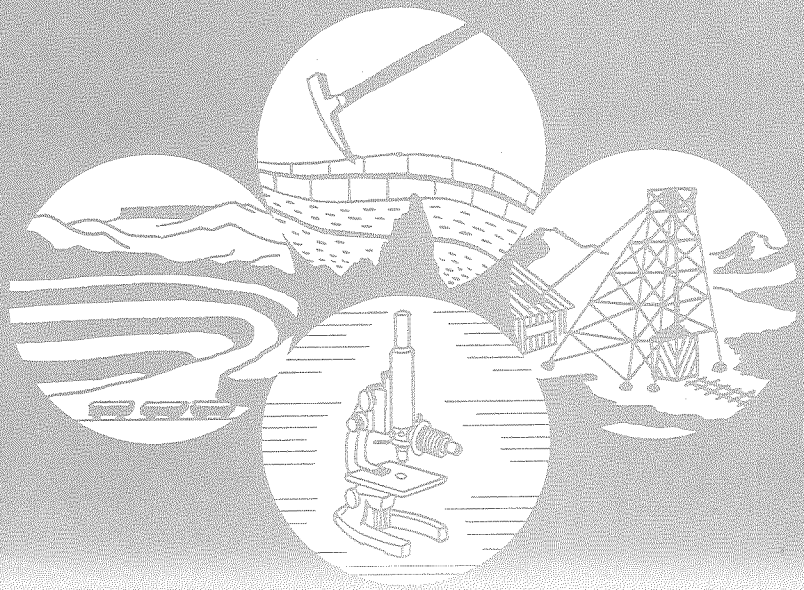
MINERAL DEPOSITS OF THE GILA RIVER INDIAN RESERVATION, ARIZONA

by
Eldred D. Wilson

THE ARIZONA BUREAU OF MINES

Bulletin 179
1969



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THE UNIVERSITY OF ARIZONA

TUCSON

FOREWORD

This report by the late Eldred D. Wilson, Geologist, Arizona Bureau of Mines, presents the findings of a survey made by the Arizona Bureau of Mines, University of Arizona, for the United States Department of the Interior, Bureau of Indian Affairs, Pima Agency, Sacaton, Arizona.

The basic purpose and essential scope of the work were those of conducting a geological survey of the Gila River Indian Reservation of Arizona to ascertain what potentially valuable metallic and nonmetallic (industrial) mineral and rock deposits occur within the boundaries of the Reservation.

Permission to publish the findings as a technical bulletin of the Arizona Bureau of Mines kindly has been granted by the United States Department of the Interior, Bureau of Indian Affairs.

J. D. Forrester, Director
Arizona Bureau of Mines
University of Arizona
Tucson, Arizona

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INTRODUCTION

GENERAL STATEMENT

Scope of Study

This study concerns the distribution, geologic character, probable extent, and potential economic importance of those various mineral substances that have been found to occur within the Gila River Indian Reservation in Arizona. Information regarding these items was obtained by means of geologic examination and mapping, supplemented by laboratory tests and analyses, during a period which extended from April 17 to August 18, 1963.

The report offers suggestions for future prospecting and field exploration, but it does not attempt to give quantitative (tonnage) estimates of the occurrences of economic materials or the total value for any of the mineral deposits.

Previous Geologic Work

No descriptions of the mineral deposits in the Gila River Indian Reservation have been published previously. Reports * by the following authors deal primarily with water resources and irrigation in the region: Newell (1891); Davis (1897); Lippincott (1900); Lee (1904, 1905); Cushman (1952); Wolcott (1952). Some information on the general topography and geology has been given by Bryan (1925) and by Darton (1925, 1933). The Geologic Map of Pinal County (Wilson and Moore, 1959) depicts the broad geologic and topographic features of the Reservation on a scale of 1:375,000. This is the approximate equivalent of 1 inch being equal to 6 miles.

PHYSICAL FEATURES

Location and Extent

The Gila River Indian Reservation, which was established in 1858, occupies an irregularly shaped tract, approximately 46 miles long from east to west by 29 miles wide from north to south. It lies in northwestern Pinal County and southeastern Maricopa County, Arizona (fig. 1). According to Mr. W. Baskin † of the Bureau of Indian Affairs, it includes 372,022 acres.

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* See list of literature cited, p. 33.
† Oral communication.

Topography

The general topographic and cultural features of the Reservation, including the main surface-transportation routes and selected access roads, are indicated on plate 1. For additional and more detailed information concerning these features, reference may be made to the topographic quadrangle maps issued by the U.S. Geological Survey (fig. 2). Of these maps, the 7½-minute editions, printed in 1952 or later, are especially useful for locating roads, ditches, and other cultural features.

Plains and Stream Channels. A major portion of the Reservation is covered by the Gila River plain or "valley" (pl. 1). Merging with it in the western and northwestern parts of the area are the plains of Santa Cruz Wash, Vekol Wash, and Salt River.

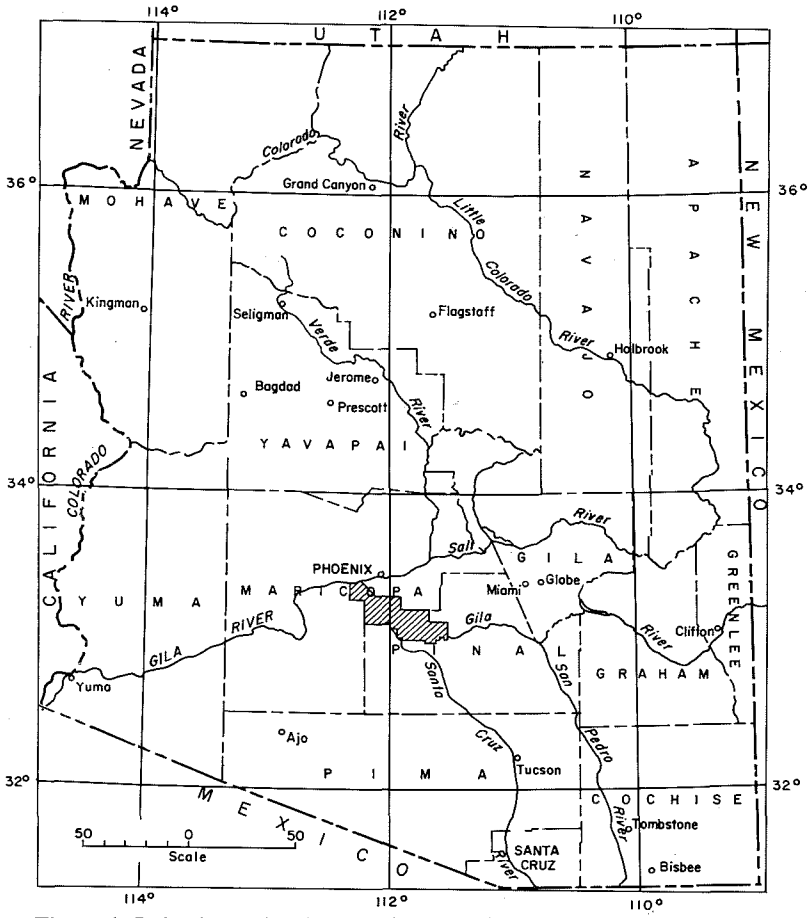
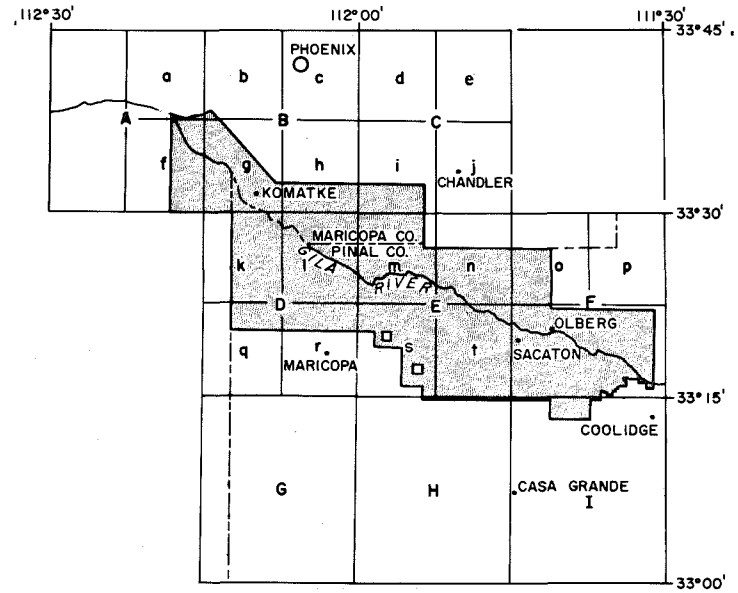


Figure 1. Index Map showing location of Gila River Indian Reservation.



7.5′ QUADRANGLES		15′ QUADRANGLES
a. Tolleson	k. Montezuma Peak	A. Cashion
b. Fowler	l. Pima Butte	B. Phoenix
c. Phoenix	m. Gila Butte NW.	C. Mesa
d. Tempe	n. Gila Butte	D. Maricopa
e. Mesa	o. Chandler Heights	E. Gila Butte
f. Avondale SE.	p. Sacaton NE.	F. Sacaton
g. Laveen	q. Enid	G. Antelope Peak
h. Lone Butte	r. Maricopa	H. Casa Grande
i. Guadalupe	s. Sacaton Butte	I. Signal Peak
j. Chandler	t. Gila Butte SE.	

Figure 2. Index of Topographic Quadrangle Maps issued by the U.S. Geological Survey.

The Gila River, the channel of which descends from an altitude above sea level of approximately 1,400 feet in R.8E. to 930 feet in T.1N., R.1E., has been intermittent in flow within the Reservation since the upstream development of modern irrigation systems. Historically, however, as deduced from old maps, the flow of both the Gila River and Salt River seems to have been more consistent, and their channels tended to meander notably from year to year. During more ancient times, as interpreted by Lee (1905), the course of the Salt River lay on the southeastern side of the Salt River Mountains.

The Santa Cruz, Vekol, and numerous other intermittent washes which occur within the region, are subject to seasonal floods and shifts of channels. When the channels overflow, the sheet-flooding which ensues may result in either erosion or in deposition of sediments.

The sinuous nature and the meandering patterns of the stream channels, together with the influences of flooding, are important considerations from the standpoint of possible exploitation of sand, gravel, and clay resources.

Mountains. Rising sharply from the Gila River plain are the Santan-Mineral Butte-Cholla Mountain group on the northeast, the Sacaton Mountains on the south, the Sierra Estrella on the west, and the Salt River Mountains on the northwest. Also, several isolated buttes occur in the central portions of the plain (pl. 1). Some salient features of the mountain topography are listed in the section titled AREAL DESCRIPTIONS.

Pediments. Pediments, or eroded rock surfaces, ranging in character from semi-planar to hill-contour type, tend to occur along the mountain margins, from which they slope gently outward and disappear beneath alluvium. Such surfaces are exceptionally wide in T.4S., R.5E., and in the northwestern part of T.5S., R.6E., at the northern base of the Sacaton Mountains; and in T.4S., R.7 and 8E., northeast of the Southern Pacific Railroad right-of-way. Elsewhere on the Reservation, the pediments are either relatively narrow or entirely buried.

Some pediment areas may be considered as worthy of prospecting inasmuch as many important ore deposits in southern Arizona have been discovered within pediment tracts that are more or less mantled by alluvium.

Climate

The temperatures and precipitation occurring within the Gila River Indian Reservation are exemplified at Sacaton (altitude 1,280 feet), for which the following data are abstracted from Sellers (1960).

For the period of 1908–1956, the average precipitation at Sacaton was 9.23 inches a year. The driest months were April, May, and June, which combined, received an average of 0.69 inch. The wettest months normally are July and August.

A secondary increase of precipitation usually occurs in the winter season. According to Sellers (1960), however, measurable amounts of snow at Sacaton, have been recorded only twice (on January 21, 1937, and March 12, 1922).

Summer months at Sacaton are hot; the afternoon Fahrenheit recordings generally extend into the nineties, and on most days, from mid-June through August, they exceed 100 degrees. This heat is alleviated somewhat by the low relative humidity; also, the night temperature may fall into the fifties or sixties.

From the middle of September to the middle of May, the afternoon temperatures average above 59 degrees. Even in the coldest months, they

occasionally reach into the eighties, although, owing to cold air moving from the northeast at night, the temperature usually falls rapidly into the middle or low thirties by daybreak. Minima below 20 degrees occur, on the average, for one or two mornings in every other winter.

The following extremes of temperature at Sacaton were recorded during 1908–1957 (Sellers, 1960):

Month	*Highest*	*Year*	*Lowest*	*Year*
Jan.	84	1935	9	1913
Feb.	92	1921	17	1910
March	98	1916	22	1922
April	106	1910	28	1945
May	117	1910	33	1915
June	117	1957	43	1908
July	116	1957	56	1912
Aug.	114	1957	56	1926
Sept.	114	1950	41	1908
Oct.	107	1910	28	1908
Nov.	98	1915	19	1956
Dec.	88	1916	12	1954

Vegetation

Because of the arid nature of the region, the native vegetation consists largely of shrubs, cacti, trees, and grasses of the desert type. These materials have served the Indian people throughout many centuries for domestic items such as fuel, food, shelter, and fabrics, but they would appear to be of little direct use in any future industrial program, especially as it might have reference to the development of mineral commodities.

From a geological standpoint, the scarcity of vegetation tends to promote rapid erosion. Also, the presence (or absence) of organic matter is a very important factor in controlling the physical character and the chemical composition of the soils and some commercial clays which occur in the region.

GENERAL GEOLOGY

Rock Units

The several kinds of rocks exposed on the Gila River Indian Reservation may be correlated, from youngest to oldest, as shown in table 1. For the benefit of readers unfamiliar with the chronology of the geologic eras, periods, and epochs, which are used in table 1, explanatory information is given in table 2.

Table 1. Correlation of rock units, Gila River Indian Reservation.

ERAS	PERIODS AND EPOCHS	GENERAL CHARACTER AND THICKNESS	SYMBOL ON PLATE 2
CENOZOIC	Quaternary and Tertiary	Sand, clay, gravel, and boulders, loosely to firmly consolidated; total thickness ranges from thin veneer to local maxima exceeding 1,000 feet.	Qs
		Angular discordance	
	Miocene (?)	Latite flows and pyroclastics, approximately 400 feet.	T1
		Volcanic tuff, poorly stratified, approximately 500 feet.	Tt
		Basalt flows and agglomerate, approximately 500 feet.	b
		Basaltic plugs and dikes.	Ti
		Gravel, sand, and boulders, loosely to firmly consolidated, approximately 600 feet.	Ts
		Erosion surface	
	Laramide	Aplite masses and dikes.	Lap
		Dioritic dikes.	Ld
		Granite masses and porphyry dikes.	Lgr
MESOZOIC		Dioritic masses and dikes.	di
		Dioritic to rhyolotic dikes.	Md
		Granite masses and pegmatite.	Mgr
PALEOZOIC	Devonian (?)	Limestone. Total thickness not exposed.	P
		Fault contact	
	Cambrian (?)	Quartzite. Total thickness not exposed.	P
		Angular discordance	
PRECAMBRIAN	Older	Granitic rocks (gr); strongly gneissoidal (gn).	gr gn
		Gneiss, locally schistose.	gns
		Schist.	sch

Table 2. General geologic time scale for Arizona.

ERAS	PERIODS AND EPOCHS	Millions of Years	MAJOR EVENTS IN STRUCTURAL HISTORY
CENOZOIC	Quaternary: Recent, Pleistocene		Volcanism and faulting.
		1	
	Tertiary: Pliocene, Miocene, Oligocene, Eocene		Laramide Revolution: granitic intrusions; mineralization; volcanism.
		70	
MESOZOIC	Late Cretaceous, Early Cretaceous, Jurassic, Triassic		Nevadan Revolution: granitic intrusions; mineralization; volcanism.
		200	General uplift.
PALEOZOIC	Permian, Pennsylvanian, Mississippian, Devonian, Silurian, Ordovician, Cambrian		Uplift in central Arizona. General uplift.
		550	
PRECAMBRIAN	Younger		Disturbance: diabase intrusions. Mazatzal Revolution: granitic intrusions; mineralization.
	Older	2,000+	

The geologic column, as presented in table 1, is a composite listing. That is, no single field locality in the immediate region displays the entire succession of the rock units.

The distribution and extent of the various rocks occurring in the Reservation are depicted on plates 2 and 3.

The field mapping from which plate 2 has been compiled was done on aerial photographs having a scale of one mile per inch. Also, supplementary use was made of the topographic quadrangle maps listed on figure 2. Plate 3 is based upon transit-stadia-plane table records made on a scale of 500 feet to the inch, together with an aerial photograph having a scale of 1,500 feet per inch.

Additional descriptions of the geologic mapping units are included in the section titled AREAL DESCRIPTIONS.

Structure

As deduced from what is known about the geologic history of southern Arizona, the region encompassed within the Gila River Indian Reservation experienced intervals of crustal disturbances that were of revolutionary intensity during Older Precambrian, Triassic-Jurassic, and Laramide (Late Cretaceous-Early Cenozoic) times. On the other hand, disturbances which took place during Younger Precambrian and Late Cenozoic times seem to have been generally of much less intensity (table 2). Each major period of crustal unrest was marked by folding, fracturing, and igneous invasion. Furthermore, the events of each interval influenced subsequent geologic history and mineral deposition.

During Older Precambrian time, the existing sedimentary and igneous rocks were compressed into close folds of northeastward trend, and they were invaded by granite, and metamorphosed into schist and gneiss. Also, the effects of Mesozoic, Laramide, and later Cenozoic folding may be inferred from the rock fabric (lineaments) and fracture patterns which occur.

The rock masses have been broken by many fractures, the greater number of which show little or no evidence of differential movement (faulting). In places, however, faulting is revealed by the presence of gouge or slickensides and by the occurrence of affiliated topographic features; but in most of these places the amount of displacement is indeterminate. Nevertheless, as the mountain ranges themselves are believed to represent relatively elevated fault blocks, considerable displacement may be inferred as having taken place along their boundary faults or fault zones, which now are concealed by alluvium.

The dominant strikes or trends of fracturing within the Reservation are systematic, rather than haphazard, as indicated by tabulations in the section titled AREAL DESCRIPTIONS.

MINERAL OCCURRENCES

The mineral occurrences which have been noted within the Gila River Indian Reservation are described in the section titled AREAL DESCRIPTIONS. They are tabulated here, as follows:

Nonmetallic Minerals

COMMODITIES	LOCATIONS	REMARKS
Sand and Gravel	River plains or "valley" areas	From the commercial standpoint, sand and gravel have been the most important mineral commodities on the Reservation. The production obtained through permits which have been issued during the past 7 years has amounted to 447,-196 tons and the reserves available to exploitation are enormous.
Clay	River plains	In addition to the clay occurrences which have been used locally for fabrication of adobe, there are several deposits of clay suitable for brick manufacturing. Also, other clays occur which have the bloating qualities requisite for manufacture of light-weight aggregate. The reserves are large.
Quartz	Sierra Estrella; Sacaton Mts.; Pima Butte	Quartz of high purity and suitable for use as smelter flux and roofing granules is found in some vein deposits. Also, quartz occurs with mica and feldspar in pegmatites.
Mica	Sierra Estrella; Pima Butte	Mica occurs in pegmatites and schist, and is a potential source of ground mica, if warranted by future markets.
Feldspar	Sierra Estrella; Pima Butte	Feldspar has been noted in pegmatites where it is commonly associated with mica and quartz. It is a potential source of ground feldspar, depending upon markets.

COMMODITIES	LOCATIONS	REMARKS
Granite	Sierra Estrella	Granite of excellent quality, which may serve as a source of dimension stone, occurs favorably situated with respect to quarry sites and transportation routes. Granite, suitable for use as rip-rap and railway ballast, occurs in several other localities.
Limestone	Sacaton Mts.	A small deposit of relatively impure limestone occurs here.
Corundum	Sacaton Mts.	The corundum deposit apparently is comparatively small.
Nitrates	Flats of Santa Cruz Wash	Nitrates occur as salty incrustations containing generally less than 1 percent sodium nitrate.

Metallic Minerals

COMMODITIES	LOCATIONS	REMARKS
Copper	Mineral Butte area (pls. 1 and 3)	Copper mineralization is apparent in many shallow pits. Samples indicate very low associated gold and silver values. Exploratory drilling for the discovery of additional copper deposits was carried on in 1963, but the results had not been announced as of August 18, 1963.
Copper, gold, and silver	Sierra Estrella and Sacaton Mts. (pl. 1)	A small tonnage of copper, gold and silver ore apparently was mined many years ago.
Gold and silver	Salt River Mts. (pl. 1)	Only small quantities of gold and silver ores have been recovered.
Iron	Sierra Estrella	Magnetite occurs with sand in several arroyos near the eastern margin of the range. It does not appear to have a potential of commercial importance.
Titanium	Sacaton Mts. (pl. 1)	Rutile occurs associated with corundum. The exposed deposits are small.

AREAL DESCRIPTIONS

SANTAN MOUNTAIN–MINERAL BUTTE–CHOLLA MOUNTAIN AREA

Location and Topography

The Santan Mountain-Mineral Butte-Cholla Mountain area is situated in T.3, 4, and 5S., R.6, 7, and 8E. (pls. 1 and 2).

The topography of this mountain tract is characterized by steep, rugged mountains, buttes, and ridges, bordered in R.7 and 8E. by a wide pediment which, in its southwestern portion, includes mesas and steep-sided canyons. Such details are featured on the Sacaton, Sacaton NE, Chandler Heights, and Gila Butte quadrangle topographic sheets (fig. 2).

Altitudes of the land surfaces range from 1,350 feet above sea level near the Gila River to 3,104 feet on Santan Mountain.

Rock Units

The rock materials are depicted on plates 2 and 3; see also tables 1 and 2, pages 6 and 7. The rock succession, from youngest to oldest, is as follows:

Quaternary and Tertiary. These materials are loosely to firmly consolidated gravel, sand, and clay, which surround the areas of older rocks and overlap them on pediments.

Miocene. Latitic volcanic flows or welded tuffs occur in T.3S., R.6E.; T.4S., R.7E.; and immediately to the east of the plate 3 area. The maximum thickness of the Miocene rocks situated within the Reservation is approximately 400 feet. The latitic flows rest upon older tuff and basalt.

Tuff, locally associated with some interbedded sand and gravel, occurs in the same general areas as the latite. The tuff apparently is more than 500 feet thick where it exists in the eastern locality but it wedges out in R.6E. It rests upon older basalt, granite, and schist.

Basalt flows and agglomerate occur in T.3 and 4S., R.6 and 7E. The maximum thickness of these materials is approximately 500 feet.

Loosely to firmly consolidated boulders, gravel, and sand exist in the northwestern portion of T.4S., R.7E. They are presumably analogous to the Whitetail Conglomerate.

Laramide. Aplite, classified as being of Laramide age, occurs as a small stock apparently intruding earlier Laramide granite, southeast of Mineral Butte. As identified microscopically, the aplite is 60 percent orthoclase, 10 percent oligoclase, 10 percent quartz, 8 percent biotite, and 12 percent other, minor constituents. Dikes of dioritic composition also have been observed.

Granite, in the form of a stock some 3.75 miles long, and intruding Precambrian schist and granite, occurs in R.7 and 8E. The stock extends northward across the Reservation boundary; it is 0.8 mile in maximum total width. By microscopic examination, a sample of this granite was found to be 50 percent orthoclase, 35 percent quartz, 3 percent sericite, 4 percent hydrous iron oxides, and 8 percent other constituents. Some granitic dikes also have been observed.

Mesozoic (?). Dikes of rhyolitic to dioritic composition, believed to be of Mesozoic age, have been observed in the region.

Older Precambrian. Granite, of coarse- to medium-grained texture has been noted. Samples of these rocks, examined microscopically, were found generally to contain from 54 to 70 percent orthoclase, 1 to 14 percent oligoclase, 15 to 18 percent quartz, 6 to 10 percent biotite, and 4 percent, or less, muscovite. Possibly this rock unit, as mapped, includes also some granites of younger ages.

Schists of sedimentary and igneous origin have been observed.

Structure

The attitudes of foliation in the schist and of layering in the volcanic rocks which exist in the area are indicated in a general way on plates 2 and 3. Fracturing which has transpired of the Laramide and older rocks, as exemplified in the Mineral Butte area, may be characterized as follows:

STRIKE	DIP	REMARKS
N. - S.	Steep to 90°	Locally effect lamination as in ridge saddles. Some fractures contain dioritic dikes. Some are mineralized.
N.60°W.	60°NE. to 90°	Closely spaced in places. Some contain dioritic dikes. Locally mineralized.
N.30°W.	45°SW. to steep	Form zones in places. Some contain dioritic dikes. Locally mineralized. Displacement evident on some, particularly the fault immediately southwest of Mineral Butte.
N.45°W.	Steep	Tend to form zones.
N.75°W.	45°-60°SW.	Locally show displacement and mineralization.
E. - W.	Medium to steep	Some contain dioritic and granitic dikes. Locally mineralized.
N.45°E.	Steep	Commonly mineralized.

STRIKE	DIP	REMARKS
N.60°E.	Medium to steep	Many are mineralized. Contain dikes of diorite porphyry and granite in northwestern portion of T.4S., R.8E.
N.75°E.	45°NW. to steep	Locally contain veinlets of iron oxide; parallel to main ridges.

Copper Deposits

The reddish-brown, iron-stained outcrops and other evidences of mineralization which occur in the Mineral Butte vicinity, T.4S., R.7 and 8E., attracted prospectors at an early date, and the area extending east and south from Santan Mountain, through Cholla Mountain, became known as the Blackwater (or sometimes the Black Rock) District. Some gold, silver, and copper ores were mined more than 40 years ago in the district, but from localities lying outside the limits of the Reservation.

Within the Reservation, many claims were located in the northeastern portion of T.4S., R.7E. and in the northwestern portion of T.4S., R.8E. Under regulations of the Act of June 30, 1919, as amended November 11, 1920, a large group of the claims was surveyed (U.S. Mineral Survey No. 3739) in 1921, but these claims were not patented. Six claims of the group were resurveyed (U.S. Mineral Survey No. 3922) in 1922 for the Sacaton Copper Company, but they were not patented.

The Sacaton Copper Company, controlled by Magma Copper Company, undertook some exploratory drilling* here and presumably put down in 1922 the three old churn-drill holes, indicated by "CH" on plate 3.

At the time of the field work for this report, the Bear Creek Mining Company was drilling in the Mineral Butte area on both sides of the Reservation boundary; the sites of some of these holes are indicated by "DH" and "DdH" on plate 3. As of August 1963, no results from this exploratory work had been announced.

The principal surface evidence of mineralization in the Mineral Butte area may be summarized as follows:

Chysocolla and copper stain as they occur in fractures existing in the Laramide granite stock, are exposed at many places (pl. 3). The copper minerals commonly replace silicified, somewhat sericitized granite for short distances into the fracture walls.

The Laramide granite for the most part, although not everywhere, contains sufficient quantities of iron oxides to color it brownish-red. The oxidized iron is relatively more abundant in associaton wth some fracture zones and, in places, it exhibits the texture and purplish-red color suggestive of gossan material.

* Weed, W. H., 1925, The Mines Handbook, Vol. XVI, p. 371.

The aforementioned surface indications were prospected many years ago by numerous shallow pits and trenches, the general features of which are summarized in table 3.

Table 3. Data of prospect pits featured on plate 3 (Those pits that are not listed are either barren or not significant).

LOCATION COORDINATES North	East	GENERAL FEATURES
796,810	601,590	Trench, 55 ft. long x 15 ft. wide x 10 ft. deep. Chrysocolla and copper stain irregularly distributed in hanging-wall zone of the N.75°W. fault over a length of 55 feet; relatively abundant in three spots, 5-10 feet in diameter, where tight N.45°E. and N.60°E. fractures intersect the hanging-wall zone. General samples: Visibly mineralized zone, 3.4 percent copper, no gold, and 0.07 oz. silver per ton; adjacent wall rock, 0.06 percent copper, trace of gold, and 0.05 oz. silver per ton.
796,880	601,770	Shallow, copper mineralization along N. 60°E. fracture.
768,390 768,280	602,420 602,480	Pits 6 and 8 feet deep in trench along the N. 30°W. fracture; chrysocolla and copper stain where this fracture is intersected by N.60°E. and N.45°E. fractures. General samples: Visibly mineralized zone, width 7-19 ft., 2.7 percent copper, no gold, and 0.05 oz. silver per ton; adjacent wall rock, 0.08 percent copper, trace of gold, and 0.05 oz. silver per ton.
768,360	602,520	Shallow, copper mineralization along N. 60°E. fractures.
768,405 768,575	602,520 602,900	Pits 3 ft. deep. Copper mineralization along N.30°W. fractures.
768,430	602,590	Pit 5 ft. deep. Copper mineralization along N. 45°E. fracture.
768,340	603,420	Pit 6 ft. deep. Copper stain 2-6 in. wide along N. 45°E. fracture.
768,860	605,190	Pit 3 ft. deep. Copper stain 2-3 in. wide along N. 60°E. and E.-W. fractures.
770,440	605,370	Pit 25 ft. deep on dioritic dike 4 ft. wide; shows local slight copper stain.
770,260	606,000	Pit 2 ft. deep shows slight copper stain in dioritic dike 2 ft. wide.
770,120	605,980	Pit 30 ft. long x 8 ft. deep. Slight copper stain on N.-S. fracture that has andesitic dike 5 ft. wide on footwall side.
770,520	606,820	Pit 2 ft. deep on iron-stained shear zone. Slight copper stain in dioritic dike.

The surface evidence here is not entirely conclusive as to whether or not the hypogene (primary) copper mineralization was sufficiently strong and widespread to constitute ore bodies of commercial size and grade at depths below the zone of surface leaching.

Nonmetallic Deposits

Considerable granite was quarried for railway fill in T.5S., R.8E., during 1924 or 1925.

From the small hill immediately southeast of Olberg, granite and basalt were obtained for use as fill and for rip-rap along the Gila River diversion dam which was built near Olberg.

Rough basalt boulders, suitable for construction of exterior rock walls, occur favorably situated with respect to transportation routes in T.3 and 4S., R.6E.

SACATON MOUNTAINS

Location and Topography

The Sacaton Mountains are located in T.4 and 5S., R.4, 5, 6, and 7E. (pls. 1 and 2).

Two main groups of steep, dissected ridges and some outlying smaller masses constitute the Sacaton Mountains. A broad pediment appears along the northern and eastern margins of the larger western group. Details of the topographic relations are featured on the Sacaton, Gila Butte SE., Sacaton Butte, Casa Grande, and Signal Peak quadrangle topographic sheets (fig. 2).

Altitudes in this mountain unit range from 1,280 feet above sea level at the northern edge of the pediment, to 2,800 feet on Sacaton Peak.

Rock Units

The rock materials have been depicted on plate 2; see also tables 1 and 2, pages 6 and 7. The succession of the rocks, from youngest to oldest, is as follows:

Quaternary and Tertiary. Loosely to firmly consolidated gravel, sand, and clay, surround the areas of older rocks and overlap them on the pediments.

Tertiary. Basaltic dikes.

Laramide or Mesozoic (?). Granitic porphyries in sec. 7, T.5S., R.6E., and near Sacaton Peak; and felsite in sec. 12, T.5S., R.5E., occur as dikes and masses not separately distinguished from Precambrian granite on plate 2. These rock materials are described on pages 17–19.

Pegmatites, invading especially the Precambrian darker granite, occur in the area.

Mesozoic (?). Dioritic masses and dikes, which have been classified here as being of Mesozoic age, occur in the area. As determined microscopically, the dioritic masses include at least two main types, one of which contains approximately 12 percent orthoclase, 39 percent andesine, 24 percent quartz, 15 percent biotite, and 7 percent hornblende; and the other, 10 percent orthoclase, 59 percent oligoclase, 6 percent quartz, 11 percent biotite, and 11 percent pyroxene. The dioritic dikes contain up to 20 percent andesine, little or no quartz, and up to 80 percent amphibole.

Paleozoic. Devonian (?) limestone exists in the southwestern portion of sec. 7, T.5S, R.6E. It is described on pages 17–19.

Cambrian quartzite occurs in fault contact with Devonian (?) limestone. This material is described on pages 17 and 18.

Older Precambrian. Granite of medium- to fine-grained texture has been observed in the vicinity. Its constituent minerals commonly display lineation. This phenomenon is most strongly developed in the area which has been mapped as gneiss, in the southern portion of T.5S., R.7E. (pl. 2). The gneiss, as well as the granite west of R.7E., is of a darker gray color than the granite in Sacaton Peak. West of Highway 187, the darker granite includes some masses of the lighter-colored variety.

A sample of the granite from Sacaton Peak has been determined by microscopic methods to contain 60 percent orthoclase, 2 percent oligoclase, 30 percent quartz, and 5 percent biotite. A sample of the darker granite, from the southern portion of T4.S., R.6E., contains 35 percent orthoclase, 25 percent oligoclase, 15 percent quartz, 20 percent biotite, and 3 percent hornblende. A sample of the gneiss is comprised of 33 percent orthoclase, 10 percent oligoclase, 50 percent quartz, 4 percent biotite, and 1 percent pyroxene. It seems probable that the unit, mapped on plate 2 as Older Precambrian granite in the Sacaton Mountains, includes rocks of two or more ages; the granite in Sacaton Peak is very similar mineralogically to the granite that intrudes Paleozoic quartzite in sec. 7, T.5S., R.6E. To map the varieties adequately, however, would require more field work than was devoted to this report.

Structure

The rocks of the Sacaton Mountains have been broken by numerous fractures, which are characterized as follows:

STRIKE	DIP	REMARKS
N.60°W.	50°-80°W.	The most prominent system; parallel in trend to the principal ridges; locally followed by dioritic dikes. Mineralized in sec. 7, T.5S., R.6E.

STRIKE	DIP	REMARKS
N.45°E.	80°SE.	Strongly developed; parallel in trend to numerous ridges and to the larger dioritic masses. In places contain dikes.
N.30°W.	25°SW. to 45°NE.	Locally contain dioritic and pegmatite dikes.
N.45°W.	Steep	Parallel to some ridges; locally contain dikes.
N.75°W.	80°SW.	Tend to form zones.
E. - W.	Steep	Parallel to some ridges.
N.15°W.	Vertical	Parallel to some ridges.
N.60°E.	Steep	Locally contain dioritic dikes. Mineralized in sec. 7, T.5S., R.6E.
N. - S.	45°E.	Parallel to some ridges.

Copper

Copper mineralization occurs in the central and southwestern portions of sec. 7, T.5S., R.6E., within a pediment area that is partially mantled by alluvium. The exposed deposits are small and appear to offer very little promise of future commercial importance.

In the central portion of the section, the exposed rock is grayish granite porphyry. A sample of it, as examined microscopically, contains 50 percent orthoclase, 30 percent oligoclase, 5 percent quartz, and 6 percent biotite.

On the northwestern edge of a fracture zone, 6 feet wide, that strikes N.60°E. and dips 85°NW., is a shaft (Cu 4 on pl. 1) 23 feet deep. It shows chrysocolla occurring irregularly along the fractures, the wall rock of which is stained reddish-brown. Some ore probably was produced from a near-surface stope, 15 feet long, 8 feet wide, and 5 feet high in maximum dimensions. An assay of a "grab" sample taken from the dump on the surface indicated a content of 2.8 percent copper, in addition to 0.03 of an ounce of gold, and 0.9 of an ounce of silver per ton.

A few hundred feet northwest of the Cu 4 workings, a prospect shaft extends to a depth of 25 feet in a fracture zone that strikes N.60°-75°W. and dips 75°SW. It shows iron oxide and some chrysocolla irregularly distributed throughout a maximum width of three feet. Similar mineralization occurs about 50 feet northeast of this prospect.

In the southwestern portion of sec. 7, a low, westward-trending ridge of quartzite, approximately 2,500 feet long by a maximum of 250 feet in width, is faulted against limestone along its northern flank. This limestone crops out intermittently with a maximum width of a few tens

of feet and eventually passes beneath alluvium further to the north. On the south, the quartzite is bounded, apparently with intrusive contact, by diorite (pl. 2). Lithologically, the quartzite resembles typical Cambrian Bolsa, and the limestone resembles Devonian Martin.

A shallow cut in the limestone exposes much fracturing, which trends predominantly in northeasterly directions. In close association with this pattern of fractures are small, irregular replacements containing iron oxides together with some oxidized copper minerals. An assay of a sample of this mineralized material indicated contents of 0.8 percent copper, no gold, and 0.05 of an ounce of silver per ton.

A small mass of granite porphyry which, as identified microscopically, contains 60 percent orthoclase, 35 percent quartz, and less than 1 percent biotite, has intruded the quartzite.

Titanium

Rutile (titanium oxide) occurs associated with corundum in the southeastern portion of sec. 12, T.5S., R.5E., as described on page 19. The deposits appear to be very small and discontinuous.

Nonmetallic Deposits

Silica. Deposits of quartzite and quartz of excellent quality and favorably situated with respect to routes of transportation and possible quarry sites occur in T.5S., R.6E.

The Cambrian quartzite ridge, in the southwestern portion of sec. 7 and described on page 17, constitutes a large tonnage of silica. A sample of the quartzite, as analyzed, contains 0.62 percent iron, and other impurities appear to be fairly low. It eventually might find use as smelter flux. Also, this quartzite, with its dull grayish-white color, may have commercial possibilities as a source for roofing granules.

Near the Cu 4 workings (page 17) quartz crops out as two knolls, of which one is approximately 250 feet long by 150 feet wide by 25 feet high, and the other is about half of this size. The quartz is lustrous and white, with only very slight, local iron stain. A sample chipped across the larger knoll showed, upon analysis, not more than a trace of iron. These two knolls contain commercially important tonnages of high-purity silica above the pediment floor; also, the quartz is of a vein or pegmatite type that would justify prospecting of its continuity to such depths as might be planned for quarrying.

In sec. 9, immediately east of Highway 187, the outcrop of a quartz vein forms a knoll some 60 feet long by 25 feet wide and 8 feet high. The quartz appears to be of high purity, but the deposit does not seem to be of sufficient size to provide much tonnage per vertical foot of depth.

Limestone. The analysis of a sample of the Devonian (?) Limestone gave the following percentage composition:

CaO	46.0	$CaCO_3$	80.9
MgO	6.7	$MgCO_3$	14.0
SiO_2	4.0	SiO_2	4.0
Fe	0.8	Fe_2O_3	1.1

The commercial importance of this limestone deposit would appear to depend upon the development of a tonnage larger than is indicated on the surface, as well as the availability of a market for lime having a magnesia and silica content, as given above.

Corundum. A deposit of corundum, which has been prospected by bulldozer cuts, occurs in the southeastern portion of sec. 12, T.5S., R.5E. However, elsewhere on this pediment area, an irregular mantle of alluvium interrupts the continuity of the rock outcrops. A few trenches made for prospecting have exposed coarse-grained, locally iron-stained granite, intruded by dikes of dioritic porphyry and hard, dense felsite. The felsite, when examined microscopically, reveals the occurrence of very fine-grained, mostly cryptocrystalline quartz, together with alteration products derived from feldspar.

Also, crystalline corundum, along with rutile and quartz, forms irregular masses, up to several inches in diameter, within the felsite. The irregularity of this mineralization is demonstrated by the fact that none of the corundum-rutile material was seen in place, although several tons of it are on the dump of one of the prospect trenches. A sample of the material on this dump was found, by spectroscopic examination, to contain a little chromium, possibly about 0.5 percent.

This deposit does not seem to be commercially important as a possible source of corundum. This is because of its limited, irregular characteristics, plus the fact that artificial abrasives have largely eliminated the market for natural corundum.

SIERRA ESTRELLA

Location and Topography

The Sierra Estrella is located along the western boundary of the Gila River Indian Reservation, in T.1, 2, 3, and 4S., R.1 and 2E. (pls. 1 and 2).

The topography is steeply rugged and the crest of the range is sharp and serrated. Details of these features are depicted on the Avondale SE., Laveen, Montezuma Peak, and Enid quadrangle topographic sheets (fig. 2).

The northern base of the range, near the junction of Gila and Salt Rivers, is at an altitude of 943 feet above sea level. The southern base, near the Reservation boundary, is at 1,330 feet. Butterfly Mountain and Montezuma Peak are respectively 4,119 feet and 4,354 feet in elevation.

Rock Units

The rocks of the Sierra Estrella are depicted on plate 2; see also tables 1 and 2, pages 6 and 7. The succession from youngest to oldest materials is as follows:

Quaternary and Tertiary. Loosely to firmly consolidated gravel, sand, and clay, which overlap the base of the mountain range.

Mesozoic (?). Pegmatite, invading older rocks.

Granite, invading older rocks in southern portion of T.3S. A sample, as analyzed by petrographic microscope, contains 12 percent orthoclase, 15 percent microcline, 5 percent oligoclase, 40 percent quartz, and 20 percent biotite.

Dikes of dioritic composition, intruding older rocks.

Older Precambrian. Granite, invading older rocks in T.3S. A sample, examined microscopically, is estimated to contain 50 percent orthoclase, 17 percent oligoclase, 15 percent quartz, and 10 percent biotite.

Gneiss, locally schistose, formed mainly from various igneous rocks.

Schist, formed by metamorphism of igneous and sedimentary rocks.

Structure

The principal lamination, or banding, of the schist and gneiss strikes northeast to eastward with dips ranging from 30° to vertical (pl. 2). Reversals of dip, as for example in sec. 19, T.2S., R.2E., indicate that the schist and gneiss underwent close folding in Older Precambrian time.

The rocks have been broken by numerous fractures whose general characteristics are summarized as follows:

STRIKE	DIP	REMARKS
N.60°E.	Steep	Locally show evidence of displacement.
N.35°W. to 45°W.	40°-75°SW.	Locally show evidence of displacement. Mineralized in sec. 6, T.3S., R.2E.; contain pegmatite and quartz in sec. 19, T.2S., R.2E.
N.30°W. to N.60°W.	Steep	Contain pegmatite in secs. 7 and 8, T.4S., R.2E.
N.20°W. to 25°W.	Steeply SW.	Contain dioritic dikes in T.2S.; quartz veins in sec. 31, T.3S., R.2E.
N. - S.	45°W.-50°W.	Locally contain quartz veins.
N.45°E.	12°SE.-90°	Well displayed in the granites.

Copper-Gold Deposits

Because of their proximity to early routes of transcontinental travel, the Sierra Estrella was explored by prospectors before 1868. In that year, a U.S. Land Office plat of T.3S., R.2E., noted the presence of "several copper mines, as yet but partially developed."

Under regulations provided by the Act of June 30, 1919, nine lode claims in T.3S., R.2E. were surveyed in 1920 (U.S. Mineral Surveys No. 3657 and 3658), but they were not patented. These old claims are on the northeastern slopes of the range, at elevations between 600 and 1,100 feet above its base. The northernmost two locations are accessible by trail from the end of an unimproved road in sec. 5, T.3S., R.2E., as shown on the Montezuma Peak quadrangle topographic sheet, but the others, spread over a length of more than 2½ miles, are difficult to reach. As indicated by old claim plats, four of the claims, as of 1920, had been developed only by discovery cuts, and the others by shallow openings, located as shown on plate 1. Where examined in April 1963, little or no further development was evident. A small stope on the old Sunrise claim, the decomposed remains of a small hand-made aerial tram along the trail, and fragments of copper-bearing quartz at the site of a former loading bin, suggest that a little ore was produced.

The prevailing rock is gneiss (locally schistose) in sec. 6, 7, and 8, and Precambrian granite in secs. 17, 20, and 21.

In the vicinity of the Sunrise workings, the gneiss strikes N.60°E., and dips 35°SE., and it is markedly schistose for 10-20 feet on each side of quartz veins. The principal vein consists of fractured, brecciated quartz ranging from less than one foot to 15 feet wide, striking N.45°W., and dipping 55°SW. This quartz is vitreous, colorless to white, and coarsely crystalline. It contains scattered small masses of chrysocolla, together with limonite and hematite; the mineralization is relatively abundant near the hanging wall. An adit, approximately 5-10 feet high and 2-6 feet wide, extends horizontally inward from the surface for a distance of some 30 feet. It was driven in the hanging wall zone and it terminates where the vein narrows to a width of less than 18 inches. A general sample (Cu, Au 1 on pl. 1), taken across the back of this adit, yielded the following assay: copper, 3 percent; gold, 0.22 of an ounce per ton; silver, 0.35 of an ounce per ton.

Commercially, the copper-gold deposits in the Sierra Estrella range do not seem to offer much future promise; besides being difficult of access, they are small, lenticular, and not of high grade.

Mica, Feldspar, and Quartz

Pegmatite dikes or veins, consisting mainly of feldspar and quartz, together with various amounts of mica, occur abundantly in secs. 6, 7, and

8, T.4S., R.2E. Elsewhere within the Reservation portion of the Sierra Estrella, the pegmatites are small and relatively inaccessible, as exemplified in sec. 19, T.2S., R.2E.

The readily accessible pegmatite masses, which crop out in secs. 7 and 8, T.4S., R.2E., were prospected by shallow pits and bulldozer trenches at some time prior to 1952, as indicated on the Enid quadrangle topographic sheet. The remains of a foundation for a screening plant, together with small quantities of tailings, suggest that a little experimental production of the pegmatite minerals was attempted in the past.

Within this area, grayish schist, apparently derived from fine-grained granite or arkose, strikes N.30°-60°E. and dips steeply.

The pegmatites occupy fractures of various strikes and dips (page 20). Aside from a few notable exceptions, the pegmatite outcrops tend to range from less than one foot to 15 feet in width and are shorter than 50 feet in length.

Mica in the pegmatites occurs as sparse, irregularly scattered books composed more commonly of biotite than of muscovite. Most of these books are thin and less than an inch in diameter. Exceptionally, however, those which are of biotite composition measure as much as 2 inches thick, 6 inches wide, and 12 inches long. All of the mica sheets are more or less ruled, rumpled, or flawed.

The feldspar and quartz of the pegmatites within this area occur intergrown with one another. As determined microscopically, the feldspar consists of microcline and oligoclase; spectroscopic tests show that they do not contain more than traces of lithium.

The largest of the pegmatites crop out in the southwest quarter of sec. 8, T.4S., R.2E. There, exceptional ones range from 18 inches to 40 feet in width and up to 100 feet in length. Small, discontinuous portions of the pegmatites are relatively high in mica.

In the southwest quarter of sec. 19, T.2S., R.2E., a prospect shaft (shown as an adit on the Montezuma Peak quadrangle topographic sheet) reaches a depth of about 20 feet in a pegmatitic quartz vein (indicated as SM on pl. 1).

This vein strikes N.45°W. and dips 75°SW. It is 6 feet wide at the shaft but lenses out within 25 feet southeastward and 50 feet northwestward.

In addition to the quartz, it contains irregularly shaped books of flawed muscovite, 3 inches thick, 4 inches wide, and 6 inches long in maximum dimensions. The mica books are relatively plentiful within a zone from 1 to 2 feet wide, adjacent to the footwall, but sparse elsewhere in the vein.

Also, mica is an abundant constituent of the schist at some localities, and the schistose wall rock of the pegmatites tends to be relatively rich in

coarse flakes of muscovite throughout zones ranging in width from 2 to 20 feet, or more.

A sample of such muscovite schist, taken across a width of 15 feet adjacent to one of the larger pegmatites in sec. 8, T.4S., R.2E., was found, by means of screen analysis after dry crushing, to contain 21.8 percent muscovite.

In the southwest quarter of sec. 31, T.3S., R.2E., two quartz veins, indicated as S on plate 1, strike N.20°W., and dip 65°SW. They form *en echelon* outcrops standing several feet above the surface. The southern vein measures 30 feet in length by 5 feet in average width, and the northern one, 25 feet in length by 1 to 5 feet in width. The quartz is of massive texture, milky-white color and apparently of high purity.

The mica, feldspar, and quartz in the pegmatites do not appear to constitute bodies of sufficient tonnage and grade for economic mining and mineral separation, at present-day costs of operation and market values of the minerals.

The muscovite or mica schist offers some promise for low-cost mining and concentration. The feasibility of such an operation, however, would depend upon the results of prospecting to prove the tonnage and grades available. Industrially, none of the mica could qualify for uses other than those of the ground-type of commodity, which enters into the manufacture of roofing and various other products.

The quartz veins are a possible source for limited quantities of roofing granules.

Granite

The Mesozoic granite in the southwest quarter of T.3S., R.2E. (pl. 2) appears to be well suited for use as dimension stone. It weathers into large, massive blocks, bounded by widely spaced fractures of which one system strikes north-south, with a dip of 45°W., and the other strikes N.45°E., with a dip of 12°SE. Owing to its mineralogic composition, described on page 20, the color of this granite on fresh surfaces is gray, mottled with black. It is unaltered, hard, and difficult to break. The stone, especially in secs. 27, 33, and 34, is favorably situated with respect to possible quarry sites and transportation routes.

FOOTHILLS OF THE SALT RIVER MOUNTAINS

Location and Topography

The foothills of the Salt River Mountains are situated along the northern boundary of the Gila River Indian Reservation, in secs. 3, 4, 5, and 6, T.2S., R.3E.

The typical topography is that of small, rounded hills. The altitudes above sea level range from 1,130 to 1,364 feet. Details of the topographic features are depicted on the Lone Mountain quadrangle topographic sheet.

Rock Units

The succession from youngest to oldest rocks is as follows:

Quaternary and Tertiary. Loosely to firmly consolidated gravel, sand, and clay, overlapping the bases of the hills.

Mesozoic. Rhyolitic porphyry dikes. A sample, as analyzed by petrographic microscope, contains 20 percent orthoclase, 2 percent albite, 10 percent quartz, 2 percent biotite, and 66 percent cryptocrystalline and opaque minerals.

Older Precambrian. Gneiss, locally schistose, derived mainly from various pre-existing igneous rocks.

Structure

The principal lamination or banding of the gneiss strikes mainly northeastward and less commonly northwestward. Its dip ranges from 25° to 35°.

The rocks have been broken by numerous fault fractures with undetermined displacement, as follows:

STRIKE	DIP	REMARKS
N.30°W.	30°NE.	In places, contain rhyolite-porphyry dikes; locally mineralized.
N.10°W.	70°-85°NE.	In places, contain rhyolite-porphyry dikes.
E. - W.	45°N.-90°	Some contain quartz veins.
N.80°W.	80°NE.	Locally form zones.
N.60°W.	60°-75°NE.	Some contain quartz veins.
N.10°-15°E.	Steep	Locally form zones.
N.45°W.	25°NE.	Some occur in zones; mineralized in places.

Gold Deposits

This area, which is part of the Gila Crossing or Salt River mining district, was prospected many years ago by numerous shafts, adits, and open cuts. A little ore apparently was treated in arrastres, and some was shipped, prior to 1900. Three claims in the northeast quarter of sec. 5, T.2S., R.3E. were surveyed in 1919 (U.S. Mineral Survey No. 3615), and two claims in the northeast quarter of sec. 4, in 1925 (U.S. Mineral Survey No. 3979), but they were not patented.

Prospecting has been done on quartz veins and brecciated zones, as well as on many barren fractures, which strike and dip as noted in the foregoing tabulation. As a rule, the veins and brecciated zones are thin and lenticular, and their continuity is more or less disrupted by faulting. They commonly range from less than 2 inches to 24 inches in width.

The quartz of the veins is of coarse-grained texture and grayish-white color, and is locally iron-stained.

The brecciated zones consist of iron-stained, locally silicified fault breccia and gouge, together with sparse, thin lenses and veinlets of quartz.

The gneiss wall-rock has been altered to silicified chloritic schist.

The principal workings are shown on the Lone Butte quadrangle topographic sheet and located as follows:

Workings	Feet south of Reservation Bndy.	Feet from sec. 4-5 line
Au 1, pl. 1	2,200; near top of hill	3,550 W.
Au 2, pl. 1	2,100; near top of hill	3,350 W.
Gold Coin	1,200; altitude 1,300 ft.	1,300 W.
Au 3, pl. 1	1,200; altitude 1,350 ft.	1,000 W.
a	1,500	1,250 W.
b	1,600	900 W.
Au 4, pl. 1	700	3,300 E.
Au 5, pl. 1	850	3,200 E.
Au 6, pl. 1	1,050	3,250 E.

Some features exposed at these workings are as follows:

Workings	Deposit	Strike	Dip	Width	Sample, assay (oz. per ton)
Au 1: 50-ft. incl.	Bx. zone	N. 30°W.	30°NE.	12 in.	Au, 0.39; Ag, 0.3
Au 2: 50-ft. incl.	Bx. zone	N. 45°W.	25°NE.	14 in.	Au, 0.14; Ag, 0.15
Gold Coin: 100-ft. sh.	Fracture	E. -W.	90°	Tight	
Au 3: 75-ft. incl.	Fr. zone	N. 15°E.	60°SE.	24 in.	Au, 0.007; Ag, 0.10
a: 25-ft. sh., adit	Fracture	N. 10°W.	70°NE.	Tight	Apparently barren
b: adits	Fr. zone	N. 10°E.	Steep	Tight	Apparently barren
Au 4: incl.	Qtz. vein	E. -W.	45°N.	1-2 in.	Dump: Au, 0.14; Ag, 0.15
Au 5: cut	Qtz. vein	N. 80°W.	80°N.	4 in.	Au, 0.7; Ag. 0.10
Au 6: cut	Qtz. vein	N. 60°W.	75°NE.	3-18 in.	Au, 0.17; Ag, 0.30

The gold deposits in the foothills of the Salt River Mountains are not of immediate economic interest. Given a substantial increase in the price of gold, however, a few of them might justify small-scale operations.

PIMA BUTTE AREA

Location and Topography

The Pima Butte area is in secs. 13, 23, 24, 25, 26, and 27, T.3S., R.3E.

The topography is characterized by Pima Butte, rising approximately 600 feet above the Gila River plain, and by two isolated, small, low hills in secs. 13 and 24. These details are featured on the Pima Butte quadrangle topographic sheet (fig. 2).

Rock Units

Pima Butte is made essentially of Older Precambrian micaceous schist, extensively invaded by pegmatites, and is surrounded by Quaternary alluvium. The two hills in secs. 13 and 24 consist of granite, presumably Mesozoic in age, likewise surrounded by Quaternary alluvium.

The pegmatites occur as veins or dikes and irregular masses, which range in width from a few feet to 100 feet, or more. They consist largely of feldspar and quartz, together with sparse muscovite. In a few places, they show weak copper staining.

Nonmetallic Minerals

Mica. The schist wall-rock of the pegmatites tends to be rich in flaky muscovite. Adjacent to the larger pegmatite masses, especially in the northern spur of Pima Butte, the schist is highly micaceous throughout zones ranging in width from a few feet to 30 feet, or more.

As stated regarding the mica schist in the southern portions of Sierra Estrella (page 23), this material seems worthy of consideration as a potential source of ground mica.

Feldspar and Quartz. Laboratory tests indicate that the feldspar and quartz, which are contained in the larger masses of pegmatite, could be separated into reasonably pure products, if market conditions warrant exploitation of them.

Stone. Granite from the hill in sec. 13 was quarried many years ago to supply broken or crushed rock, presumably for railway construction. This old quarry is favorably situated beside the paved highway (pl. 1) which occupies approximately the former route of the Maricopa Branch of the Arizona Eastern Railway.

RIVER PLAINS

Clay Deposits

Large reserves of clay occur within the Gila River Indian Reservation. Most of this material is suitable for local use as adobe. Furthermore, as indicated by laboratory tests, the clay in many of the deposits would be good for making fired bricks and, also, in several localities, the clays have the bloating or expanding qualities requisite for manufacture of light-weight aggregates.

In general, the better clay deposits are restricted to those portions of the Gila River plain that generally have escaped sand and gravel sedimentation from floods or from tributary washes. In developing the study of this report, samples of clay were taken only in those localities (see pl. 1 and tables 4-A and 4-B) that appeared to be relatively favorable for production purposes.

The horizontal and vertical dimensions of the various deposits may be determined only by extensive prospecting. Where sampled by auger drilling (table 4-B), the clay ranged from 1.25 to 11 feet in thickness.

Bloating Clay: As shown by X-ray examinations, the bloating clays consist principally of the mineral illite. Laboratory tests indicate that the bloating qualities are best if the iron content approximates 5 percent, or if it is brought up to this amount by admixing hematite.

Samples taken of clay occurring in T.3S., R.5 and 6E., and in T.4S., R.6, 7, and 8E., at sites as indicated on plate 1, were found to be of bloating quality. The results of bloating or expanding tests are listed in table 5.

Brick Clay: Samples taken in T.1S., R.1E.; T.2 and 3S., R.2E.; T.3S., R.5 and 6E.; and T.4S., R.6, 7, and 8E. were found to represent material suitable for use as brick clay (pl. 1). The results of burning tests are summarized in table 6.

Adobe Clay: A recent development in the industrial field of adobe construction is exemplified at Sacaton. There, durable non-fired blocks have been made from local adobe, stabilized with cement and subjected to hydraulic pressure. According to Mr. Baskin,* these blocks, costing about two cents each, will be used for building some fifty houses in Sacaton.

Other experiments, as, for example, on the use of additives in the making of burned-adobe blocks, appear to be justified.

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* Oral communication.

Table 4-A. Locations of clay pit-samples.
(Samples from pits less than 3 feet deep.)

Sample No. PLATE I	Sec.	T. S.	R. E.	Sample No. PLATE I	Sec.	T. S.	R. E.
C 1	4	5	8	C 20	22	3	5
C 2	33	4	8	C 21	15	3	5
C 3	25	4	7	C 22	22	3	5
C 4	30	4	8	C 23	26	3	5
C 6	31	4	8	C 24	26	3	5
C 7	14	4	6	C 25	23	3	5
C 8	19	4	7	C 26	36	3	5
C 9	21	4	7	C 27	17	3	6
C 10	22	4	7	C 28	29	3	6
C 11	31	4	8	C 29	29	3	6
C 12A				C 30	31	3	6
(0-1 ft.)	30	4	8	C 31	14	1	1
C 12B				C 33	6	1	1
(1-2.5 ft.)	30	4	8	C 34	6	2	2
C 13	30	4	8	C 36	10	3	2
C 14	24	4	7	C 37	10	3	2
C 16	11	4	6	C 38	35	3	3
C 18	3	4	6	C 39	4	4	5
C 19	9	3	5				

Table 4-B. Locations of clay auger-samples.

Sample No. PLATE I	Sec.	T. S.	R. E.	Depth, ft.
C 40	34	2	2	0 - 2
C 41	10	3	2	0 - 3
C 42	27	2	2	5 - 6
C 43	30	4	8	0 - 7
C 44	27	2	2	5 - 6.5
C 45	30	4	8	0 - 3
C 46	30	4	8	1.25 –3
C 47	30	4	8	3.25 –7
C 48	30	4	8	0 - 1.25
C 49	27	2	2	0 - 5
C 50	30	4	8	3 - 4.5
C 51	21	2	2	0 - 6
C 52	21	2	2	6 - 11
C 53	34	2	2	2 - 6
C 54	28	2	2	0 - 3
C 55	15	2	2	0 - 3

Table 5. Results of bloating or expanding tests.

Sample No. (PLATE I)	Per cent Fe	Per cent $CaCO_3$	Quality of bloating
C 1	3.8	3.5	Poor
C 2			Poor
C 3	4.0	4.0	Good
C 4			None
C 6	3.5	4.4	Poor
C 12A	3.9	4.0	Good
C 12B	3.9	3.9	Good
C 13			Poor
C 18			Good
C 19			Fair
C 20	3.8	3.6	Very poor
C 21			Sintered at 1120°C.
C 22	3.2	2.8	Core of pellet bloated
C 23	2.5	4.4	Poor
C 24	3.8	5.4	Good
C 25	3.5	4.2	Poor; bloated and sintered 1125°C.
C 28			Good at 1100°C.
C 31			None
C 33			None
C 36			Poor; sintered at 1200°C.
C 37			Poor; sintered at 1200°C.
C 39			Poor; reddish sinter at 1150°C.
C 40			None
C 41			Sintered at 1150°C.
C 43			Fair
C 44			None
C 45			Poor
C 46			Good
C 47			Fair
C 48			None
C 51			Poor
C 52			None
C 54			None

Table 6. Results of burning clay made into bricks.

Sample No. (PLATE I)	Per cent Shrinkage Air	Per cent Shrinkage Fire	Color	Temp. (°C.)	Quality	Comments
C 1	10	2	Whitish	1150	Poor	Efflorescence
C 2	7	2	Lt. red	1150	Good	
C 3	7	4	Brick	1150	Poor	Some blistering
C 4	4	3	Brick	1150	Good	
C 6	8	3	Brick	1150	Good	
C 7	2	1	Salmon	1150	Poor	Efflorescence
C 8	2	1	Lt. Brown	1150	No good	Efflorescence
C 9	3	2	Brown	1050	No good	Efflorescence
C 10	2	1	Gray	1150	No good	Efflorescence
C 11	crumbled					
C 12A	12	6	Red	1150	Good	Very dense
C 12B	9	5	Red	1050	Fair	
C 13	2	2	Whitish	1050	Poor	Efflorescence
C 14	3	4	Brick	1050	Excellent	
C 16	5	3	Brick	1050	Good	Slight efflores.
C 18	5	4	Brick	1050	Good	
C 19	7	3		1050	No good	
C 20	6	3	Brick	1050	Fair	
C 21	10	7	Red	1050	Poor	Spotted
C 22	5	3	Brick	1050	Good	
C 22	5	4	Brick	1150	Excellent	
C 23	7	5	Red	1050		Good color
C 24	8	3	Brick	1050	Good	
C 25	7	3	Brick	1050	Good	
C 26	3	1	Pale Pink		Fair	Slight efflores.
C 27	2	1	Brick		Poor	Crystalline
C 28	2	1	Pale Brick	1050	Poor	
C 29	7	2	Brick	1050	Good	
C 30	6	2	Brick	1050	Good	
C 31	4	3	Gray	1050	No good	Heavy efflores.
C 33	8	2	Brick	1050	Good	Efflores. Dense
C 34	9	2	Brick	1050	Good	Slight efflores. Dense
C 35	5	1	Brick	1050	Good	
C 36	7	3	Gray	1050	Good	Efflorescence
C 37	11	4	Brick	1100	Poor	Checked
C 38	3	1		1100	No good	Friable
C 39	7	2	Lt. Pink	1100	Poor	Efflorescence
C 40	7	3	Salmon	1050	Good	Efflorescence
C 41	6	1	Pale Brick	1050	Good	Efflorescence
C 42	6	2	Pale Brick	1050	Good	Efflorescence
C 43	8	1	Brick	1050	Good	
C 44	7	1	Gray	1050	Good	Efflorescence
C 45	9	3	Brick	1050	Good	
C 46	8	2	Brick	1050	Good	Slight efflores.
C 47	4	1	Brick	1050	No good	
C 48	10	3	Brick	1050	Good	
C 49	4	1	Brick	1150	No good	
C 50	9	2	Brick	1050	Good	
C 51	5	1	Brick	1050	Soft	Efflorescence

Table 6 (*Continued*)

Sample No. (PLATE I)	Per cent Shrinkage Air	Per cent Shrinkage Fire	Color	Temp. (°C.)	Quality	Comments
C 51	5	3	Brown	1150	Good	Efflorescence
C 52	7	1	Brick	1050	No good	
C 53	3	1	Gray	1050	Soft	
C 54	4	2	Brown	1050	Poor	
C 54	4	2	Brown	1150	No good	

Sand and Gravel Deposits

Production and relative importance. Sand and gravel are commercially the most important mineral commodities on the Gila River Indian Reservation. Production under permits to outsiders during the past seven years has amounted to 447,196 tons, approximately as follows: *

Fiscal Years	*Tons*
1962-1963	326,845
1961-1962	48,158
1960-1961	7,500
1959-1960	5,619
1958-1959	9,906
1957-1958	38,502
1956-1957	10,666
Total	447,196

The output under such permits during 1942-1945, is estimated to have been more than 150,000 tons. In addition to the yield under permits, considerable tonnages have been produced during recent decades for local Indian Service projects.

The reserves of sand and gravel within the Reservation are very large. Demands for them, especially from neighboring urban areas, presumably will continue to increase.

Distribution and Character. Sand and gravel, underlying and interfingering with silt and clay, constitute a large portion of the Cenozoic sedimentary units (table 1), mapped as Qs and Ts on plate 2. The choice of productive pit-sites (pl. 1), among the numerous deposits of satisfactory quality within this extensive area, has depended largely upon proximity of transportation routes and construction projects.

Inasmuch as the sand and gravel have been laid down by meandering, shifting drainage systems, the composition, texture, thickness, and lateral

* Figures supplied by C. V. Gage (oral communication).

Table 7. Some data of sand and gravel workings.

Location (PLATE I)	Features
NE. ¼ sec. 8, T. 2 S., R. 4 E.	Pit, 1,000 ft. in diameter and 8-15 deep. Sand and gravel with rounded pebbles ⅛-2 in. diameter; silty overburden approx. 6 ft. thick.
SE. ¼ sec. 23 and SW. ¼ sec. 24, T. 3 S., R. 3 E.	Two small, shallow pits at base of Pima Butte. Sandy gravel consisting mainly of angular fragments of quartz, feldspar and schist.
NE. ¼ sec. 20 and NW. ¼ sec. 21, T. 3 S., R. 5 E.	Pit, more than 300 feet long by 150 feet wide, near eastern base of Gila Butte.
S. ½ NE. ¼ and SE. ¼ NW. ¼ sec. 13, T. 3 S., R. 5 E.	Two pits, more than 1,000 ft. long, 150-400 ft. wide, and 20 or more feet deep. Sand and gravel with pebbles generally ⅛-3 in. diameter.
SW. ¼ NW. ¼ sec. 31, T. 3 S., R. 6 E.	Pit, 150 ft. long and 75 ft. wide. Sand and gravel with pebbles mostly less than 2 in. diameter.
NE. ¼ sec. 17, T. 3 S., R. 6 E.	Pit, approx. 200 feet long and 100 feet wide.
NE. ¼ sec. 28, T. 3 S., R. 6 E.	Pit relatively shallow.
Near Gila River, northeast of Sacaton.	Large pit. Sand and gravel with pebbles mostly ⅛-5 in. diameter.
SE. ¼ sec. 35, T. 4 S., R. 5 E.	Several pits, large and small, not more than 6 ft. deep. Sand and gravel granitic fragments ⅛-¾ in. diameter.
NE. ¼ sec. 7, T. 5 S., R. 7 E.	Pit, irregularly shaped, approx. 1,000 feet long. Sand and gravel granitic fragments ⅛-½ in. diameter.
NE. ¼ sec. 31 and NW. ¼ sec. 32, T. 4 S., R. 8 E.	Two pits; one on W. side of road is large. Relatively coarse sand with gravel, pebbles ¼-5 in. diameter.
SW. ¼ sec. 3 and SE. ¼ sec. 4, T. 5 S., R. 8 E.	Two pits approx. 25 ft. deep. Succession down from surface: Silt and sand, 5 ft.; sand and gravel with pebbles mostly ⅛-½ in. diameter, 5 ft.; gravel with sand, pebbles ¼-5 in. diameter.
SE. ¼ sec. 8, T. 2 S., R. 4 E.	Numerous, scattered prospect pits, caved. Pebbles in dump gravel ⅛-6 in. diameter.
NE. ¼ NW. ¼ sec. 19, T. 3 S., R. 5 E.	Prospect pits filled. Pebbles in dump gravel mainly less than 2 in. diameter.
SW. ¼ sec. 20, T. 3 S., R. 5 E. NW. ¼ sec. 29, T. 3 S., R. 5 E.	Prospect trenches. Sand and gravel with pebbles mostly less than 4 in. diameter.
NE. ¼ SE. ¼ sec. 23, T. 4 S., R. 5 E.	Numerous prospect pits, covered. Pebbles in dump gravel ¼-3 in. diameter.

extent of their deposits range widely from place to place. So far as known, they can be appraised satisfactorily only by prospecting.

The lateral variability of the deposits is well displayed by the character of material exposed in the widely-spaced existing pits. The changes which take place in going to depth are exemplified by the log of a deep well at Sacaton, which according to Lee (1904, p. 14), showed the following succession:

Depth (feet)	*Materials*
0-32	Sand and silt.
32-112	Gravel and boulders.
112-164	Decomposed granitic debris.
164-176	Boulders, granitic (?).
176-200	Gravel and boulders to bottom of well.

The ratio of sand and gravel to bouldery waste material appears to be more favorable for the deposits thus far developed within the Reservation (pl. 1) than it is for those along the Salt River in T.1N., R.1E., outside the Reservation.

Some features observed at the pits and prospects featured on plate 1 are listed in table 7.

Nitrate Deposits

Minor quantities of sodium nitrate occur in thin, grayish-white surface crusts, and in the upper few feet of the silt flats of Santa Cruz Wash, within secs. 7, 8, 17, and 20, T.3S., R.3E.

Analyses indicate that the crusts contain generally less than 0.1 percent sodium nitrate, together with 1.5 to 2.6 percent sodium chloride. Downward from the surface, the saline content progressively diminishes.

The nitrate deposits are presently of no known commercial importance.

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