the Gila Mountains by a low saddle, but, from the east, where the plain is some 500 feet higher, it appears like a separate range.

Everywhere, as indicated by Plate 25, the Gila Mountain slopes are sharply furrowed by canyon systems. The surface run-off gathered by these canyons follows many arroyos towards the Gila River. Farther south, this east-side drainage empties into Coyote Wash, a northward-trending, ephemeral tributary of the Gila. The west-side drainage of the northern twelve miles of the range gathers into a large wash that leads it north-northwestward to the Gila River. Farther south, however, most of the west-side run-off spreads out and sinks into the sandy wastes of the Yuma Desert.

GEOLOGY

Schists:[156] The oldest rocks exposed in the Gila Mountains are schists which outcrop, as shown by Plate 1, over much of the northern eighteen miles of the range. In places, as indicated in part by the map, they give way to masses of gneiss and intrusions of granite, pegmatite, and lamprophyre.

[155] Wilson, Eldred D., New mountains in the Yuma Desert, Arizona: Geog. Review, vol. 21, No. 2, pp. 221-228. April, 1931.

[156] See also pp. 192, 202-207.

These schists are predominantly metamorphosed sedimentary rocks; they show abundant traces of their original stratification and contain notable marble members (see pages 202-207). A few gneissic members are present. Freshly broken surfaces of the schist range in color from various shades of gray to black, but weathered surfaces are predominately brownish. The black colors are generally due to biotite or hornblende, and the gray represents medium to fine-grained quartz (see microscopic character descriptions, pages 192-193, 203).

Regional metamorphism has produced incipient recrystallization and a parallel arrangement of certain minerals within these rocks, but has not been sufficient to induce any marked foliation. The original, even bedding, which is mostly a few inches or less than one foot thick, strikes across the range and dips steeply southward in a succession of great magnitude. The thickness thus shown was believed by Blake[157] to be at least 10,000 feet, but, because of faulting, no estimate of the total can readily be made.

No definite age is assignable to these schists. Because of their metamorphic character, Blake[158] correlated them with the pre-Cambrian schists of southern Arizona, but the possibility that they may be younger can not be denied. Although no fossils have been found within them, their marble members, when struck by a hammer, give off abundant hydrogen sulphide, indicating that the waters from which they were deposited contained prolific organisms.

Economically, the schists are the most important rocks of the Gila range. They contain the Fortuna gold veins and the Dome marble deposits, and they probably held the gold veins that gave rise to the Gila City placers.

Gneiss: Apparently younger than the schist is gneiss which outcrops, as shown on Plate 1, over a considerable area of the Gila Mountains. It forms the larger portion of the range from ½ mile south of Telegraph Pass to ½ mile north of the Fortuna mine, and appears in another prominent mass two miles east of the latter place. It also outcrops as a narrow band along the northern end of the range, below the marble belt.

In color, the typical gneiss is gray to white, marked by more or less speckled bands of black along its main surfaces of lamination, but most weathered surfaces are pale brown. Its texture is similar to that of a medium-grained granite, but, at the northern end of the range and elsewhere, a few notably coarser phases occur. Viewed in thin section under the microscope, the typical gneiss is seen to consist essentially of quartz, feldspar, and mica. The quartz and feldspar grains, which are from 0.04 to 0.1 inch long and from 0.01 to 0.1 inch wide, are surrounded and deeply

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[157] Blake, Wm. P., The Fortuna gold mine, Arizona: Eng. & Min. Jour., vol. 63, pp. 664-665. 1897.

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

corroded by finely granular quartz. Aside from this groundmass, or matrix, the quartz probably constitutes at least 60 percent of the rock. The feldspar is partly orthoclase and partly albite. The mica consists of biotite and less abundant muscovite, in shreds up to 0.06 inch long and from 0.012 to 0.03 inch wide, in places feathering out into the groundmass or matrix. A little epidote, in grains up to 0.025 inch in diameter, occurs scattered throughout the rock. The large proportion of quartz in this rock suggests a sedimentary origin.

Regional metamorphism has recrystallized the original constituents of the gneiss and has arranged their directions of elongation roughly parallel. Consequently, a distinct lamination obtains, but it is rather massive and easily confused with jointing in other directions. This lamination, where observed, strikes across the range and dips rather steeply southward.

The thickness of the gneiss was not estimated. It is intruded in places by granite, pegmatite, and lamprophyre. Like the schists, its age is uncertain, but tentatively regarded as pre-Cambrian.

Economically, the gneiss of the Gila Mountains has not been important, but, at various places, it contains small quartz veins with visible gold.

Granite: As shown by Plate 1, granite, which intrudes the schist and gneiss, outcrops in two notable areas of the Gila Mountains. The smaller area, beginning at the northernmost high peak, constitutes the range for three miles southward. A much larger area, of batholithic proportions, begins three miles southeast of the Fortuna mine and forms all of the range southward. Tongues and dikes of this granite extend into the schists. Dikes of similar material are found in the gneiss, but no large bodies of granite in contact with gneiss are exposed within the range. The granite in turn is cut by dikes of pegmatite and lamprophyre. Its age has been tentatively regarded as pre-Cambrian, but it might be late Mesozoic or Tertiary.

Most of the granite is light gray to nearly white, but some phases are darker, and weathered surfaces are of a pale-brown, sandy color. The light colors are due to feldspar and quartz, and the dark represent biotite and hornblende. When the rock is viewed in thin section under the microscope, these minerals are seen to be rather coarse grained, ranging up to 0.15 inch or more in diameter. The feldspar is mostly microcline and orthoclase with minor albite. Not much alteration beyond a moderate, persistent development of epidote has affected this rock. Its darker phases seem due to a relatively greater abundance of biotite and hornblende.

Economically, the granite of the Gila Mountains has been of importance for railroad ballast (see page 207).

Amphibolite: A belt, from 1 to 1½ miles broad, of locally sheared, somewhat metamorphosed, black rock intrudes the schists 1¼ miles south of the Fortuna mine and extends east-northeastward across the range. On Plate 1, this formation is not separated from the granite with which it forms an apparently gradational contact that may be located only by more detailed work. This apparent gradation may be due to marginal assimilation of the black rock by the granite batholith.

Microscopic examination of a powdered sample of this black rock shows it to consist essentially of hornblende, biotite, and plagioclase. A considerable portion of the plagioclase is andesine-labradorite. Accordingly, the rock might be classed as a mica diorite, but, for the mass as a whole, the general term, amphibolite, is more fitting.

Red Top granite and allied pegmatites: An area of muscovite granite, 1¾ miles long from east to west and up to ½ mile wide, forms the crest of a peak locally known as Red Top, some 2,000 feet above and two miles northeast of the Fortuna mine. This granite intrudes the schist and gneiss.

Examined microscopically in thin section, this granite is seen to be made up of a coarse-grained, irregular mosaic of feldspar, quartz, and muscovite. The feldspar is mostly microcline and albite, with less orthoclase.

Three areas similar to this muscovite granite mass, but elongated in a north-northeast direction, outcrop about three miles farther south.

Extending outward in every direction from Red Top Peak and from these three other masses are numerous pegmatite dikes which parallel the bedding and also follow fissures. These dikes outcrop over lengths ranging from a few feet up to more than a mile, with widths of a few inches up to more than fifty feet. Pegmatite dikes occur somewhat less abundantly near the northern end of the range, but are comparatively scarce in the southernmost portion.

Mineralogically, the pegmatites of the Gila Mountains consist simply of orthoclase, quartz, and muscovite, with more or less red garnet, magnetite, tourmaline, and manganese oxide locally developed. The quartz and feldspar, which generally show some tendency towards graphic structure, vary in grain size from a small fraction of an inch up to several inches. In places, the muscotive books are more than an inch across (see page 202). The garnets generally are less than 0.1 inch in diameter. Part of the magnetite is in scattered, minute grains, but, in places, it occurs as blebs of lodestone that are more than an inch in diameter.

The tourmaline, which occurs as aggregates or felted masses of small crystals, appears to be generally more abundant in the vicinity of notable developments of magnetite. Manganese oxide occurs in places as very thin films within fractures and coating the surface of the pegmatite.

At several localities, but most notably ¼ mile southeast of the Fortuna mine, the pegmatite contains biotite in books up to several inches wide. As such biotite occurs only where the wall rock is black schist, it may represent an assimilation or reworking of ferromagnesian minerals originally present in the schist.

Economically, the pegmatites of the Gila Mountains have been of interest for their deposits of muscovite mica (see page 202). Furthermore, they may be genetically related to the gold-quartz veins with which they are locally associated. Some of these quartz veins seem to grade out from the pegmatites, but more detailed field work will be required to distinguish their true relations.

Lamprophyre dikes: At a few places in the Gila Mountains, narrow, gently irregular, black dikes cut the schist, gneiss, and granite. A sample of such a dike at Telegraph Pass shows, in thin section under the microscope, a felted aggregate of hornblende, biotite, and calcic feldspar together with abundant long needles of apatite and prominent epidote. Considerable secondary calcite occurs interstitially. This rock is a lamprophyre. These dikes were not feeders for any existing, near-by lava flows, and are of no apparent economic importance.

Tertiary (?) beds: Faulted against the northern end of the main mountain mass is a series of probable Tertiary rocks that consists of well-stratified, weakly consolidated sandstones, arkoses, silts, and clays, locally mud-cracked. The sandstones and arkoses, which locally show cross-bedding, are mediumly coarse to pebbly, but most of the formation is fine grained with no progressive variation in texture to the very base of the mountains. Such uniform texture, together with the local mud cracks and cross-bedding, points to deposition in shallow water bodies of considerable size and at a distance from any high mountains.

Large areas of fine silts are exposed along both flanks of the range and, in places, extend to the base of the mountains. The relation of these silts to the beds just described has not been learned. In the prominent indentation at the western end of Telegraph Pass, near where U. S. Highway 80 enters R. 20 W., they give way rather abruptly to an exposed thickness of some 600 feet of coarse conglomerate which rests upon a rough surface of the schists. This conglomerate consists largely of subangular to poorly rounded gneiss and schist boulders, up to twelve feet in diameter, firmly embedded in a matrix of sandy arkose. Its weathered slopes, if viewed from a distance, resemble those of gneiss. In places, well-stratified red sandstone is interbedded with the conglomerate. Immediately south of Telegraph Pass, at an elevation of 1,200 feet, the conglomerate is coarse, but also contains semi-rounded pebbles less than one inch in diameter and has a matrix of coarse red arkose. In the road cut about ½ mile east of the summit, a small patch of bouldery red arkose rests upon the schist. This conglomerate and arkose bear a striking resemblance to the supposed Tertiary strata of the Baker Tanks region (see page 169).

Quaternary gravels: A mantle of gravel, up to fifteen or twenty feet thick, overlies the eroded, bevelled surface of the Tertiary (?) beds and caps smooth-topped spurs. In places, hillocks of the underlying beds protrude through it. In places, this gravel mantle extends across the fault that separates the Tertiary (?) rocks from the main mountain mass and continues, as narrowing terraces, for some distance headward in the canyons. Most of the material in these gravel beds has been eroded from the mountains, but part of it is residual from erosion of the Tertiary (?) beds.

STRUCTURE

Attitude of principal formations: The schists of the Gila Mountains, except within areas of relatively intense faulting, prevailingly strike a few degrees south of west, which is across the trend of the range, and dip from 30° to 85° south-southeastward. As already stated, this lamination of the schist is parallel to the original bedding of the formation. Likewise, the most pronounced layering of the gneiss, wherever observed, strikes across the range and dips rather steeply southward. The weakly consolidated Tertiary (?) beds at the northern base of the mountains strike and dip in various directions.

Folds: Folding is of very minor importance in the Gila Mountains and consists of local, small-scale drags within the schist and gneiss.

Faults: The Gila Mountains, as pointed out by Bryan,[159] owe their present elevation to faulting. At their northern base, a clearly visible fault separates them from faulted, tilted beds of probable Tertiary age. Within the range itself, many faults of less than 100 feet displacement and a few of greater magnitude exist. They offer the lines of least resistance to erosion and, hence, find surface expression in nearly all of the major canyons and topographic saddles. In places, the fault planes may be seen, or they may be readily inferred from evident discordances and drags of bedding. Not enough detailed work was done to determine completely the various systems of faulting, but the following trends were observed: N. 30° to 45° W.; N. 30° to 40° E.; N. 70° to 80° E.; and N. to S. Most of these faults dip steeply, but some lie at rather low angles. A few of them may be of reverse character.

Part of this faulting preceded the intrusion of the pegmatites and the deposition of the quartz veins, but much of it is later. Late Tertiary or early Quaternary faulting is recorded in the tilted, bevelled sandstones and clays at the northern foot of the

[159] Bryan, Kirk, U. S. Geol. Survey Water-Supply Paper 499, p. 189.

range. Faulting of the same general age resulted in an uplift of at least 800 feet in the basalt of Raven Butte, which is beyond the southern end of the range. How many other periods of faulting have affected these mountains can be told only after much detailed geologic work.

Joints: All of the rocks of the Gila Mountains are marked by joints of several systems. Each system gives the effect of massive layering to metamorphic and igneous rocks alike. Strong jointing parallels most of the major canyons.

In the schist and gneiss, the principal jointing strikes at right angles to the bedding or layering and dips rather steeply eastward, but another strong system dips in the opposite direction. Still another strikes parallel to the bedding but dips opposite to it. In the granite, the major joint system parallels the axis of the range and dips steeply eastward. The major jointing in the pegmatites is at right angles to the bedding of the schists.

MINERAL DEPOSITS

The only mineral deposits of the Gila Mountains that have been worked at a profit are the Fortuna gold-quartz vein and the Gila City gold placers. Other gold-bearing veins, as well as deposits of marble, mica, and copper have been prospected to a minor extent.

LA FORTUNA MINE

Situation and accessibility: La Fortuna gold mine is situated at the western base of the Gila Mountains, about 14½ miles south-southeast of their northern extremity. From the railway at Blaisdell station, it is accessible by some fifteen miles of unimproved road that crosses the Yuma-Gila Bend highway at a point 16½ miles from Yuma and continues, as the dim, western fork of the Camino del Diablo, southeastward beyond the mine, to Tinajas Altas. In former years, a wagon road, some twenty miles long, led from the camp eastward across the range to Wellton, but its mountainous portions are no longer passable.

History: The Fortuna vein was discovered between 1892 and 1895 by Messrs. Chas. Thomas, Wm. Holbert, and two other prospectors. For some years previously, gold had been known to occur in these mountains, but this vein had been overlooked by hundreds of skilled prospectors who, half a century earlier, had passed along the Camino del Diablo, within a few hundred yards of the outcrop. In 1896, Mr. Chas. D. Lane, of Angels Camp, California, bought the property for $150,000, and organized La Fortuna Gold Mining and Milling Company.[160] This company built a twenty-stamp mill (described on page 196), laid a pipe line to a shallow well near the Gila River at Blaisdell, and operated actively until the close of 1904.

[160] Eng. & Min. Jour., vol. 93, p. 372. 1912.

The mine and mill employed 80 to 100 men who lived in the flourishing town of La Fortuna. Blake [161] has described this town as follows: "This camp has been built up entirely by the merit of the vein or mine, and is sustained by that mine alone, for there are no other claims or mines being worked to any extent in that region. The camp consists of the usual motley assemblage of improvised houses, tents, and adobes, grouped irregularly around the mill of the company. We drove to the hotel, kept by a Chinaman, where we got most excellent meals, with good ice water, such as it was, somewhat saline to the taste, and, as I afterwards found, capable of eating holes in wrought and cast iron."

The following additional notes on the history and production of the mine have been compiled by J. B. Tenney: The first four months' run netted $284,600, from ore taken out within 150 feet of the surface. In the next two years, the two-compartment inclined shaft was deepened to 350 feet, the vein was developed at 100-foot intervals, and the mill was run intermittently on ore from the development faces. Full production started in 1898. About 75 percent recovery was made in the mill, and, by the end of 1899, a 100-ton cyanide plant was constructed to treat the accumulated tailings which ran $5 per ton. The banner year for the mine was 1900 when a production of $467,700 was made from ore and tailings.

In 1900 and 1901, another shaft was sunk to an inclined depth of 1,000 feet, and much deep lateral work was done in an unsuccessful attempt to find the faulted segment of the vein. From 1901 to the end of 1904, the mill was run on pillars above the 800-foot level.

As shown by the table on page 198, the total production of the mine from September, 1896, to December, 1904, was $2,587,987 in bullion sent to the Selby smelter.

The property remained dormant until 1913 when it was acquired by the Fortuna Mines Corporation which repaired the shafts and made a small production from pillars. This company also conducted brief exploration underground, but without success, and abandoned the project at the end of 1914.

In 1924, the Elan Mining Company purchased the seven patented claims of the property and patented five more. Five stamps of the old mill were reconditioned, the mine was reopened, and a small production was made. In 1926, after an unsuccessful program of searching for the lost vein, the mine was again closed.

Since that year, all of the easily removable surface property has gradually been stolen, and the shafts have caved at the surface.

Topography: The Fortuna mine is at the western foot of the Gila Mountains, at an elevation of about 775 feet above sea level.

[161] Blake, Wm. P., Report of the Territorial Geologist, in Report of the Governor of Arizona, 1898: Misc. Repts., Washington, pp. 251-254. 1898.

The mountains here consist of sharp, rugged spurs, separated by westward-trending canyons which, near the margin of the range, are floored by dissected benches of detrital gravel and boulders. Along the margin of the plain is a dissected bench, from 25 to 150 feet high and up to 1½ miles wide, that represents an elevated pediment. This pediment, which shows only narrow, lim-

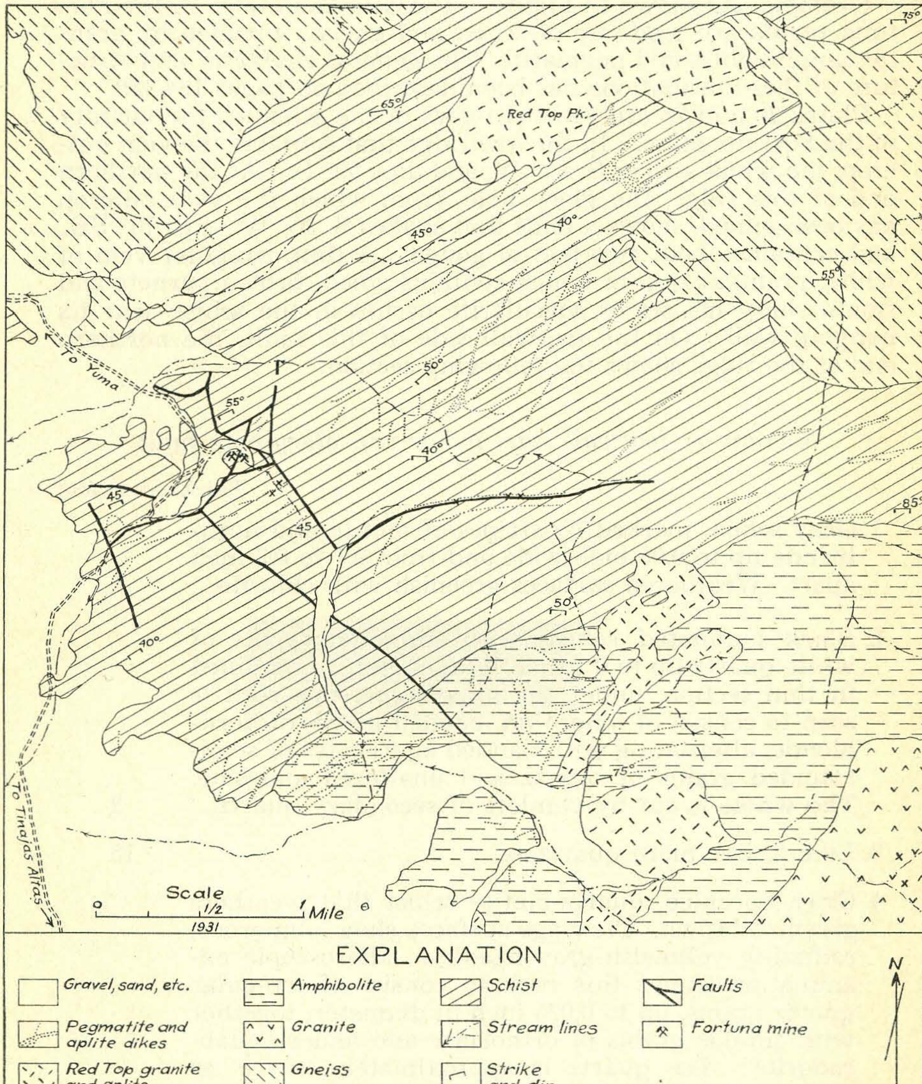


Fig. 7.—Geologic map of Fortuna region, Gila Mountains.

ited exposures on the hard rocks, is cut mainly on unconsolidated Tertiary (?) sediments, mantled by a relatively thin cover of gravels. Immediately west of the mine, it is surmounted by several relatively low, sharp, isolated, northwestward-trending ridges. The Fortuna vein outcrops a few feet above the alluvium at the northwestern tip of one of these ridges.

Geology: As shown in Figure 7, the Gila Mountains in the Fortuna region are made up of schist and gneiss, intruded by granite, amphibolite, and pegmatite. The general character and structure of these formations has been described on pages 184-189.

Plates 26 and 28 are general views of the schist in the vicinity of the Fortuna mine. In the low ridge that contains the vein outcrop, the schist strikes S. 80° W. and dips 50° S. At the northern end of this ridge, the glory hole, from which the vein outcrop has been mined, shows a fault that strikes S. 40° W., dips 70° SE., and contains about two feet of gouge. A thin, irregular vein of white, granular quartz which contains small, brown garnets and small, shiny masses of specularite occurs in the schist near its hanging wall. On the footwall side of this fault, the northern end of the ridge shows the following section:

Section on footwall side of Fortuna glory-hole fault

	Thickness in feet
1. Gray schist, marked by stripes of biotite and hornblende up to 0.05 inch wide and from 0.1 to 0.3 inch apart. Weathered surfaces greenish with chlorite....	6
2. Black laminated schist, with numerous spots of white quartz up to 0.1 inch in diameter. Examined in thin section, under the microscope, this rock is seen to consist of long, thin, banded leaves of hornblende, alternating with banded aggregates of semirounded grains of quartz and unaltered andesine. The whole is cut by veinlets of secondary quartz....	2
3. Like 2, but more quartzose..	15
4. Gray, speckled, quartz-biotite schist that weathers greenish brown. Cleavage surfaces show numerous, radiating yellowish-gray needles. Microscopic examination shows this rock to consist of irregular quartz grains, up to 0.025 inch in diameter, together with similar grains of orthoclase and andesine-labradorite. The quartz is approximately twice as abundant as the feldspars. A few shreds of biotite appear in the section. These minerals are penetrated by long, tabular, radiating crystals of andalusite and pyroxene..	4

5. Like 2, but with abundant small spots of calcite	3.5
6. Resembles 3, but finer grained and more sharply banded. Weathers brown	0.5
7. Like 2	2
8. Dark-gray quartz schist, sharply banded with hornblende. Cleavage surfaces show radiating needles of andalusite and pyroxene	6.5
9. Dense, finely banded, black schist	3.5
10. Mined out for width of five feet. Contains remnants of granular, faintly straw-colored quartz, marked in places with iron and copper stain.	
11. Black schist, with gray quartzose bands up to 0.1 inch wide. Base concealed by alluvium. Microscopic examination of a specimen adjacent to the vein quartz of 10 shows an aggregate of hornblende, pyroxene, andalusite, epidote, biotite, quartz, and calcite, cut by coarse-grained, secondary quartz	10

Structure: The schist west, north, and northeast of the Fortuna mine prevailingly strikes S. 80° W. and dips 50° S., but, in the area immediately south and southeast, the strike changes to S. 80° E. Such variations in strike and dip are due to faulting.

The rocks of this vicinity have been cut by a network of faults. In some places, the faults are clearly visible, but most of them are obscured by local creep and talus. As revealed by test-pits sunk in talus-covered saddles, the straight gulches and canyons follow fault lines. Due to the rather obscure stratigraphy of the schist, the faulting of this region can be analyzed only after much detailed geologic work. During the present brief study, faults trending S. 35° E., S. 50° E., N. 80° E., N. 40° E., N. 5° W., N. 5° E., N. 20° W., and S. 70° E. were observed. Most of them dip steeply, but a few lie at low angles and may be of reverse character. Certain faults of the first three directions mentioned seem to be of the greatest magnitude, with displacements of more than 100 feet. Part of this faulting preceded the mineralization, and part was later. The earlier structures were responsible for the localization of the vein, and the later faulting is reported to have cut it off.

Vein: The outcrop of the Fortuna vein has been almost entirely mined out through the caved stope, or glory hole, mentioned on page 192. This outcrop was within a fault zone that strikes S. 40° W., dips 70° SE., and cuts schist that in turn strikes S. 80° W., and dips 50° S. According to Mr. F. J. Martin,[162] manager of the property during most of its activity, the vein outcropped in two branches of which the main one was twenty feet

[162] Written communication.

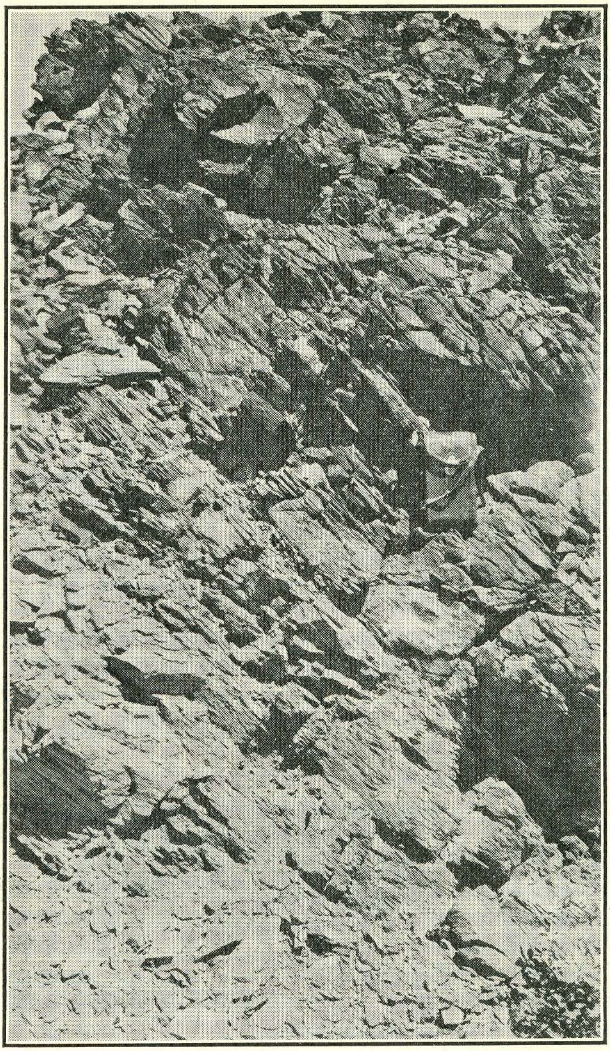


Plate 26.—Schist south of Fortuna mine, Gila Mountains.

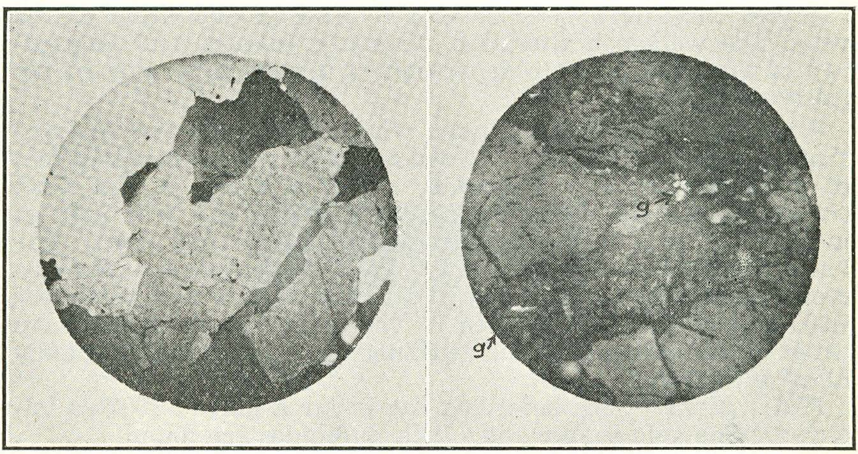
long by a maximum of twelve feet wide, and the lower one (No. 10 of section given on page 193) was thirty feet long by a maximum five feet wide. He writes that these branches were a few feet apart at the surface, but joined at a depth of approximately 500 feet below the surface, and formed a continuous ore body from 1½ to twelve feet wide. The ore body was lost by faulting at about the 800-foot level, and only a small segment, between the 900- and 1,100 foot levels was found by further exploration.[163]

[163] Written communication from Mr. F. J. Martin.

Blake,[164] who visited the mine in 1897, stated that the lode was a southwestward-pitching chimney with two branches that joined in depth, and that the hanging wall, for a width of two or three feet, contained small quartz stringers running parallel to the main body. He gives the following description of the temporary loss of the vein near the 500-foot level:[165] "When the workings reached, or came near, the point of intersection of this big vein they suddenly came into a lot of barren ground; in fact, they ran out of ore and into rock. The ground above this rock was considerably broken, and between this rock and the hanging wall there was the merest seam, not thicker than a knife blade, if so thick. . . . . . . In the mining parlance of the Cornishman it was a 'horse,' and a dead horse at that. As soon as the superintendent had cut through this rock mass he came into the unchanged ore or quartz below."

Blake [166] also stated that "The vein probably does not measure more than 100 feet horizontally on the line of the drifts (at a depth of about 500 feet) . . .

"The quartz is without lamination or ribbon structure. It carries the gold throughout its substance in little grains, or particles. . . . It is a free-milling ore. A little green stain here and there



—Photograph by Robt. E. Heineman.

Plate 27-A.—Photomicrograph of thin section of high-grade quartz, Fortuna vein—Magnified twenty diameters.
B.—Photomicrograph of polished section of high-grade quartz, Fortuna vein—Brightest grains (g) are gold—Magnified approximately 150 diameters.

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[164] Blake, Wm. P., Report of the Territorial Geologist, in Report of the Governor of Arizona, 1898: Misc. Repts., Washington, pp. 251-254. 1898.

[165] Work cited.

[166] Blake, Wm. P., The Fortuna gold mine, Arizona: Eng. & Min. Jour., vol. 63, p. 664. 1897.

indicates the presence of some copper ore, and copper was found in the bullion in more abundance in the upper levels than below, where there has been less decomposition of the sulphides.

"The gold is very fine and high grade, averaging .890 fine, and gives a pure, clean bullion."

According to Mr. F. J. Martin,[167] the ore down to the 200-foot level averaged more than $30 per ton, and all of the rock milled averaged between $15 and $16 per ton.

As seen in specimens, the gold-bearing quartz is coarse grained, vitreous, pale straw colored, and locally stained with malachite. Examined microscopically in thin section, it is seen to consist of irregular, interlocking crystals, up to 0.15 inch long by 0.07 inch wide, as shown by Plate 27-A.

Microscopic examination of a polished section of the high-grade quartz shows minute grains and small, irregular to interlacing veinlets of hematite, locally altered to limonite. The gold appears as round grains within converging, hair-like cracks, and also as thin, irregular veinlets within the limonite. These relations are illustrated in Plate 27-B.

The wall-rock alteration accompanying the Fortuna vein consists mainly of carbonatization and silicification. Andalusite, garnet, epidote, and pyroxene also occur in the adjacent schist, but they may have been developed prior to deposition of the vein. The wall-rock alteration, structure, texture, and mineralogy of this vein point to deposition in the lower portion of the mesothermal zone.

Workings: The Fortuna mine workings include two inclined shafts, illustrated in Plate 28, together with several hundred feet of drifts, stopes, etc. The older shaft, which is on the ridge above the mill and some 250 feet southwest of the vein outcrop, inclines 60° in a N. 34° E. direction and is 350 feet deep. The lower shaft, which is approximately 100 feet southeast of the outcrop, inclines 58° in a S. 54° E. direction and is approximately 1,000 feet deep. When visited by the writer, these shafts were caved at the surface, and the workings were reported to be partly filled with water.

Mill: Blake[168] has described the Fortuna mill of 1897 as follows: "The gold is free; very little sulphides are found. . . . . . The mill is fitted for free milling ore exclusively. The rock is broken by a Blake crusher high up, so as to give extensive bin space. . . . In the material hoisted there are fragments of the wall rocks, some of which are thrown out, but many pieces pass through the mill. They would prefer to reject most of this wall rock, but it would take more time and expense than it does to mill it, and there is a chance of some of it containing gold. . . . . . The stamps are of unusual weight, 13,500 pounds each, and the arrangements for catching gold are simple. Long silver plates

[167] Written communication.

[168] Blake, Wm. P., Report of the Territorial Geologist, in Report of Governor of Arizona, 1898: Misc. Repts., Washington, pp. 251-254. 1898.

or aprons of continuous sheets of silvered copper are used for the collection of gold. There are two tiers of these silvered plates at a very sharp incline, and each tier 25 feet long, falling about one inch in eight inches, as about the incline of descent. The gold passes over fifty feet of apron, and most of it is caught upon the silvered plates, with the exception of that which is caught in the battery. After passing these silvered plates of fifty feet, all the tailings, water, and pulp are carried together in an ordinary wooden box sluice, where the current is swift enough to carry off the tailings, but this box sluice is provided with riffles, and it is about 150 feet in length, carrying the tailings to considerable distance away from the mill, and emptying them into a pond, where they are saved. In this long-tailed sluice box some amalgam is saved, for when it is cleaned, about every month or six weeks, they gather some $400 or $500 out of the tail sluices.

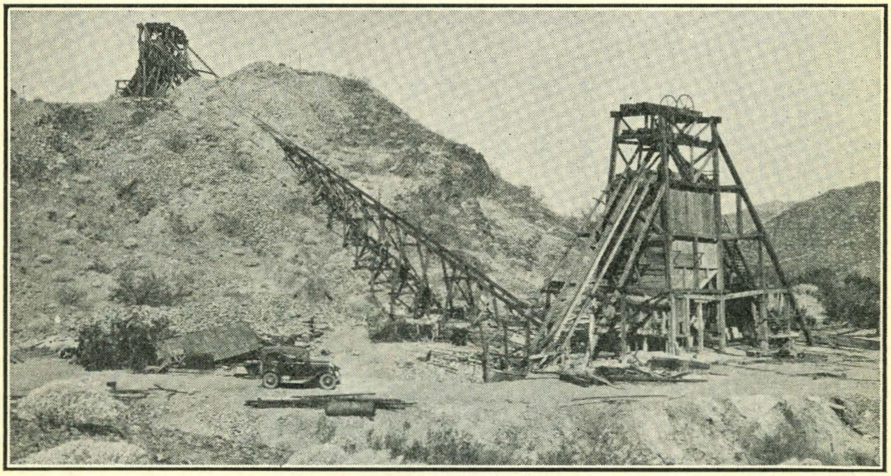

Plate 28.—Looking northwestward at Fortuna mine, Gila Mountains.

"Instead of amalgamation in the battery they have a lining of corrugated steel plates of unusual construction. These corrugated steel plates are placed at the back and at the ends of the mortar instead of across and upon the chock block in front. They may be described as a series of steel shelfs; the corrugations are in such a form as to catch and retain the amalgam. The effect of this series of steel shelfs and corrugations is to catch amalgam and retain it when it is splashed and thrown up in the battery, and it is such an effective retainer of the amalgam that after a month's run these troughs are nearly filled with solid amalgam, and the amalgam may be lifted out in solid bars, like bars of solder. The function, then, of these corrugated plates is to catch the amalgam and prevent it dropping back under the stamps, which saves the wear and breaking up of the gold, and of course saves the loss of

PRODUCTION, LA FORTUNA MINE
Data compiled by J. B. Tenney

Date	Price silver	Ounces silver	Ounces gold	Total value	Remarks
1896	$0.68	1,208.41	14,872.08	$ 308,224	June to December, La Fortuna Mining & Milling Co.
1897	0.60	1,283.09	15,789.92	361,522	La Fortuna Mining & Milling Co.
1898	0.59	1,563.48	15,976.13	331,121	La Fortuna Mining & Milling Co.
1899	0.60	1,595.12	21,078.75	440,770	La Fortuna Mining & Milling Co.
1900	0.62	1,447.40	22,596.58	467,960	La Fortuna Mining & Milling Co.
1901	0.60	783.35	11,994.46	248,411	La Fortuna Mining & Milling Co.
1902	0.53	662.09	9,576.94	198,319	La Fortuna Mining & Milling Co.
1903	0.54	603.88	6,730.95	139,820	La Fortuna Mining & Milling Co.
1904	0.58	1,032.59	4,414.69	91,840	
Total 1896-1904		10,179.41	123,030.50	$2,587,987	
1913-1914			435.00	9,000	Fortuna Mines Corporation (est.)
1926			774.00	16,000	Elan Mining Company (est.)
Total 1896-1926			124,239.00	$2,612,987	

the very fine particles of gold which might be carried off by the strong current of water. These corrugated plates are found to work in a most satisfactory way, and to successfully replace the ordinary amalgamating plates in a battery."

In another article, Blake [169] stated that "The bars poured are of large size and great weight, for greater security in transportation. They weigh usualy from 150 to 200 pounds.

"For the first four months' run of the mill the yield was as follows: Ore crushed per day, 52½ tons; assay value of the ore per ton, $40; amount saved in the mill per ton, $35."

In 1899, a 100-ton cyanide plant was built to treat the large accumulation of tailings that contained $5 or so per ton.

According to Mr. F. J. Martin,[170] manager of the property during most of its producing period, about 2,000 tons of ore per month, and a total of 185,000 tons, went through the mill. Approximately eighty percent of the gold was saved in the mill, and sixteen additional percent of it was recovered by the cyanidation.

MINOR GOLD DEPOSITS

Gold-bearing veins occur at many places in the Gila Mountains, other than at the Fortuna mine, but the ones so far explored have not been of notable economic importance. Some of these deposits were discovered soon after the Gila City placers, while others remained unnoticed until recently.

Fortuna area: Many quartz veins cut the schist in the vicinity of the Fortuna mine. In general, this quartz is coarse grained, white, and locally copper stained, but lacks the straw color characteristic of the Fortuna lode. Most of these vein outcrops have been prospected by tunnels and shallow shafts, some of which now serve as catches for rain water. A little gold has been found in some of the veins, but no production is reported from any of them.

Golden Dream group: The Golden Dream group of seven claims is on the crest of the Gila Mountains, three miles north-northeast of the Fortuna mine. It is accessible by about two miles of steep trail at the end of 3½ miles of road that branches eastward from the Yuma-Fortuna road at a point some ten miles south of Blaisdell station.

Here, sharp, rugged peaks rise from 500 to 700 feet above their intervening saddles, or more than 2,000 feet above the adjacent plains. Many of the mountain slopes lie 45° from the horizontal, and some of them are nearly vertical. Long, rocky canyons lead down from saddles and outward to the plains.

This portion of the range is made up of gneiss the lamination of which strikes approximately east-west and dips 60° southward. Considerable jointing and minor faulting are apparent. The prin-

[169] Blake, Wm. P., The Fortuna gold mine, Arizona: Eng. & Min. Jour., vol. 63, pp. 664-665. 1897.

[170] Written communication.

cipal jointing strikes at right angles to the bedding and dips rather steeply eastward, but another strong system dips in the opposite direction. Other joints strike nearly east-west and dip steeply northward. Several pegmatite dikes cut the gneiss and in places contain garnet and lodestone.

These claims were located early in 1931 by Mr. John Miller. When visited in June of that year, they were held by Messrs. John Miller and C. R. Norman, who were exploring them with a few shallow cuts. These prospectors obtained water for their camp from a few rather inaccessible rock tanks of the region. As burros were found unable to carry enough water for their own needs, all supplies and equipment had to be packed to the crest of the ridge by men.

A shallow prospect hole on the eastern slope showed an eight-inch quartz vein that strikes a few degrees south of east and dips southward. This quartz, which is rather fractured and cellular at the surface, contains abundant iron oxide and a little visible gold. Although this vein pinches and swells, it is traceable for some distance eastward.

A few hundred yards farther southwest and on the opposite slope, a horizontal cut into the steep slope exposes a vein that strikes N. 20° W. and dips about 15° NE. As exposed, this vein contains more pulverent iron oxide than quartz and has an irregular width of not more than one foot. It appears to follow a fault, and is traceable, with minor interruptions, for about ½ mile southward. Many fractures and a few minor faults join it, but without effecting any visible displacement. Part of the iron oxide of the vein is red, and much of it is black and sooty, but chemical tests of the black portion failed to reveal any manganese. The quartz is of even grain, but broken by many fractures that are filmed with iron oxide. In places, thin, fine flakes of gold are abundantly scattered over the fracture surfaces, and a few rounder particles are within the more solid quartz. Pyrite, generally in grains less than 0.03 inch in diameter, occurs sparsely scattered throughout the quartz. Many specks of iron oxide, probably representing altered pyrite, are similarly present. In places, veinlets of iron-stained calcite occur within the quartz. A little sericite occurs in the immediately adjacent wall rock.

Several hundred yards farther north, a nearly vertical quartz vein, about one foot wide, strikes southward. It shows abundant iron oxide and some copper stain.

McKay Prospect: The McKay Prospect is near the northeastern tip of the Gila Mountains, in a saddle 500 feet above sea level.

Here, black schist strikes N. 75° W., dips 70° S., and has been cut by several faults. Two neighboring quartz veins, generally less than two feet wide, strike and dip approximately with the schist. The quartz of these veins, which is dense, vitreous, and white, contains fairly numerous small pseudomorphs of limonite after pyrite. In places, it is extensively brecciated, and cemented with ferruginous calcite and hematite that weather black.

Workings on these veins consist of an old, shallow shaft and a few old tunnels.

A short distance farther north, a small vein of similar quartz is slightly stained with copper carbonate.

COPPER PROSPECTS

Blue Butte copper prospect: The Blue Butte claim is four miles southeast of the Fortuna mine, at a fork in a rugged westward-trending canyon, 1,500 feet above sea level.

In this vicinity, the granite is extensively sheeted by several systems of jointing, of which the most prominent dip steeply and strike N. 15° W., S. 40° W., and S. 40° E. It is cut by a few narrow pegmatite dikes the feldspar of which locally contains crystals of hematite. A quartz vein, up to six inches thick, strikes NE., dips 35° SE., and is traceable for more than 200 feet. It contains a few inclusions of biotite. The quartz, which normally is coarse grained, vitreous, and white, has been extensively stained by copper. It contains small, irregular masses of malachite, azurite, and chalcocite. For three or four inches from the vein, the feldspars of the wall rock are stained with copper, and thin fractures extending out from the vein are lined with malachite and hematite for distances up to one foot.

McPhaul copper prospect: A copper prospect, held by Mr. Harry McPhaul, is at the northern end of the Gila Mountains, in the central segment of the marble deposit described on pages 202-207.

Here, the schist and marble, which strike S. 85° W. and dip from 55° to 75° S., have been cut by several faults of minor magnitude. A strike fault, with schist footwall and marble hanging wall, contains a vein of coarse-grained, vitreous, gray quartz that ranges from a few inches up to four feet thick. This vein contains chrysocolla, malachite, limonite, and hematite in irregular cavities and narrow fractures. In places, the copper minerals are sufficiently abundant to color the whole width of the vein. Near the surface, and particularly near the walls, abundant small crystals of wulfenite occur associated with the copper minerals or grouped within small cavities and fissures. In places, the quartz contains numerous small pseudomorphs of limonite after pyrite. The vein carries a small amount of gold. Along the vein walls, coarse-grained sericite is abundant.

Workings on this prospect consist of a few shallow pits.

MICA DEPOSITS

Small deposits of muscovite mica occur within pegmatite dikes that cut the schist in the central portion of the Gila Mountains. The most prominent of these deposits are exposed in the central segment of a decomposed pegmatite dike that follows a fault zone for 1½ miles west-southwestward from the divide 2¼ miles east of the Fortuna mine. The schist near this dike shows intense alteration to coarse-grained sericite and, for distances up to 150 feet on each side, is marked by brown and yellow limonitic stain. A tunnel through this zone shows the following section:

Section through mica-bearing zone 1½ miles east of Fortuna mine

	Thickness in feet
1. Slope mantled by clay containing flakes of muscovite	5
2. Aggregate of kaolin, gypsum, fragments of fine-grained pegmatite, and thin books of muscovite plates up to three inches across	1.5
3. Fine-grained, graphic, garnetiferous pegmatite containing less mica than 2	3.0
4. Quartz-feldspar-kaolin aggregate rich in mica	1.5
5. Like 4, but contains less mica and more iron oxides	8.0

The mica exposed throughout this section forms thin books that generally are less than one inch across. Although very clear and highly cleavable, it is slightly ruled and plicated, and probably could be used only for grinding. In 1929, workings on the deposit consisted of a few surface cuts and short tunnels. According to Mr. S. E. Montgomery, holder of the claims, the mica in the decomposed portion of the vein is easily concentrated by washing.

MARBLE DEPOSITS

SITUATION AND ACCESSIBILITY

Marble deposits occur within a belt that extends across the northern portion of the Gila Mountains, southwest of Dome, a station on the Southern Pacific Railway. The western limit of these deposits is accessible by a mile of road that branches eastward from the Dome-Yuma highway at the railway trestle 1¾ miles north of Blaisdell station. Their east-central portion is reached by 1½ miles of secondary road that leads southwestward from Dome, and their easternmost exposure extends into the railway right-of-way between culvert markers 754H and 754I.

HISTORY

Because of its nearness to the Gila River, railway, and highway, this marble has long been known, and portions of it have been held as copper claims. At present, ten claims upon the marble belt are held by H. Duty, H. McPhaul, and others, of Yuma. Considerable assessment work has been done, but very little marble has been produced.

TOPOGRAPHY

Here, the Gila Mountains rise steeply for more than 1,400 feet above a pediment cut on loosely consolidated Tertiary beds. The range is 1,616 feet above sea level at its northern end, but rises higher southeastward. Many V-shaped, steep-sided canyons trend perpendicularly to the borders of the mountain mass and everywhere culminate in sharp-edged features, such as are shown in Plate 29. Slopes on the hard rock are generally steeper than 35° from horizontal, but, on the adjoining, dissected pediment, they flatten abruptly to 150 feet or less per mile. Around the northern end of the range, the Gila River has limited this pediment to a width of ¼ to 1¼ miles, and, on the northeastern edge, has entirely removed it.

GEOLOGY

Plate 1 indicates the distribution of rock formations at the northern end of the Gila Range.

Schists: The oldest exposed rocks are sedimentary schists that strike eastward, dip 20° to 80° southward, and occupy an irregular area slightly more than 3½ miles long by one mile or less wide. Local, small-scale folding is apparent in them. Faulting, mostly transverse to the strike, is common but not of important magnitude except in the eastern half and at the western end of the area. Several systems of jointing obtain. Near the northernmost peak of the range, a large mass of granite intrudes the schists and forms the main mass of the mountains for some three miles southeastward. Irregular dikes of granite, pegmatite, and aplite have invaded the older rocks at many places. The total exposed thickness of the schists was roughly estimated at 2,000 feet.

Where first seen upon ascending the central portion of the northern end of the range, these rocks are fairly constant in character for a maximum exposed thickness of approximately 1,000 feet. They are marked especially by angular, blocky erosional forms, patterned upon joints and beds. Weathered surfaces are brownish, but fresh surfaces are light gray, mottled and streaked with black. Close scrutiny shows that the gray portion is fine-grained quartz, the black is partly mica, and the brownish coat is mainly iron oxide. Viewed in thin section under the polarizing microscope, this rock is seen to be more than ninety percent quartz, arranged in a granular mosaic with minor amounts of biotite mica and pyroxene. Most of the quartz grains are less than 0.01 inch in diameter, except in certain veinlets of secondary origin, in which they are several times larger. In the main mass of the rock, the quartz grains are of rather round contour and regular size, but, in the veinlets, they are of very irregular shape. All of the quartz shows wavy extinction. The biotite mica is generally grouped in longitudinal zones of small flakes or of sharply irregular leaves as much as 0.5 inch long. Associated with it are a few small, granular and tabular masses of epidote. Small, black specks (magnetite?) occur as inclusions in the secondary quartz. This schist probably originated through the regional metamorphism of a fine-grained sandstone.

The next higher member of the schist series is a belt of gneiss with a maximum thickness of some 350 feet and the same general strike and dip as the lower schists. Its weathered surfaces, which are characteristically dark brown, streaked with black, and mottled with lighter brown, form blocky cliffs that alternate with steep gravelly slopes. Fresh surfaces are light gray, striped irregularly with black. This rock consists of eye-shaped to subangular masses of feldspar, in places more than an inch in diameter, within a groundmass or matrix of granular feldspar and banded, curving foils of flaky, black mica. Its feldspar is orthoclase and microcline. The origin of this gneissic member, whether sedimentary or igneous, could not be determined.

Above the gneissic member are approximately 350 feet of black schist that locally weathers greenish. Its lamination is better developed than that of the lower schist member, and, as a result, its slopes weather less blocky. In thin section under the microscope, this rock is seen to be more than half hornblende. Feldspar (mostly labradorite) and quartz are present in a ratio of about one to five, and a little epidote occurs in places. Texturally, the grains of this rock are a little coarser than, but as well rounded as, those of the lower schist member. It is clearly of sedimentary origin.

In apparent conformity above this black schist is the marble-bearing member described on pages 204-207. It has a maximum observed thickness of approximately 150 feet.

Lying with apparent conformity upon the marble-bearing member is black schist that resembles the lower schist except that it weathers into forms that are more massive and are streaked with many white and gray bands a foot or so in maximum width. Southward, it gives way to granite (see page 185) so that its thickness amounts to only about 200 feet. A few veins of quartz and numerous dikes of pegmatite and of the granite cut this schist. In places, these granite dikes contain floated blocks of marble.

Marble-bearing member: The marble-bearing member of the schists extends as a light-gray band across the black, northern face of the Gila Mountains (see Plate 29). East of the large canyon that bisects the northern end of the range, faults have broken the eastern 1½ miles of this band into two segments of which the eastern one progressively thins, but persists to the foot of the range at the railway. West of the canyon, the marble belt continues almost uninterruptedly for two miles to the place where it pinches out. One-fourth mile farther west and a short distance from the pediment, however, it reappears as a faulted block upon a tongue of granite.

This marble-bearing member dips southward, into the mountains, from 30° to 70°. The following sections, measured downward, show its character and variations.

Northwest of high peak

	Thickness in feet
Black schist.	
Granite tongue.	
Marble, mostly white with some brown. Rather fissile. Contains small bunches of vesuvianite. Cut by pegmatite	15
Marble, generally gray and thin bedded. Lower five feet white and more massive	30
Schist, fissile and weathers brown. Thin section shows it to consist of quartz, epidote and brown mica	7
Marble, white and thin-bedded	2
Schist, black	18
Marble, gray and thin-bedded	3
Marble, white and thin-bedded	3
Schist, fissile and siliceous	10
Marble, white and gray banded	3
Quartzite, cross-bedded	12
Marble, brown to white. Elevation, 1,100 feet	25
Total thickness	128
Granite tongue.	
Black schist.	

One-half mile west of main canyon (¾ mile east of first section)

	Thickness in feet
Black schist.	
Marble, white and rather siliceous upward	30
Quartzite, very thin-bedded	40
Marble, gray to white, thin-bedded	18
Schist	3
Marble, gray to white, thin bedded	20
Quartzose beds	25
Limestone, metamorphosed. Elevation, 700 feet	15
Total thickness	151
Black schist.	

One-half mile west of railway (two miles east of first section)

	Thickness in feet
Schist, epidotized and weathers pinkish.	
Marble, white streaked by wavy gray. Upper portion weathers badly, but lower portion is of better quality	5
Quartzite, thin-bedded	10
Marble, gray	½-2
Quartzite, light gray	3
Marble	1
Schist and quartzite	2
Marble, gray and impure	1½
Quartzite, micaceous	3
Marble, gray	5
Marble, white, but impure. Grades into schist	2
Schist, quartzose to black, weathers dark green	12
Marble, white but with some green silicate impurities in thin lenses along bedding. Elevation, 275 feet. Cut by dikes of granite and pegmatite	10
Total thickness	56
Schist.	

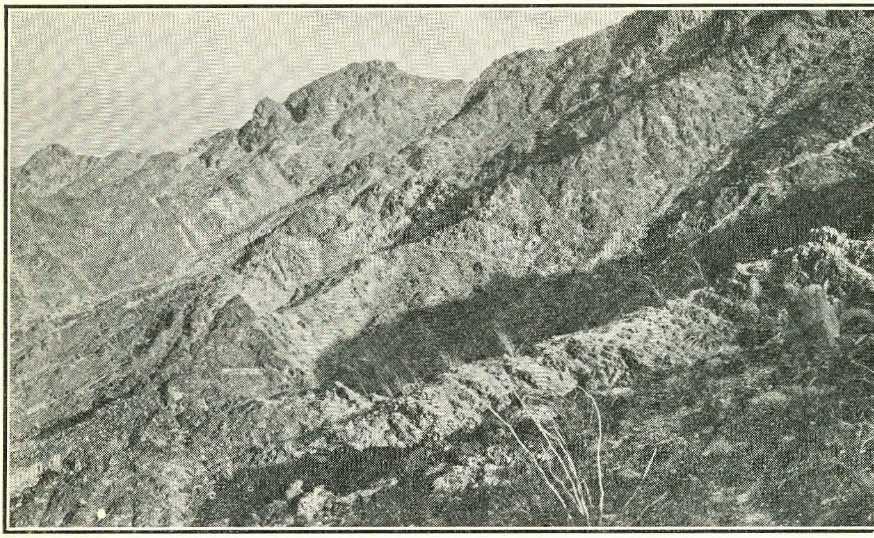

Plate 29.—Looking eastward at marble-bearing belt (gray) in schist at northern end of Gila Mountains.

According to these measurements, the whole marble-bearing member of the schist is 68 percent marble in the first section, 55 percent in the second, and 48 percent in the third. This thinning out of the marble eastward may be the result of differential squeezing during regional metamorphism,, or it may have been due to a lensing out of the limestone in the original sediments. The former possibility seems more likely. Recrystallization of the original limestone into marble was brought about partly through regional metamorphism and partly, as suggested by the epidote, garnet, and vesuvianite, through contact action of the granitic intrusion.

COMMERCIAL ASPECTS

In 1931, development of this marble deposit consisted of only a few small, open cuts. The largest cuts were upon the westernmost exposure, where, as already stated, a block of marble lies faulted upon a tongue of granite in a low hill at the northwestern end of a ridge. An improved, desert road, one mile long, leads westward from this place to the railroad and highway, 1¾ miles north of Blaisdell.

Here, part of the marble-bearing schist member outcrops, with a length of about 1,200 feet and a maximum width of 200 feet, to form the crest and southern side of this hill. In places, it is cut by small dikes of granite, and its fault contact with the underlying granite dips steeply south-southeast. In a few places, considerable amounts of epidote, garnet, and vesuvianite occur.

A new cut on the south side of this hill shows the marble there to be coarsely crystalline, white, and very pure, but crossed by fractures at intervals of every two or three feet. On the northern slope, a much smaller area of gray marble outcrops above the granite. In an old quarry cut, it is seen to be finer grained than the white, but marked by light streaks that dip steeply north-northwest. A little epidote is present near its base. This gray marble smells very fetid when struck by a hammer.

So far as is known, no marble from the Gila Mountains has been sold for building or ornamental stone. Considerable fissuring and jointing are evident throughout the deposit, but, as is shown in many marble quarries elsewhere, part of the surface cracks may disappear within a few yards of depth. At several places, this deposit appears capable of yielding slabs three or more feet across. The hard epidote, garnet, and other silicates, whose hardness would render the costs of quarrying and polishing prohibitively high, appear to be localized in avoidable masses.

The following analyses of samples from the western part of the deposit wre made in 1926 by G. G. Pohlman, of the University of Arizona:

	White marble	Gray marble
CaO	54.7	52.7
MgO	1.4	3.0
Insoluble	1.13	3.73

This high degree of purity appears to be typical of a large portion of the marble throughout its extent in the Gila Mountains. Such material, situated so near the railroad and highway, has commercial possibilities for the cement, lime, and chemical industries.

ROAD BALLAST

Crushed granite from the northern portion of the Gila Mountains has been very successfully used as railway ballast on the old line of the Southern Pacific from Yuma to Gila Bend and on about 100 miles of the new Phoenix line, as well as at several places in California. This granite is quarried and crushed at Granite Spur, about two miles southeast of Dome.

Here, the Gila Mountains rise with slopes of 40° or steeper, and are sharply carved by erosion. The granite is notably jointed in several directions, the principal one about parallel to the margins of the range. Its weathered surfaces are somewhat crumbly and are pitted by numerous small caverns.

In March, 1931, the Southern Pacific Company was operating this quarry with a force of 45 men, and producing about 45 cars of ballast per day. The broken rock was passed through a Blake crusher, a grizzly, and a finer crusher, so that all of the final product was under 2½ inches in size, but very little as fine as 200 mesh. Power for the plant was generated in steam boilers.

This granite is superior for road ballast because it is easily crushed to angular fragments that, upon packing, interlock into a tough, solid aggregate. Such a ballast is quite durable in climates of low rainfall whereas gravel ballast needs periodic re-surfacing.

GILA CITY OR DOME PLACERS

Situation and accessibility: The Gila City placers are at the northern end of the Gila Mountains, between the schists and the Gila River alluvial flats. This placer field has been worked over an east-west length of approximately two miles and a width of ¼ to ¾ mile. Gila City was about 1½ miles west of the present site of Dome, near the mouth of Monitor Gulch. The Southern Pacific Railway and the old Yuma-Gila Bend road skirt the northern margin of this placer ground.

History:[171] The Gila City placers became well known in 1858. Hinton,[172] in 1878, recounted their early history as follows: "Within three months of their discovery, over a thousand men were at work prospecting the gulches and canyons in this vicinity. The earth was turned inside out. . . . Enterprising men hurried to the spot with barrels of whisky and billiard tables. Jews came with ready-made clothing and fancy wares; traders crowded in with wagon-loads of pork and beans. . . . There was everything in Gila City within a few months but a church and a jail. . . . The diggings continued rich for four years and have been continuously worked on a smaller scale up to the present time."

Farish[173] states that Lieutenant Mowry found, in 1859, about 100 men and several families working the gravels at Gila City and saw more than $20 washed from eight shovelsful of dirt. He was told that from $30 to $125 per day was recovered by each worker.

Although the cream of their production was skimmed before 1865, these placers have been worked more or less every year down to the present time, and all the known productive gravel areas have been dug over at least once.

So far, this gold has been commercially recoverable only by dry washing or by panning of dry-washer concentrates at the river. Many plans have been made for large-scale recovery of the gold, but few of them ever got beyond the experimental stage. One such enterprise, attempted in 1870, has been mentioned by Raymond[174] as follows: "At Gila City a San Francisco company has during the last year erected works to pump water from the Gila up into a large reservoir on top of the highest foothills in order to work the placers of the vicinity by hydraulic power. They use a nine-inch pipe through which they pump the water." Numerous mechanical contrivances, large and small, have been tried out here, but most of them were of inadequate design. The remains

[171] See also page 46.

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

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

[174] Raymond, R. W., Statistics of mines and mining in the states and territories west of the Rocky Mountains, (1870); p. 272. Washington, 1872.

of one ponderous screw-trommel device, brought here scores of years ago, is still visible.

The total production of the Gila City placers has been roughly estimated by J. B. Tenney at $500,000 (see page 23), most of which was made prior to 1865. Their annual output during the seventies amounted to a few thousand dollars.[175]

Topography: Opposite the northern end of the Gila Mountains, the Gila River bottom lands, which lie about 165 feet above sea level, are bordered on the south by a gently northward-sloping, dissected bench that rises abruptly for 35 to 300 feet higher. From this bench, which is from ¼ to 1 mile wide, the main mass of the Gila Mountains rises steeply. Numerous canyon systems, originating in the mountains, have cut steep, northward-trending gulches, from 35 to 150 feet deep, in this bench.

Local geology: The geology of the northern portion of the Gila Mountains has been described on pages 202-207. Faulted against the schist of the main mountain mass is the series of probable Tertiary sedimentary rocks that constitute the so-called bedrock of the bench and of the placer deposits. These beds consist of well-stratified, weakly consolidated, locally mud-cracked clays, marls, arkoses, and sandstones. Their color is pale gray, buff, light green, or red, and their texture is generally fine grained, even to the very base of the mountains. This consistently fine-grained character indicates that they were deposited when no high mountains were very near, and the well-developed, locally mud-cracked strata point to deposition in shallow water bodies of considerable size.

More or less faulting and tilting are evident throughout the formation. In the road and railway cuts about 2½ miles north of Blaisdell, the beds strike N. 80° E. and dip 25° SE. The age of these sediments is regarded as probable Tertiary, although, as Bryan[176] pointed out, they are not so thoroughly cemented as the Tertiary sediments east of Wellton.

A mantle of gravel, up to fifteen feet thick, overlies the eroded, roughly bevelled surface of these beds and caps the smooth-topped spurs of the dissected bench. This mantle extends across the fault that separates the Tertiary (?) sediments from the schist, and continues, as narrowing terraces, for some distance headward into the canyons of the main mountain mass. Most of the material in these gravels appears to represent outwash from the Gila Mountains, but part of it is residual from erosion of the Tertiary (?) beds. Bryan[177] interprets this outwash as having been deposited when the Gila River bed stood about 75 feet above its present level. The age of these gravels is regarded as Quaternary.

The gulches that dissect this terrace are floored by gravel, sand, etc., that are partly of local origin, but mostly have been swept

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[175] Raymond, R. W., work cited, volumes for 1872-1875.
[176] Bryan, Kirk, U. S. Geol. Survey Water-Supply Paper 499, p. 63. 1925.
[177] Work cited, p. 67.

down by flood-waters from the mountains. At the edge of the mountains, this material contains subangular to rounded boulders that are as much as two feet in diameter, but, northward, it becomes progressively finer.

Gold-Bearing Gravels:[178] This Quaternary outwash material constitutes the gold-bearing gravels of the Gila City placers, and the underlying Tertiary (?) sediments form their bedrock. Most of the gold was found at or near bedrock in the gulches, but a considerable amount was recovered from the benches. Practically all the gulches and benches from ¼ mile east to three miles west of Dome carry some gold, but Monitor Gulch, 1½ miles west of Dome, was the scene of the active mining.

Northward from a point not far south of the railway, the bedrock is reported to extend under the water table. Depths of more than fifteen feet to bedrock have not appeared to be profitabl for mining.

Origin: The gold of the Gila City placers probably came originally from various gold-quartz veins in the northern end of the Gila Mountains. As no high-grade veins have yet been found there, the negative conclusion that many pockety or small, low-grade veins supplied the gold seems most reasonable. During deposition of the fine-grained Tertiary (?) sediments, the Gila Mountains probably were marked by very low relief, slow erosion, and relatively deep rock decay. After uplift, they suffered rapid erosion, and the weathered quartz veins of such decayed rocks readily parted with their gold. Floods in the young canyon systems swept this detritus northward, dropping out the gold as the stream gradients lessened. Further milling of these gold-bearing gravels by repeated floods concentrated the gold along the bottom of the channels where the clayey bedrock caught it.

Present Conditions: The gold not yet mined from these gravels is distributed in a rather spotty fashion. In 1926, Messrs. Neal and Morgan found an $88 nugget on one of the benches near Monitor Gulch. They found the gravel to run about fifty cents per cubic yard in a few cuts, but ten cents or less in many places.[179] The fineness of this gold was about $19 per ounce. About half of the nuggets were larger than match heads, and a fourth of them were from $3 to $6 in size. Almost all of the gold particles were rough, and the large nugget contained some white quartz.

In 1931, Mr. G. H. Mears was conducting small-scale hydraulicking operations in Monitor Gulch. Water for this enterprise was obtained from a shallow well near the railway and pumped through about ¼ mile of small pipe.

Various individuals carry on small-scale dry-washing in the Gila City placers at certain seasons, and now produce several hundred dollars' worth of gold every year.

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[178] Part of this information was furnished the writer by Messrs. Robert Morgan, Harry McPhaul, and the late W. M. Neal.

[179] Oral communication.

CHAPTER XXIV — LAGUNA MOUNTAINS

SITUATION

The Laguna Mountains, also known as the San Pablo Mountains, are twelve miles east of Yuma and immediately north of the Gila River, in Ranges 21 and 22 W. As considered on the U. S. Land Office map and in the present report, they extend northward for fourteen miles to Castle Dome Landing on the Colorado River. Various other maps, however, regard their northern nine miles as a separate unit. The Laguna Mountains, as here considered, have a maximum width of seven miles, and include an area of approximately 38 square miles. They derived their name from certain lagunas, or swamps, along the Colorado River.

ACCESSIBILITY

The Laguna Mountains have no permanent population, but several families live at Laguna Dam and on farms along the Colorado and Gila rivers. Because of its gold mineralization and proximity to settlements, many prospectors explore this range every year. The nearest water obtainable is from wells in the river bottom lands.

As shown by Plate 1, the Yuma-Quartzsite highway passes, via McPhaul Bridge, around the southeastern margin of the Laguna Mountains. Branching from it, the Silver District road lies within a few miles of their eastern margin and skirts their northern end. Roads on each side of the Colorado River lead to Laguna Dam, at the southwestern tip of the range. The Southern Pacific Railway is ¾ mile south of these mountains, and a U. S. Reclamation Service railway extends, on the California side, to Laguna Dam.

TOPOGRAPHY

The Laguna topographic sheet, issued by the U. S. Geological Survey in 1929, includes the Laguna Mountains. Their southern portion has a maximum elevation of 1,081 feet above sea level, or 900 feet above the Gila River. Sugarloaf, or Squaw, Peak, which is 1¾ miles south of Laguna Dam and 675 feet above sea level, constitutes one of the most prominent landmarks in the vicinity. Where cut on hard rocks, the Laguna Mountain slopes are steep, rugged, and intricately dissected, but, where formed on loosely consolidated material, they are gentler. A pediment, elevated from 25 to 100 feet above the Gila River flood plain, and somewhat dissected, surrounds the southeastern margin of the range.

The northern portion of the Laguna Mountains is separated from the southern portion by a pass that is more than a mile broad and, on the west, more than 150 feet high. Although relatively low, this northern portion is intricately dissected into steep-sided, rugged forms. The alluvial plain that borders the range on the east is from 200 to 300 feet higher than the Colorado River along its western margin. A width of about three miles of this plain rises terrace-like above the Castle Dome plain which borders it on the east.

Run-off from the southern portion of the Laguna Mountains flows in arroyos directly to the Gila and Colorado rivers. From the northern portion, it flows to the Colorado River in arroyos that, for the most part, cut across the range from the adjacent, eastern plains.

GEOLOGY

Plate 1 shows the distribution of rocks in the Laguna Mountains. The range is made up of schist, gneiss, weakly consolidated sediments, and lavas, all partly buried by a remarkable accumulation of loosely cemented gravels.

Schists and Gneisses: The oldest rocks are schists and gneisses that are similar in general character and composition to those of the Gila Mountains. In the southeastern portion of the range, the schists strike N. 35° E. and dip 20° NW. East of Laguna Dam, the principal grain of the gneiss strikes N. 60° W. and dips steeply northward. There, one prominent system of joints, striking northward and dipping steeply eastward, is intersected by another system that strikes S. 56° E. and dips steeply northward.

In places, pegmatite dikes and quartz veins occur approximately parallel to the major lamination of the schist and gneiss. Some of these quartz veins carry gold.

Tertiary (?) sedimentary rocks: Strata of probable Tertiary age outcrop from beneath later gravels at several places around the margin of the Laguna Mountains. South of Castle Dome Landing, they appear to underlie the volcanic rocks.

North of McPhaul Bridge, these sediments are nearly identical to those occurring 1¼ miles farther south, at the northern base of the Gila Mountains (see pages 187-188). They consist of well-stratified sandstone, silts, and gypsiferous clays, which range in color between maroon, cream, gray, and pale green. The sandstones tend to be mediumly coarse with a cross-bedded texture, but locally contain rounded pebbles up to two inches in diameter. The finer layers show ripple marks and mud cracks.

These beds develop no progressive variation in texture to the very base of the Laguna Mountains, with which they are in fault contact. Other faults cut them, and they are tilted in various directions from 20° to 30° or more. Due to such faulting, their total thickness is unknown.

In the northern portion of the range, the piedmont sediments are predominantly finer grained and ligther colored. On the California side of the Colorado River near Laguna Dam, they consist mainly of poorly stratified, coarse, subangular, granitic gravels which extend under basalt flows.

Because of their structure, locally indurated character, and stratigraphic position beneath lavas, these strata are regarded as Tertiary in age. They are of economic importance because they constitute the bedrock for most of the placers in the Laguna Mountains. Some of their clays are of economic interest, but no geologic study has been made of them.

Volcanic rocks: In the western portion of this range, near the Colorado River, several areas of volcanic rocks rest upon a rough erosion surface of the gneiss. For a short distance south of Castle Dome Landing, similar rocks seem to overlie unconsolidated sediments. Megascopically, these volcanic rocks appear to be of andesitic composition. Their lower portion is glassy and contains foreign granitic fragments, but passes upward into gray tuffs and lavas that weather from dark to reddish brown. The total thickness of this volcanic series probably amounts to several hundred feet, but, because of considerable faulting and tilting, it was not measured. So far as known, they have not been of any economic importance.

Quaternary formations: Resting upon the bevelled surface of the Tertiary (?) beds, and overlapping upon the rough surfaces of the gneiss, schist, and volcanics, is a thick series of poorly stratified, weakly consolidated gravels, together with minor sands, clays, and silts. Apart from initial dips, their stratification appears to be horizontal. Generally, their constituents are of coarser texture near outcrops of hard rock. Northwest and west of McPhaul Bridge, this series constitutes much of the Laguna range and attains a height of 695 feet above sea level, or more than 500 feet above the Gila River. Near the base, it is fine grained and consists mainly of reworked portions of the underlying Tertiary (?) strata. Upward, however, more gravel is present within the formation and residual upon its weathered slopes.

The gravels are of rather heterogeneous character, varying from fine to bouldery, and round to subangular. They include quartz, quartzite, schist, granite, gneiss, lava, etc., partly of local origin and partly derived from a distance. A few rounded pebbles of blue dumortierite, such as is known to occur in place no nearer than some forty miles farther up the Colorado River, were observed.

Stratified sand, silt and clay, probably either contemporaneous with or later than these gravels, constitute the saddle between the northern and southern portions of the Laguna Mountains, and floor much of the plains northeastward. Along the Silver District road, these sediments are mantled by a thin veneer of rounded pebbles, and in places littered with petrified wood (see description, page 33). A few small fragments of fossil bone were found in them. These gravels, sands, silts, and clays are believed to have been deposited by the Colorado and Gila rivers when, in Quaternary time, they occupied considerably higher levels than at present.

MINERAL DEPOSITS

The only mineral deposits that have been of economic importance in the Laguna Mountains are the gold-quartz veins of Las Flores district, and the gold placers of the southern portion of the range.

The veins occupy zones of shearing and brecciation within schist. The longest is traceable for more than 300 feet, but most of them are of irregular or lenticular form. Some of the more lenticular veins are highly shattered. The quartz is of coarse texture and white to grayish color. In places, its massive structure is interrupted by groups of small cavities. Abundant iron oxide and locally abundant carbonate occur in the cavities and fractures. Sericite and yellow iron oxide, together with minor amounts of manganese dioxide and gypsum, are intermingled with the more shattered quartz. Certain veins contain ragged grains of gold in the quartz and also associated with iron oxide within fractures or cavities. No sulphides occur down to the shallow depth exposed, but their original presence and subsequent oxidation are indicated by the physical and mineralogic character of the veins.

The principal alteration of the vein walls consists of sericitization along with less marked silicification and carbonatization. These veins clearly belong to the mesothermal type.

LAS FLORES DISTRICT

Las Flores district is in the southeastern portion of the Laguna Mountains and 1¼ miles north of the Gila River. It is accessible by ¾ mile of road that branches northwestward from the Yuma-Quartzsite highway at a point about 3¼ miles from McPhaul Bridge. By this road, the district is approximately 4¾ miles from the railway.

Mineralization here was probably discovered prior to 1865, but almost no details of the local history or production have been learned. Raymond[180] stated that, in 1870, "At Las Flores, a small five-stamp mill has been at work for a part of the year, crushing gold quartz from some small veins in the vicinity. The enterprise seems to be a success . . . . . ." Mexican and Indian placer miners founded the town of Las Flores during the sixties. At present, nothing of this settlement remains except a few ruined adobe buildings, near the highway.

Here, the Laguna Mountains rise to 1,081 feet above sea level, or more than 900 feet above the Gila River, and are sharply dissected by short, eastward-trending canyon systems. Las Flores

[180] Raymond, R. W., Statistics of mines and mining in the states and territories west of the Rocky Mountains, (1870): p. 272. Washington, 1872.

district is near the head of an alluvium-floored re-entrant, at an elevation of 300 to 400 feet above sea level.

Black, striped, well-laminated schists, similar to those in the northern portion of Gila Mountains (see page 203), make up the prevailing rocks. They generally strike N. 35° E. and dip 20° NW., but some notable local variations, due to faulting, occur. A prominent phase of this schist is seen, in thin section under the microscope, to consist of angular to semi-rounded grains of orthoclase, microcline, and quartz. Part of the quartz is of secondary origin. Abundant shreds of biotite, arranged roughly parallel, are present. The feldspars and the sparse matrix are considerably sericitized. The rock is probably a metamorphosed arkose.

In places, dikes and irregular masses of gray granite intrude the schist and are in turn cut by a few narrow dikes of pegmatite and of fine-grained, white, aplitic granite. Microscopic study of the gray granite shows it to be made up of irregular crystals of quartz and feldspar together with minor amounts of chloritized biotite and less muscovite. The feldspars are mostly orthoclase and microcline, but some albite is present. This rock is a microcline granite.

Traeger or Agate mine: The old Traeger or Agate mine is on a quartz vein that outcrops a few feet west of a parallel dike of the aplitic granite. Considerable silicification marks the schist near this dike. The quartz vein, which is two feet or more wide, dips westward and extends S. 15° W. for about 300 feet, beyond which it changes in strike and narrows in width. Most of this quartz is coarse grained and white, blending into bluish gray near the vein walls. It is generally massive, but contains some cellular portions. In certain places, it shows considerable fracturing. Abundant iron oxide fills most of the fractures and cellular cavities. Sericitic alteration is apparent in the vein walls.

This vein has been stoped from the surface for a length of about 75 feet and a maximum depth of 25 feet. An inclined shaft extends for some distance down the dip of the vein below this stope. These workings are said to have been made fifty or more years ago, but no information regarding the grade of the ore and the production are available. The only remaining surface equipment consists of an old boiler, a steam engine, and a pan amalgamator.

Golden Queen claim: Northeastward, the dike, silicified zone, and quartz vein of the old Traeger mine are interrupted by detrital gravels, but a similar zone, striking also S. 15° W., outcrops about ¼ mile farther north, on the Golden Queen claim. This claim is held by Messrs. C. D. Schoening, C. G. Norton, C. O. Baker, A. McIntyre, W. L. Kerr, and J. C. Martin. Here, the schist is considerably fractured and iron stained. Several lenticular quartz veins occupy divergent fault zones and have been considerably fractured, predominantly in directions parallel to their walls. In a low saddle, the principal vein strikes eastward, dips irregularly southward, and is from a few inches to 1½ feet thick. Its white to gray, brecciated quartz is somewhat intermingled with gouge, sericite, and yellow iron oxide. The quartz itself is locally stained by iron oxide that follows many fine fractures and occupies small cavities. Minor amounts of manganese dioxide and gypsum also occupy certain fractures. Locally, ragged grains of gold, up to 1/20 inch in diameter, occur in the quartz as well as within the iron-stained fractures and the iron oxide cavity-fillings.

A few shallow old stopes indicate that ore was mined from this vein during the early days. During 1931, a small quantity of rich ore was mined from the outcrop. A 22-foot shaft cut through the principal vein and exposed a parallel brecciated, sericitized zone with very little quartz. Early in 1932, Mr. J. C. Martin and others sank an eighty-foot shaft fifty feet farther north, and started a crosscut southeastward towards the vein. Except for a few thin, low-grade or barren quartz veins, these workings were in barren ground.

Surface equipment on this property includes a 6 h.p. hoist, a 2 h.p. gas engine, a 2-drill compressor, and a small blower.

A little placer mining has been done in the shallow gully for about 300 feet southward from the outcrop and also in the gulch northeast of the shaft.

Pandino claim: The Pandino claim is a few hundred feet northwest of the old Traeger mine. In 1931, this claim was held by Messrs. C. Baker and A. McIntyre. Workings consisted of some recent shallow cuts and an old shaft, probably about 190 feet deep. This shaft, which inclines 30° W. near the surface, is sunk on a granitic dike that is about three feet thick and has a thin, lenticular vein of somewhat fractured white quartz along its footwall. Black iron oxide marks many of these fractures, but iron oxide of a redder tint fills numerous small cavities. In places, this quartz contains a little free gold. The vein walls show sericitic alteration.

Near by, above the granitic dike, a few narrow, irregular, iron-stained quartz veins traverse the schist.

In June, 1932, according to Mr. J. C. Martin, several tons of sorted ore were shipped from this claim.

India claim: The India claim, some 750 feet southeast of the Golden Queen shaft, is held by Mr. W. L. Kerr. Here, a few shallow open cuts have been made on silicified, sericitized, brecciated zones in the schist. Some of them show narrow, lenticular quartz veins that pan a little gold. This quartz, which is of white to grayish color and coarsely granular texture, contains many interlacing veinlets of brown calcite and more or less iron stain.

LAGUNA PLACERS

McPhaul area: Considerable placer mining has been done in the southern portion of the Laguna Mountains, from near the

Gila River to about 1¼ miles north of McPhaul Bridge. Most of this work was done many years ago, but a little dry-washing is still carried on. No production figures for this particular area are available. During some years, its yield was lumped with that of Gila City.

These placers conform to the exposure of tilted, bevelled, Tertiary (?) sediments that constitute their bedrock. They occupy an area of approximately ¾ square mile, limited on the north and east by the hard rocks of the Laguna Mountains, on the south by the Gila River bottom lands, and on the west by the high gravel capping of the range. The Tertiary (?) strata, whose general character has been described on page 212, strike and dip in various dirctions, but a northerly or northwesterly strike appears to predominate. Many southeastward-trending arroyos have dissected the area. Most of the evidences of placer mining activity are confined to the inter-arroyo benches near the base of the overlying gravels, but some at lower elevations and also along the arroyo bottoms are evident.

Las Flores area: According to Raymond,[181] placer mining was carried on in the Las Flores area, chiefly by Mexicans and Indians, at about the time when the Gila City placers were most active. Part of this placer gold occurred in the vicinity of the Golden Queen and India claims (see pages 215, 216), and some was followed downstream to the bank of the Gila River. A little placer mining has been done in several gulches along the southern margin of the mountains. No record or estimate of the amount of gold recovered is available.

Laguna Dam area: At the eastern end of Laguna Dam, masses of black schist and coarse, granitic gneiss rise steeply for 250 feet above the Colorado River. Erosion of certain quartz veins in these rocks has given rise to coarse placer gold that, in places, extends into the bed of the Colorado River. In 1884 or 1885, a crude attempt was made to recover this river-channel gold by dredging, but a flood destroyed the dredge before it attained any success.

In 1907, during the construction of Laguna Dam, placer nuggets and a small gold-quartz vein were found at the river margin of these mountains.[182] Considerable placer prospecting has been done in several of the gulches of this area, and certain potholes, up to 100 feet above the river, were found to carry rather coarse gold. This coarseness points to a local origin rather than to a long transportation by the Colorado River. The U. S. Mineral Resources report from the Laguna placers a production of $1,457 in 1910 and $1,989 in 1912. The potholes yielded most of this amount, and they have made some production since then.

Similar, but more extensive, pothole placers occur on the California side of the Colorado River.

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[181] Raymond, R. W., work cited, p. 272.

[182] Oral communication from Mr. A. B. Ming.

CHAPTER XXV — MUGGINS MOUNTAINS

SITUATION AND ACCESSIBILITY

The Muggins Mountains, which occupy parts of Ts. 7 and 8 S., Rs. 18, 19, and 20 W., begin at the southern end of Castle Dome Plain and extend to within two miles of the Gila River. Their oval-shaped area is fourteen miles long by nine miles wide and includes approximately 51 square miles. They are said to have been named after an early-day prospector's burro.

The Muggins Mountains are uninhabited, but many farmers live in the adjacent Gila Valley, and Wellton is six miles south of the range. As shown by Plate 1, the old Castle Dome Road touches the western end of these mountains, and an indefinite car-trail skirts their southern margin, 2½ miles north of the Southern Pacific Railway. Various obscure branches from these roads lead into the range.

TOPOGRAPHY

The Fortuna and Laguna topographic sheets, issued by the U. S. Geological Survey in 1929, include the western 4½ miles of the Muggins Mountains, and the Wellton sheet, surveyed in 1926, covers some twenty square miles of their southeastern portion. Their western area has a maximum elevation of 1,633 feet above sea level, or 1,450 feet above the Gila River, and consists mainly of two sharp, intricately dissected, northwestward-trending ridges. Slopes of 1,000 or more feet within ¾ mile are common here, and, particularly in the southwestern portion, many of the canyons have cliffy walls. Long Mountain, 1,631 feet above sea level, is the highest peak in the southern part of the range, but the reddish spires of Klotho Temple, or Coronation Peak, are more noticeable from the south. The middle four miles of the range consists of weakly consolidated gravels which weather into a somewhat lower, gentler topography, but the easternmost five miles is topographically similar to the southwestern portion.

The plains adjacent to the Muggins Mountains rise from 200 feet above sea level at the south to a maximum of approximately 600 feet above sea level at the north.[183]

Run-off from the southern portion of the range drains through many deep, steep-sided arroyos directly to the Gila River, and that from the northern side finds its way around both the eastern and western ends of the range to the same destination.

GEOLOGY

The oldest rocks exposed in the Muggins Mountains are biotite schists and gneisses that constitute the northwestern portion of

[183] Aneroid determination by Mr. Thos. W. Maddock, of the Arizona Colorado River Commission.

the range. Although no detailed study of these rocks was made during the present investigation, they are tentatively regarded as pre-Cambrian. Their principal system of jointing strikes east-southeastward and dips about 20° southward, but another prominent system strikes the same way and dips in the opposite direction, and several minor joint systems are transverse to these two. Abundant pegmatite dikes cut these rocks.

Next younger than the schists and gneisses is a series of indurated arkoses, sandstones, shales, and impure limestones that outcrop in a small area at the northeastern corner of the range. These strata are gray, brown, and maroon in color, and seem lithologically identical with the Mesozoic beds that appear twelve miles farther north in the Castle Dome Mountains. They strike west-northwest and dip 7° to 15° S. Because of faulting, no estimate of their exposed thickness was made. A medium-grained, altered, femic intrusive cuts the series at top and bottom.

Above these sedimentary rocks is a considerable thickness of andesitic lavas that weather black to pinkish brown. Unconformably above them is a thick series of breccias, agglomerates, and tuffs that in places are well stratified and nearly flat-lying. The volcanic rocks of the high, eastern portion of the range, including an area about two miles wide by four miles long (see Plate 1), appear to be of similar character. In the southwestern portion of the range, Long Mountain and Klotho Temple are made up largely of platy, rhyolitic flows that dip about 10° SW.-W. and are probably older than the agglomerates.

Outcropping at several places around the margin of Muggins Mountains, and particularly along their southern edge, is a thick series of light-colored, locally stratified clays and silts. These sediments appear to be equivalent to the probable Tertiary beds that are marginal to the Laguna and Gila mountains (see pages 187, 212). In places, the clays may be of potential economic importance.

Above these clays and silts, and overlapping the schists, gneisses, and lavas, are several hundred feet of gravels that appear identical to the high gravels of the Laguna Mountains (see page 213). They constitute the central four miles of the range. and attain elevations of more than 1,000 feet above sea level.

MINERAL DEPOSITS

Much surface prospecting has been carried on in the Muggins Mountains, but, so far, no lode deposits of any consequence have been found there. Many quartz veins, some of which carry a little free gold, occur in the range. Minor, local, copper mineralization, generally associated with quartz veins and pegmatite dikes, is evident in many places.

Minor gold placers occur at a few places along the southern margin of the range, particularly south of Klotho or Muggins

Peak where the bedrock is coarse-grained cemented gravel, older than part of the lavas and apparently derived from the gneiss and schist of the main mountain mass. A little gold is occasionally recovered from the stream channels and benches of this area. Another placer area occurs near the headward forks of the long, northwestward-trending canyon that bisects the western end of the range. This area, which is reported to have yielded many rich pockets during the early days, is still worked to some extent after heavy rains. Its gold probably accumulated from the disintegration of quartz veins contained in the neighboring schists and gneisses.

RADIUM HOT SPRINGS

A group of thermal springs is on the northern bank of the Gila River near the southeastern margin of the Muggins Mountains, in Sec. 12, T. 8 S., R. 18 W. In 1930, it was held by Dr. C. A. Eaton, of Yuma, who was developing the place for a health resort called Radium Hot Springs. From the highway at Tacna, this place is accessible by eleven miles of road.

Here, a small hill of brown sericitized andesite rises less than 100 feet above the flood plain. The thermal water, which bubbles up from the mud flat of the river at the base of this hill, is said by the manager of the resort to have a temperature of approximately 140° F. According to an analysis made in 1924 by Dr. T. F. Buehrer, of the University of Arizona, this water contains the following:

Constituents	*Parts per million*
Total dissolved solids	2,804.0
SiO_2	101.0
Fe and Al oxides	3.9
Ca	162.0
Mg	none
Na	746.0
K	17.0
Cl	740.0
SO_4	898.0
CO_3	none
Bicarbonates	73.0

Radium element (niton), 1.2×10^{-9} grams per liter, approx.

According to Dr. Buehrer,[184] the radium emanation of this water is approximately equivalent to that of most hot springs in the western United States.

The heat of this water is probably due to deep-seated, quiescent volcanic activity.

[184] Oral communication.

CHAPTER XXVI—YUMA VICINITY

In the southern part of Yuma, just west of the railway, a small hill of dark-gray, coarse-grained, biotite granite rises to about 100 feet above the plain. One mile farther southeast is a similar hill, partly reduced to a pediment, that consists largely of coarse-grained biotite gneiss. At the north side of the highway, two miles in a S. 20° E. direction from this hill, a smaller mass of dark-gray, coarse-grained biotite granite rises about 100 feet above Yuma Mesa. One mile farther in the same direction, a larger hill of similar material has an elevation of 325 feet above sea level, or 125 feet above Yuma Mesa.

The granite of the first hill has been extensively quarried for crushed rock. During the extension of the Yuma irrigation project in 1921 and 1922, material from the third hill was quarried and crushed for concrete-pipe manufacture. The second hill contains the gold-bearing quartz veins of the Jude mine.

JUDE MINE

The Jude mine consists of two claims which, in 1931, were held by Messrs. L. Hedgepeth, F. Timmons, and B. Gutchmaker. About 25 years ago, according to local people, several sacks of rich gold ore were shipped from these claims.

Here, the gneiss, which strikes approximately southwest and dips steeply southeast, has been cut by many fractures and minor faults, some of which contain narrow stringers of white quartz. The principal fault zone, which strikes and dips with the gneiss, contains a vein of coarse-grained, banded, vitreous, translucent quartz, whose irregular thickness in places amounts to two feet. Some of this quartz contains small crystals of pyrite and it is more or less iron stained. In places, the vein gives way to pockets of limonite.

Workings on this vein include several old shafts, a few short drifts, and shallow surface cuts.

PART III — APPENDIX

PREVIOUS INVESTIGATIONS

In 1909, the U. S. Geological Survey made a reconnaissance of the ore deposits of *northern* Yuma County,[185] but has described deposits only in part of one range [186] in the southern half.

In 1917, Kirk Bryan [187] and C. P. Ross,[188] of the U. S. Geological Survey, made geographic, geologic, and hydrologic reconnaissances of the Papago and Lower Gila regions, respectively. Part of their work entailed the erection of road signs and the preparation of descriptive guides to the principal watering places. Their reports, which include Bryan's monumental physiographic analysis of the Papago region, are the most detailed accounts of the whole of southwestern Arizona that have yet been issued.

In 1921 and 1922, the Arizona Bureau of Mines, in cooperation with the U. S. Geological Survey, supplemented all earlier work with a geologic reconnaissance that was concerned with obtaining data for the present topographic and geologic maps of Arizona.[189] In 1924, N. H. Darton [190] wrote a summary of Arizona geology, as then known.

Although many mining engineers and geologists have examined mineral deposits in certain portions of this area, most of their reports have remained of a private nature. As indicated in the bibliography on pages 223-227, only a few published articles deal with the mining districts. Among them, the works of the late Wm. P. Blake are particularly noteworthy.

[185] Bancroft, H., Reconnaissance of the ore deposits in northern Yuma County, Arizona: U. S. Geol. Survey Bul. 451. 1911.

[186] Jones, E. L., Jr., A reconnaissance in the Kofa Mountains, Arizona: U. S. Geol. Survey Bul. 620, pp. 151-164. 1915.

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

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[189] Published in 1923 and 1924 by the Arizona Bureau of Mines, in cooperation with the U. S. Geological Survey.

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FREIGHT RATES

The following freight rates, per ton of 2,000 lbs., existed in March, 1933, but are subject to change without notice. These rates applied to carload lots with a minimum weight of 60,000 lbs. per car. For one-ton lots, the rates to the smelters in Arizona were 140 percent of the carload rate, and to El Paso and San Francisco were 130 percent of the carload rate.

Value per ton of 2,000 lbs.	$15	$20	$30	$40	$50	$75	$100	$125	$150	$300
From Yuma, Ariz., to:										
El Paso, Tex.	$4.50	$4.80	$5.10	$5.40	$5.70	$6.30	$6.90	$7.50	$8.10	$12.50
Douglas, Ariz.	3.20	3.50	3.80	4.10	4.40	5.00	5.60	6.20	6.80	11.20
Hayden, Ariz.	2.40	2.70	3.00	3.30	3.60	4.20	4.80	5.40	6.00	7.80
San Francisco, Calif.					7.43		9.00			11.25
From Dome, Ariz., to:										
El Paso, Tex.	4.50	4.80	5.10	5.40	5.70	6.30	6.90	7.50	8.10	12.50
Douglas, Ariz.	3.20	3.50	3.80	4.10	4.40	5.00	5.60	6.20	6.80	11.20
Hayden, Ariz.	2.40	2.70	3.00	3.30	3.60	4.20	4.80	5.40	6.00	7.80
San Francisco, Calif.					9.34					11.59
From Hyder, Ariz., to:										
El Paso, Tex.	4.10	4.40	4.70	5.00	5.30	5.90	6.50	7.10	7.70	9.10
Douglas, Ariz.	3.00	3.30	3.60	3.90	4.20	4.80	5.40	6.00	6.60	7.56
Hayden, Ariz.	1.80	2.10	2.40	2.70	3.00	3.60	4.20	4.80	5.40	5.88

All interstate rates are subject to 6c per ton emergency charge.

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BULLETINS AVAILABLE

The Arizona Bureau of Mines still has the following bulletins available for free distribution to residents of Arizona. Bulletins not listed herein are out of stock and cannot be procured from the Bureau. Any three bulletins will be sent free of charge to non-residents of the State, and additional numbers may be purchased at the uniform rate of ten cents each.

120. Gold and Copper Deposits near Payson, Arizona, by Carl Lausen and Eldred D. Wilson.

122. Quicksilver (Mercury) Resources of Arizona, by Carl Lausen and E. D. Gardner.

123. Geology and Ore Deposits of the Courtland-Gleeson Region, by Eldred D. Wilson.

125. Mineral Industries of Arizona, by J. B. Tenney.

126. Asbestos Deposits of Arizona, by Eldred D. Wilson and G. M. Butler.

127. Manganese Ore Deposits of Arizona, by Eldred D. Wilson and G. M. Butler.

128. Field Tests for the Common Metals, by G. R. Fansett.

129. The Mineral Industries of Arizona (Biennial Report) by J. B. Tenney.

130. Petroleum, by G. M. Butler and J. B. Tenney.

131. Geology and Ore Deposits of the Oatman and Katherine Districts, Arizona, by Carl Lausen.

132. Arizona Gold Placers and Placering.

133. Treating Gold Ores, by T. G. Chapman.

(The following voluminous, beautifully illustrated Bulletin is sold for $1.00):

119. A Resumé of the Geology of Arizona, by N. H. Darton.