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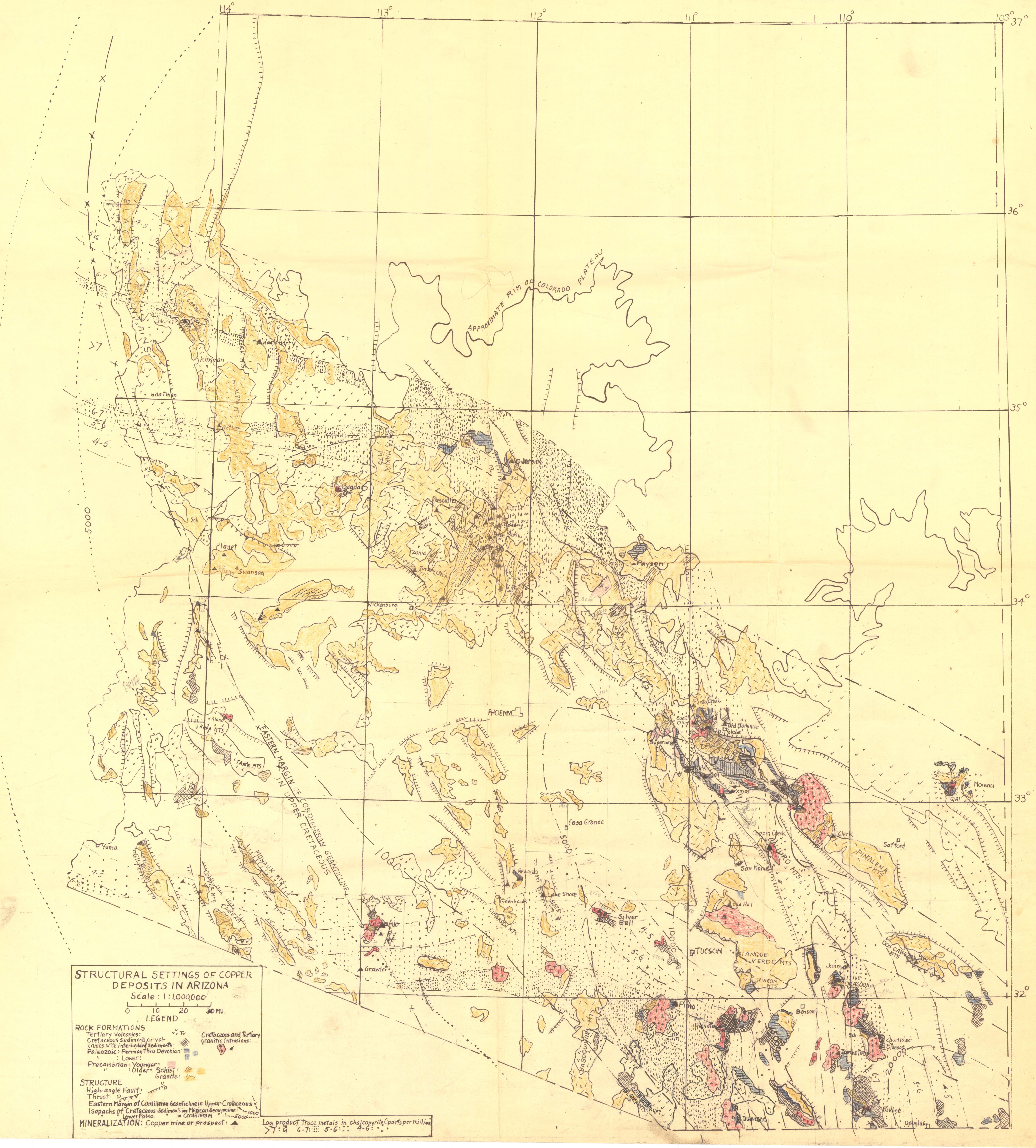
STRUCTURAL SETTINGS OF COPPER DEPOSITS IN ARIZONA
Scale : 1:1,000,000
0 10 20 30 MI.
LEGEND
ROCK FORMATIONS
Tertiary Volcanics: Tv
Cretaceous sediments or volcanics with interbedded sediments:
Cretaceous and Tertiary granitic intrusions:
Paleozoic: Permian thru Devonian:
" : Lower:
Precambrian: Younger:
" : Older: Schist:
" Granite:
STRUCTURE
High-angle Fault:
Thrust:
Eastern Margin of Cordilleran Geanticline in Upper Cretaceous
Isopachs of Cretaceous Sediments in Mexican Geosyncline: 1000
" " Lower Paleo. " in Cordilleran " 5000
MINERALIZATION: Copper mine or prospect:
Log product trace metals in chalcopyrite (parts per million)
>7: 6-7: 5-6: 4-5:
114° 113° 112° 111° 110° 109°
37° 36° 35° 34° 33° 32°
APPROXIMATE RIM OF COLORADO PLATEAU
EASTERN MARGIN OF CORDILLERAN GEANTICLINE IN UPPER CRETACEOUS
Isopach of Lower Paleozoic Sediments in Cordilleran Geosyncline
10000
5000
Kingman
Hackberry
Oatman
Bagdad
Jerome
Prescott
Planet
Swansea
Wickenburg
Payson
PHOENIX
Superior
Old Dominion
Globe
Casa Grande
Morenci
Safford
Clark
San Manuel
Silver Bell
TUCSON
TANQUE VERDE MTS
RINCON MTS
PINALENA MTS
Benson
Ajo
Growler
Yuma
MOHAWK MTS
KOFA MTS
TANK MTS
SANTA MARIA MTS
HUALPAI MTS
Courtland-Gleeson
Bisbee
Douglas
Pima
Ruby
Duquesne

Paul Eimon.

ARIZONA

FLUORSPAR

by

E. A. ELEVATORSKI

ARIZONA DEPARTMENT OF MINERAL RESOURCES

Mineral Building, Fairgrounds, Phoenix, Arizona

October, 1971

JOHN H. JETT,
Director.

ARIZONA FLUORSPAR

CONTENTS

ILLUSTRATIONS

ARIZONA FLUORSPAR

ABSTRACT

This Arizona Department of Mineral Resources publication describes fluorspar deposits in Arizona, history and production, types of deposits, grade specifications and marketing conditions. Total production of Arizona fluorspar from 1902-70 is estimated at 33,900 tons valued at $ 980,000. This report is possible through the efforts of Mr. E. A. Elevatorski. The wording, geology, interpretation and analyses are his.

Described herein are 96 fluorspar mines, prospects, and occurrences. During the period, 1966 thru 1970, E. A. Elevatorski visited and examined 56 of the properties. Where possible, all properties are located on maps, according to section, township and range. Considerable effort was made to describe routes of access to each property so that they can be visited with a minimum of effort.

Also included is a discussion on the marketing of fluorspar, current prices, factors to be considered in evaluating fluorspar deposits, and suggested guides for exploration and development of new deposits. The outlook for fluorspar, at the time of this writing is very favorable, and this report is intended as an information release, with the hope that it will be useful to those who are seeking fluorspar.

Mr. Elevatorski has permitted the publication of this paper as a contribution by him to the minerals field and as a possible stimulant to fluorspar exploration and development.

ARIZONA DEPARTMENT OF MINERAL RESOURCES

JOHN H. JETT, Director.

ARIZONA FLUORSPAR

by

E. A. Elevatorski *

Fluorspar is a strategic nonmetallic industrial mineral, and the most important source of fluorine. Early uses of fluorspar were as a flux in making steel; however, it is now the basic source for a growing chemical industry. Fluorine materials and chemicals are finding large-scale, diverse and essential applications. Marked increases in fluorspar demand can be expected to continue and will be difficult for existing mines to satisfy. It is hoped that this report will serve as a stimulus toward the re-opening of former mines or exploration-development of new fluorspar mines in Arizona.

PHYSICAL AND CHEMICAL PROPERTIES

Pure fluorspar is calcium fluoride (CaF_2), which contains 51.1 percent calcium and 48.9 percent fluorine. The terms "fluorspar" and "fluorite" are often used synonymous, but "fluorite" usually is the mineralogical term whereas "fluorspar" is a general name for the mineral and ores. The mineral crystals are in the isometric system, usually as well-formed cubes, often penetration twins. Less common crystal forms are octahedrons, and more rarely, hexoctahedrons and dodecahedrons.

Coarse crystalline fluorspar has a specific gravity of 3.0 to 3.4. It has perfect octahedral cleavage, a characteristic which is useful in distinguishing it from

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* Consultant, AIME Member, Santa Barbara, Calif.

calcite and minerals of similar appearance. The mineral is brittle, fractures easily, and has a hardness of 4 (Mohs' scale).

The mineral has a vitreous luster, and a wide range of colors, white to pale shades of yellow, pale to deep green, and light to dark purple, and colorless. The color often is concentrated on certain planes in crystals, and disappears when exposed to heating or long periods of sunlight. Fluorspar ores may be transparent, translucent, fluorescent or phosphorescent.

In Arizona, most fluorspar ores have medium to coarse crystals, with white and pale to deep green colors predominating. Some ores are banded and fine-grained. Fluorspar may occur as fine-grained, coarse-grained, massive columnar, brecciated, botryoidal, fibrous or crustified. At one location, in the Dragoon Mtns. it was found as fine-grained ore, grayish in color, with crystal-lined vugs, honey-brown in color. This particular ore is similar to fluorspar ores found in Mexico, and is unlike the coarse crystalline ores common to Arizona.

Fluorspar melts at about 2400° F. With siliceous and other refractory materials, it promotes earlier melting and greater fluidity in glass batches and in slags in the steel-making process. It is readily decomposed by sulfuric acid, liberating a gaseous hydrogen fluoride. Fluorine gas is the most active element known and combines with almost all other elements, sometimes very violently. This chemical activity makes fluorine valuable since large numbers of useful compounds can be formed, some with unique properties.

Almost all fluorspar deposits contain various amounts of impurities such as silica, calcite, barite, and metallic sulfides and therefore require beneficiation.

In weathered exposures, fluorspar is a difficult mineral to find and identify. Because it is soft and friable, some forms tend to disintegrate rapidly when exposed and a fluorspar vein at the surface may be marked by a depression or shallow trench, perhaps under a thin soil mantle. In association with other minerals such as fine-grained quartz or barite, it may be difficult to identify and evaluate in the field. For example, at the Carp deposit in Nevada, fluorspar was mistaken for barite, and the deposit was overlooked as a significant fluorspar property for many years.

USES AND MARKETING GRADES

Fluorspar is marketed in three grades that have different physical and chemical specifications, require different processing and command variable prices. The richest natural deposits do not always provide the highest-grade concentrates for industry. More often the physical nature of the occurrences, rather than the chemical purity, is the deciding factor in determining their end use, and paradoxically, the products of the highest-grade natural occurrences often reach a market with the lowest qualities for desired use. The explanation of this anomaly lies both in the nature of the occurrences and in the requirements of the consuming industries.

METALLURGICAL FLUORSPAR, also called "metspar" or "lump spar" is sold and valued on the basis of effective calcium fluoride content rather than actual calcium fluoride content. The effective calcium fluoride content is calculated by subtracting from the percentage of calcium fluoride (CaF_2) content a percentage which is 2-1/2 times the percentage of the silica content. For example, an ore containing 80 percent CaF_2 and 6 percent silica (SiO_2) would contain 65 effective units of CaF_2. Metspar users require 60 to 70 percent effective CaF_2, limit silica to 5 or 6 percent, limit sulfides to under 1/2 percent, and limit lead to under 0.25 percent. Size requirements also vary, but most steel producers require metspar to be in coarse sizes, ranging from 3/8-inch to 1-1/2 inches with fines not above 15 percent. In some cases, certain metspar consumers are now using fine-grained spar which has been processed into pellets and briquettes.

Metallurgical grade fluorspar is used as a flux in steel and as an electrolyte in aluminum smelting, metal welding, porcelain enameling and in glazing. Metspar is usually processed by crushing, sorting and screening.

CERAMIC-GRADE FLUORSPAR, also referred to as "glass" and "enamel" grade must contain not less than 95 percent CaF_2, with a maximum of 2.5 percent SiO_2 and 0.12 percent Fe_2O_3(iron oxide). It must be finer grained and its uses are in the manufacture of opaque glass, flint glass, as an ingredient in welding rod coatings, in making white and buff colored clay bricks, and in vitreous enamels for coating metal articles and appliances.

ACID-GRADE FLUORSPAR, for the manufacture of hydrofluoric acid, should contain a minimum of 97 percent CaF_2, not over 1.1 percent silica, a low content of $CaCO_3$ and sulphur. It is the highest quality marketed and commands the highest price. Uses of hydrofluoric acid are many and varied. Major uses include: the manufacture of fluorine chemicals such as refrigerants, fluorides for water fluoridation, and rocket propellants; the manufacture of synthetic cryolite essential for aluminum production; in preservatives, insecticides, aerosols, and in coatings for metals such as Teflon (trade name), a thermoplastic with a high degree of chemical resistance.

Both the ceramic and acid grades are marketed as a fine powder, usually from flotation concentrates.

MINING AND BENEFICIATION

Methods employed in mining fluorspar vary according to the nature of the deposits, and the technical and financial ability of the operators. They are similar in respects to the mining of metalliferous deposits. Mining may be done by shafts, drifts and room-and-pillar systems for long and narrow vein deposits, or by opencuts for bedded replacement deposits or wide veins. Quite commonly, mining will begin by open-pit methods and later transfer to underground mining.

Frequently, metspar requires only a minimum of processing, such as hand sorting, washing and screening. Upgrading may be accomplished by jigs and tables.

Ceramic grade and acid-grade concentrates usually require considerable treatment to achieve the necessary uniformity and high quality. The ores may be processed by heavy medium separation, or may be finely ground and concentrated by a sink-float or froth flotation process.

MODES OF OCCURRENCE

The principal Arizona fluorspar deposits are veins of hydrothermal origin which may be epithermal or mesothermal. The epithermal deposits are associated with Tertiary volcanism, and were formed near the surface under low temperature and moderate pressure. Deposits formerly mined northeast of Duncan in the Mule Creek Mtns. and those on the Vulture Mtns., south of Wickenburg, appear to be examples of epithermal deposits.

Mesothermal deposits are genetically associated with granitic intrusions and have no apparent association with Tertiary volcanic rocks. These deposits are formed at greater depth and at moderately high temperature and pressure. Fluorspar deposits mined from the Lone Star Mine in the Whetstone Mtns. of Cochise County, and the Mt. Jackson fluorspar deposit in Graham County appear to be mesothermal deposits.

Both types of deposits are believed to be the result of migration and deposition of volatile and solution-borne fluorine from cooling magma.

There are two generally recognized modes of occurrence of fluorspar, vein deposits, and replacement deposits; described as follows:

Vein Deposits

Fissure vein deposits have been the source of fluorspar mined in Arizona, and essentially, cavities and fissures formed by faults and shearing. They may be irregular, discontinuous, nearly vertical or steeply dipping, and distributed in line or en echelon. Limits of individual deposits are usually marked by zones of sheared or fractured rocks, which provided access to fluorine-rich hydrothermal solutions. Vein materials associated with fluorspar are calcite, barite, quartz, and metallic sulfides.

In Arizona, major vein deposits have been found in granite, rhyolite, andesite, diorite and schist.

Replacement Deposits

Replacement or bedded type deposits are found chiefly in limestones and dolomites where fluorine solutions entered fractured zones and reacted with calcium carbonate, forming calcium fluoride.

Both vein and bedded replacement types may occur together at a single deposit.

To date no major bedded replacement deposits have been found in Arizona, although fluorspar is found as vein fissure fillings and partial replacement of wall rocks as at Castle Dome galena-fluorspar mines in Yuma County. Although unexplored, a flat-lying bedded deposit, similar to the "mantos" deposits of Mexico was found in the Dragoon Mtns. The fluorspar at this location is grayish, fine-grained, and hard to distinguish from the limestone host rock. The areas of southeastern Arizona, having limestone and dolomite host rocks, with associated igneous intrusions, offer potential for replacement deposits.

Some fluorspar is a by-product of lead and zinc mining, such as at the Castle Dome mines in Yuma County. Fluorspar also may occur in the gangue of other metalliferous deposits and these occurrences may indicate the presence of nearby fluorspar deposits.

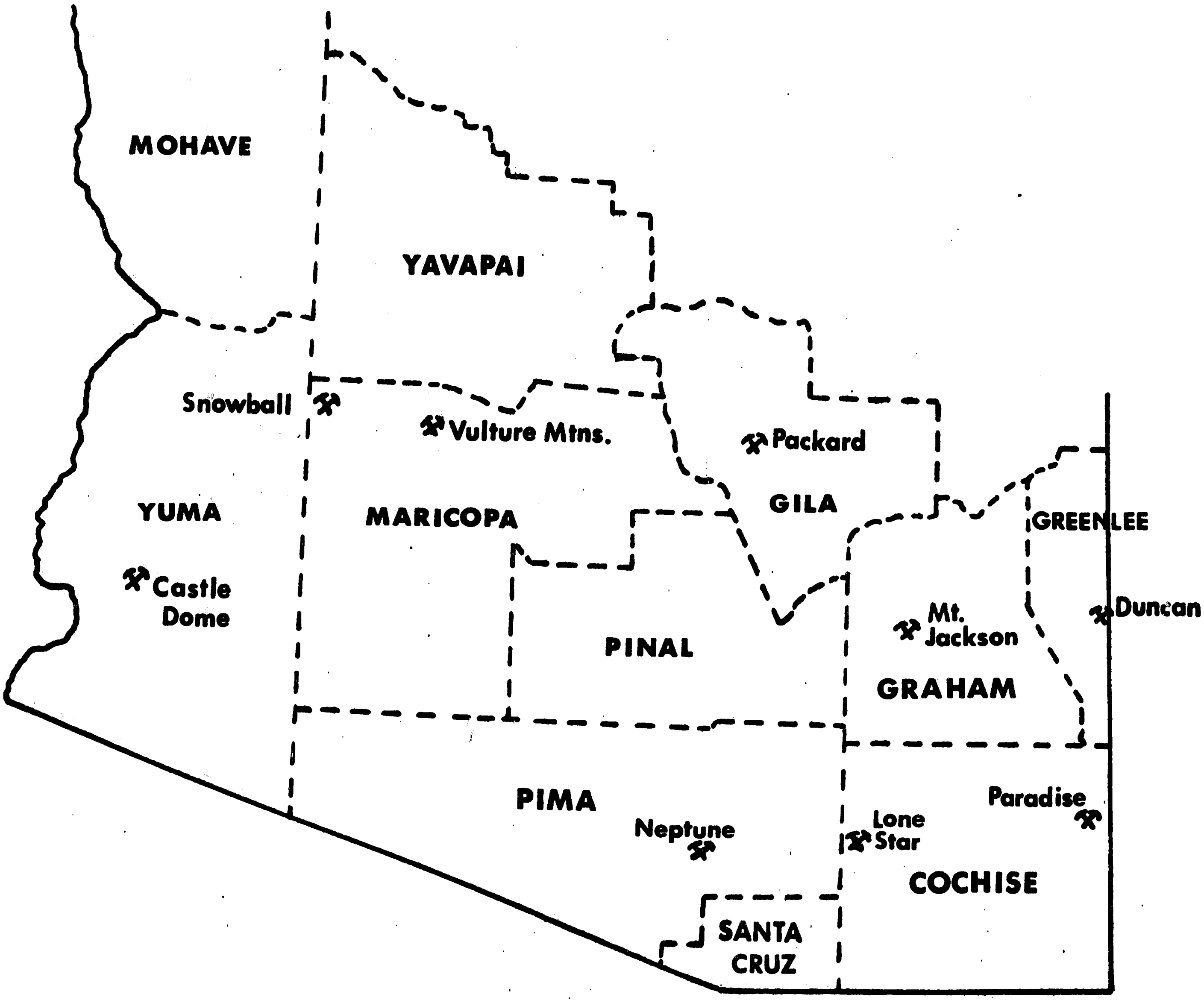
PRODUCTION

Arizona shipments of fluorspar were first recorded in 1902, when it was produced as a by-product of lead-silver mining in the Castle Dome District in Yuma County. From 1902-17, Arizona's entire production of 1150 tons was produced from the Castle Dome mines and used as a flux in making cement clinker in California.

Figure 1 shows the approximate location of producing mines, and counties having known fluorspar occurrences or prospects, which are described herein.

Beginning in 1918, new deposits were mined in the foothills of the Mule Creek Mtns. of Greenlee County, and in the Sierrita Mtns. of Pima County until 1921. This was followed by a dormant period of no production during 1921-35. In 1936, the Duncan area mines were re-opened and produced about 6500 tons from 1936-44. Some shipments also were made from the Vulture and Sierrita Mtns. and Chiricahua Mtns. in the 1940's. Most of this production was as metspar, shipped to steel plants, and the remainder shipped to the Deming and Lordsburg, New Mexico flotation mills for production of acid-grade concentrates.

From 1946 thru 1952, production was largely from the Lone Star Mine in Cochise County, Vulture Mtns. mines, and the Duncan area mines. As in the past, most



ARIZONA FLUORSPAR MINES

Fig. I

of the production was shipped as metspar. Small shipments were also made in the 1950's from the Snowball property, the Castle Dome District mines, and the Rhodes (Mt. Jackson) spar mine. In 1953, the Arizona Eastern Fluorspar Company operated a 50 tpd mill at Duncan. It was, however, closed in 1955 due to importation of lower cost Mexican fluorspar. In 1958 small shipments of acid-grade concentrates were made from a mill near Tonto Basin, with feed from the Packard Mine.

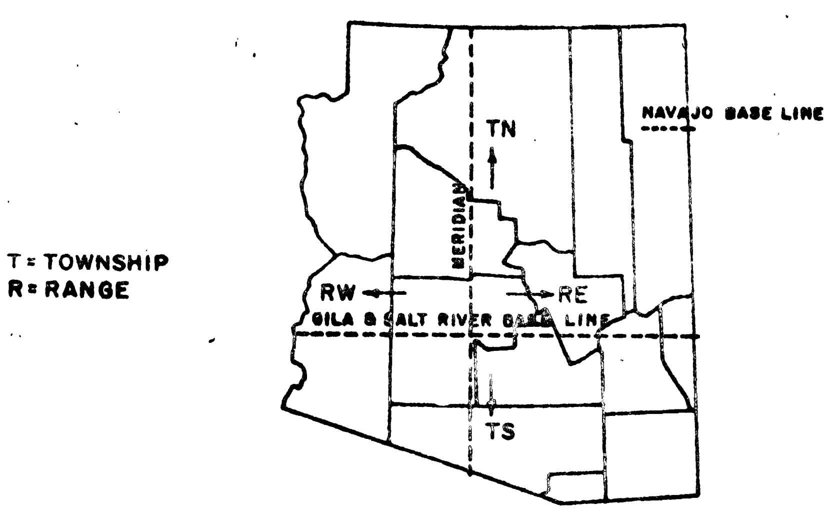
Production did not begin again until 1967, when shipments were again made from the Lone Star Mine in Cochise County. Numerous companies are currently exploring new and old properties.

Fluorspar production in Arizona for the period, 1902-70, is estimated by Mr. Frank P. Knight, Consultant, Arizona Department of Mineral Resources to be about 22,200 tons.

DESCRIPTION OF MINES AND PROSPECTS

Included herein, by counties in alphabetical order, are descriptions of former mines, prospects and occurrences. For classification purposes, a mine is defined as a property with known or recorded production.

All township-range-and-section locations are with reference to the following:



COCHISE COUNTY

Former producing mines are the Lone Star Mine near Benson and an un-named mine near Paradise, in the Chiricahua Mtns. Locations of mines and prospects and occurrences are shown in Figure 2 (page 11) and described herein.

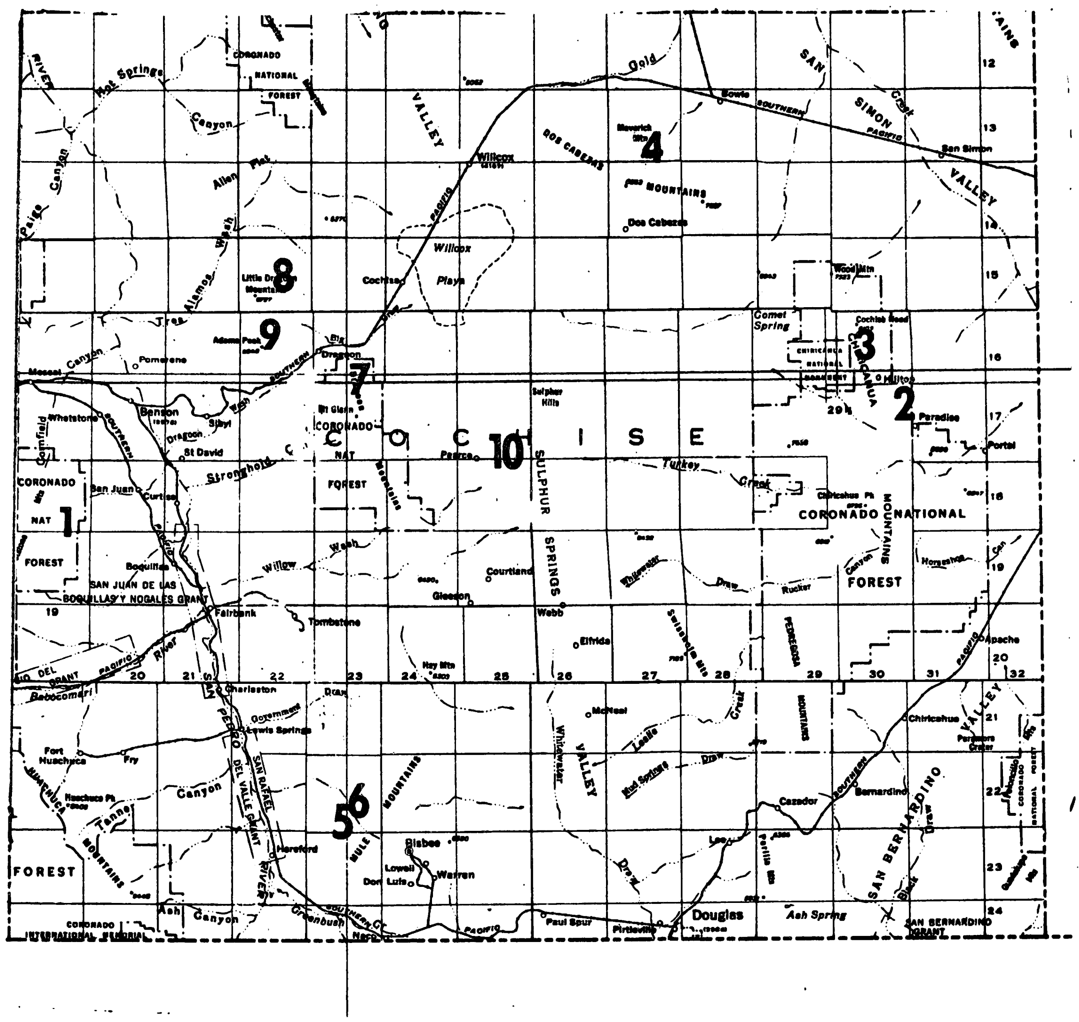
LONE STAR MINE

Located in the NE 1/4 sec. 35 and SW 1/4 sec. 26, T18S R19E, at the base of the Whetstone Mtns. about 15 miles S-SW of Benson. It can be reached by traveling south on State Hwy. 90 from its intersection with Interstate Hwy. 10, for a distance of 8.9 miles, thence west on a dirt road for 1.5 miles to the mine. Reportedly, fluorspar was discovered in 1946. The mine is believed to have been the largest single fluorspar producer in Arizona.

Development work consists of an inclined shaft to a 400-level, and an adit located northwest of the shaft.

Fluorspar occurs as fissure veins in sheared Pre-cambrian schist, intruded to the north by aplite dikes and an alaskite stock. Ore shoots average 2-1/2 ft. wide, 25 ft. long and 35 ft. high, dipping 80° S. The ore is coarse-grained crystalline, mostly pale green, white and in some cases banded. At the deeper levels of the mine, dark purple fluorspar banded with green fluorspar has been mined.

In the adit, the fluorspar is white and light green, coarse, and crystalline in veins from 1-1/2 to 4 ft. wide. Mine run ore is high-grade, between 75 and 85% CaF_2 content, and can be shipped as metspar with a minimum of processing, limited to hand-sorting, crushing and screening. The major impurity is a dense vuggy quartz, which separates easily from the fluorspar. A grab sample from a stockpile of ore assayed 87 percent CaF_2, 2.7 silica and 0.13 lead.



COCHISE COUNTY FLUORSPAR MINES AND PROSPECTS

1. **Lone Star Mine.**
2. **Un-Named Mine near Paradise.**
3. **Pague Prospect.**
4. **Buckeye Canyon Prospect.**
5. Capt Prospect
6. **Stout Prospect.**
7. **Dragoon Mtns. Prospect.**
8. **Peabody Mine.**
9. **Little Fanny Mine.**
10. **Fluorine Hill Prospect.**

Figure 2.

A regional tectonic map indicates the location of a high-angle fault, at the mine location, and although no ore outcrops are on the surface, it is possible that concealed ore bodies may be present north of the adit in a parallel shear zone.

UN-NAMED MINE

Near Paradise in the Chiricahua Mtns., in the E-1/2 T17S R30E, northwest of Paradise. In 1941-42, approximately 400 tons reportedly were shipped from a series of 6" to 12" veinlets of fluorspar mixed with white quartz in a faulted granite. Development work consists of trenches and a shallow shaft. No assays were made of ore samples.

PAGUE PROSPECT

Located 1-1/2 airline miles south of Cochise Head, at elevation 6100, in the E-1/2 sec.17, T16S R30E. Discovered in 1970, it can be reached by traveling up Indian Creek Road, 13 miles northwest of Paradise to the confluence of Indian Creek and White Tail Creek, then walk up washed-out road for 1.7 miles to the claims. Fluorspar occurs as coarse crystalline ore, green and purple, in a 4 ft. wide vein in Pennsylvanian limestone, separated by a fault from a quartz porphyry intrusive. The vein contains medium to fine silica which may be difficult to separate.

BUCKEYE CANYON PROSPECT

Located in the NE-1/4 sec. 34 T13S R27E, about 6.5 miles south of Arizona State Hwy. 86 at approx. 4500 elevation. Mixed deep purple and green veinlets in small prospect pits occur in Pre-cambrian granite, cut by Tertiary rhyolite porphyritic dikes.

CAPT PROSPECT

Located about 9 miles north of Arizona State Hwy. 92 in the NE-1/4 sec. 33

T22S R23E. To visit, take jeep road, traveling north of State Hwy 92 about opposite Valley View Ranch entrance. On a high ridge an open-cut exposes a 6 ft. vein of deep green coarse-grained crystalline fluorspar in a light-grey Carboniferous limestone intruded by pink porphyritic granite. Approximate elevation on the ridge is 6100. The property is currently undergoing exploration.

STOUT PROSPECT Located in the N-1/2 sec. 21, T22S R23E, about 200 ft. south of U. S. Hwy. 80. Reported to be a 3 ft. vein of coarse-grained green cyrstalline spar mixed with hard quartz, in a pink porphyritic granite. Development consists of an open-cut and a shaft of unknown depth, now filled partially with water.

DRAGOON MTNS. PROSPECT

Located about 7 to 8 miles S-SE of Dragoon, in the S-1/2 T16S R23E. Four prospect pits have been dug. In three of the pits, a grayish fine-grained fluorspar ore is exposed, and contains many vugs that are lined with honey-brown minute fluorite cubes, and coarse-grained cyrstalline material. The outcrop dips 4^{o}S, and the ore appears to be a replacement of limestone (Carboniferous ?) under a thin quartzite layer. A 3 ft. channel sample assayed 78 percent CaF_2, 3 percent SiO_2, and 6 percent $CaCO_3$.

PEABODY MINE

Located in the E-1/2 sec. 23 T15S R22E, in the Little Dragoon Mtns., about 1 mile north of Johnson Camp. Fluorite occurs as a gangue with copper and zinc sulfides in a Pennsylvanian limestone.

LITTLE FANNY MINE

Located approx. in center of sec. 9, T16S R22E, north of Interstate Hwy. 10, and about 4 miles northwest of Dragoon. Numerous prospect pits and two adits were dug, exposing colorless, pale blue and purple fluorspar stringers, with quartz veins, beryl and tungsten minerals. Host rock is the Texas Canyon quartz monzonite, intruded by aplite and lamprophyre dikes.

FLUORINE HILL PROSPECT

Located in secs. 33,34 and 35 T17S R25E about 2-1/2 miles east of Pearce. Prospects are on south side of hill near the crest, and expose a narrow 6" vein of dark purple fluorite with flecks of yellow uranium-bearing uranophane and autunite. The vein is in a rhyolite porphyry and can be traced on the surface for 25 feet. The U. S. Bureau of Mines reports the vein material exposed in the prospect pit contains 0.11% uranium.

OTHER PROSPECTS

The following prospects are reported, but were not visited:

Government Draw - 8 miles SE Tombstone in NE-1/4 T21S R23E, small purple stringers occur with quartz in limestone.

Empire Mine - in Tombstone District T20S R23E. Silicified area in limestone reported to contain green and purple fluorspar associated with lead.

Ground Hog Prospect - in S-1/2 sec. 22, T20S R22E, minor fluorspar reported in barite veins. Host rock is a faulted limestone.

Un-named Prospect - Located in the NE-1/4 sec. 24, T17S R22E, stringers of green crystalline fluorspar reported in a Paleozoic limestone near granite intrusion.

Swisshelm Mtns. - fluorspar reported in Carboniferous limestone near a rhyolite intrusion.

GILA COUNTY

Figure 3 (page 16) shows the location of mines and prospects.

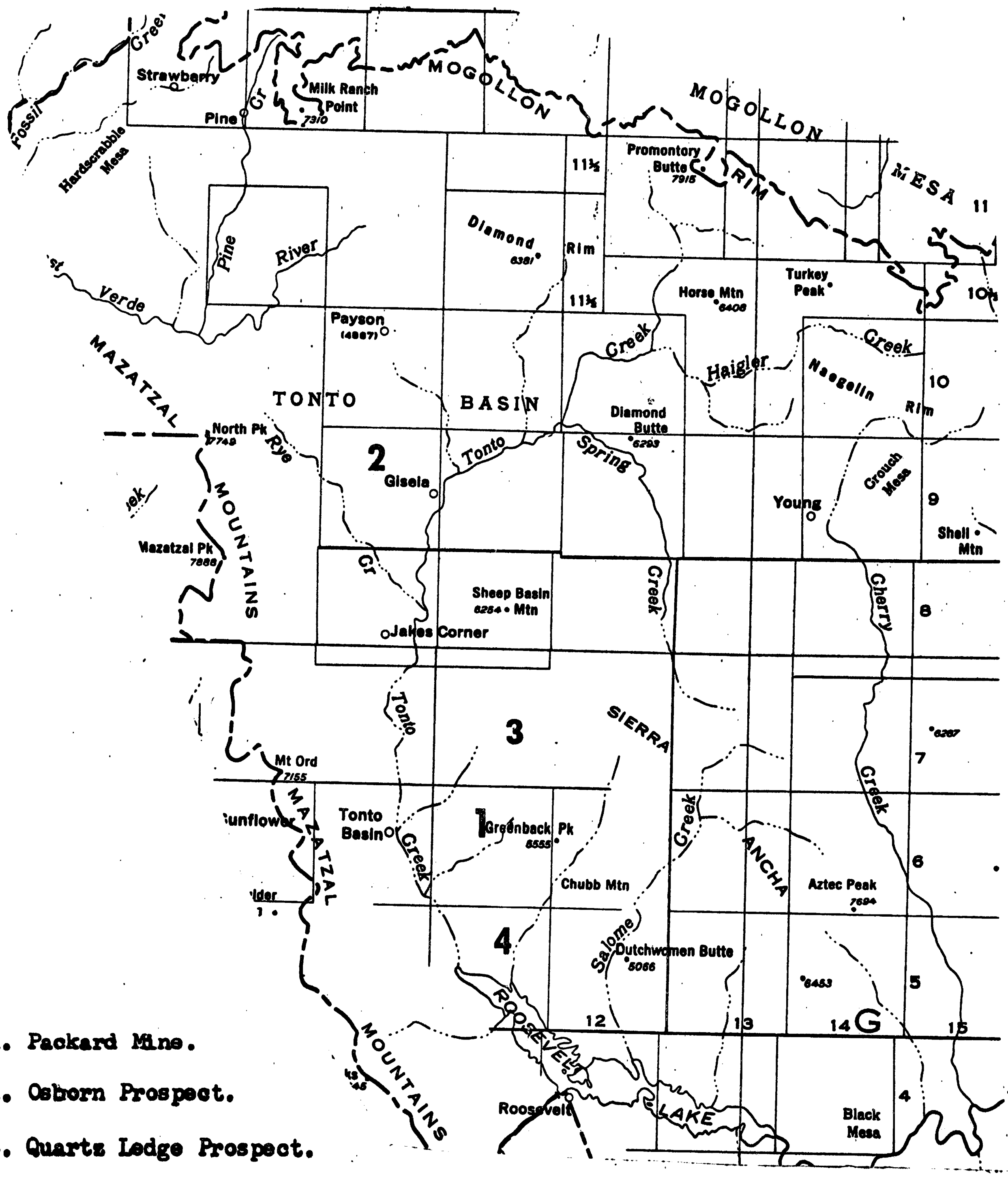
PACKARD MINE (also called Bluebird Mine)

Located in the foothills of the Sierra Ancha Mtns. in SE-1/4 sec. 9, T6N R11E, about 7 airline miles east of Tonto Basin. To reach the property take the Greenback Ranch Road, traveling east of Tonto Basin for 8.5 miles, then turn south on a truck trail for 2.5 miles to the mine located in a small canyon at approximately elevation 3400.

The property consists of 4 unpatented claims, with fluorspar reportedly discovered in 1938. Only a small amount of development work was completed prior to 1946, when the U. S. Bureau of Mines conducted an exploration program, consisting of stripping overburden, trenching, tunneling, surveying and sampling. In 1958, additional development was undertaken and a 25 ton per day flotation mill installed about 4 miles east of Tonto Basin. Small shipments were made in 1958. At the time of this writing the property is under development by Tonto Basin Mining and Milling Company who plan to produce acid grade concentrates.

Principal development workings consist of two adits, the lower adit of which was advanced 75 feet, and exposes a white, green and purple, coarse to medium grained crystalline fluorspar vein, about 2 ft. in width. The upper adit extends 320 feet, and exposes a 3 ft. wide vein of white, green and purple fine-grained crystalline to massive fluorspar. Both veins are in faulted Pre-cambrian granite. The veins strike east-to-west and dip from vertical to 70° south.

Ore samples taken and assayed by the U. S. Bureau of Mines contained 73% CaF_2, 20% SiO_2, 0.9% $CaCO_3$, 3.2% R_2O_3 and 0.5% Fe. The ore breaks cleanly



1. Packard Mine.

2. Osborn Prospect.

3. Quartz Ledge Prospect.

4. Conway Prospect.

GILA COUNTY FLUORSPAR MINES AND PROSPECTS

Figure 3.

from the host rock, and metallurgical tests indicate that acid grade concentrates can be made by flotation.

OSBORN PROSPECT

Located in the NW-1/4 T9N R10E, about 8 miles south of Payson. The prospect appears to have been worked for gold and silver values, and in the pit, 6-inch stringers of purple, coarse-grained crystalline fluorspar occur in a hornblende diorite.

OTHER PROSPECTS (not visited)

Castle Dome Copper Mine - Located about 11 miles northwest of Miami, fluorite, barite and quartz reported in a faulted quartz-monzonite. Cavities up to 3 inches across are filled with vuggy masses of large cubic fluorite crystals.

Quartz Ledge Prospect - Reported to be in the SE-1/4 T7N R11E.

Conway Prospect - Reported to be in the NW-1/4 T5N R11E.

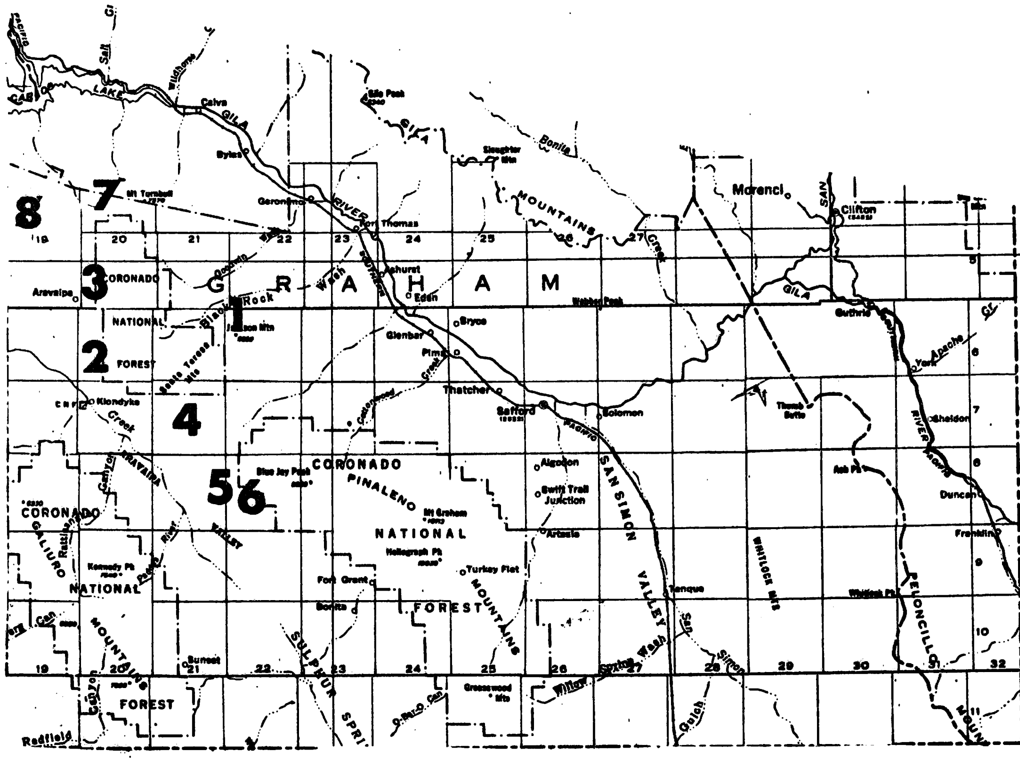
GRAHAM COUNTY

The location of mines and prospects is shown in Figure 4 (page 18).

MT. JACKSON MINE (also called Rhodes Spar Mine)

Located about 1 airline mile north of Jackson Mtn., a prominent peak about 15 miles southwest of Fort Thomas. Two patented claims, Mt. Jackson No. 1 and 2 (pat. no. 4673) are located in the SE-1/4, sec. 6, T6S R22E, and can be reached by taking the YL Ranch road from Ft. Thomas for about 12 miles. Continue past YL Ranch, and turn left 1/2 mile beyond ranch house, taking mine access road for 2.3 miles to mine.

Fluorspar mineralization is exposed in an open-cut, where the vein is about 7 feet wide. It extends on the surface southeast of the cut, to a prospect pit,



GRAHAM COUNTY FLUORSPAR MINES AND PROSPECTS

1. Mt. Jackson Mine.
2. Grand Reef Mine.
3. Landsman Prospect.
4. Edith Property.
5. Marcotte Group.
6. Graham Prospect.
7. Barium King Prospect.
8. Coronado Group.

Figure 4.

and beyond for a distance of 800 feet, varying in width from 1-1/2 to 3 feet. The fluorspar occurs as a fissure filling in a faulted Pre-cambrian granite. It is both purple and green, coarse-grained crystalline ore, showing evidence of two deposition periods, and separates easily from a coarse quartz impurity.

About 300 tons of fluorspar were mined in 1953 and shipped to the Duncan, Arizona flotation mill. An average assay for two truck loads of ore was 67% CaF_2, 3.4% $CaCO_3$, 27.0% SiO_2, and 2.4% Fe.

GRAND REEF MINE

Located in SE-1/4NE-1/4, sec. 29, T6S R20E, about 6 miles north of Klondyke. The mine was worked for silver lead values, and contains small amounts of fluorspar, quartz, galena, sphalerite, argentite, in a faulted Pre-cambrian schist, intruded by rhyolite porphyry dikes.

LANDSMAN PROSPECT

Located in sec. 29, T5S R20E, about 3 miles northeast of Aravaipa. Small stringers of purple fluorspar were found with quartz, barite, lead and silver in a faulted limestone. Rhyolite porphyry dikes are nearby.

EDITH PROPERTY

Located in sec. 22, T7S R21E, about 12 miles east of Klondyke. Several prospect pits expose 1 to 2 ft. fluorspar veins of coarse-grained crystalline texture, in a faulted Pre-cambrian granite.

OTHER PROSPECTS

The following prospects are primarily of barite mineralization, with relatively small amounts of fluorspar.

Marcotte Group - There are 12 claims located in sec. 13 T8S R21E, overlapping into secs. 11, 12, and 17, about 27 miles south of U. S. Hwy. 70. Access is by means of the Klondyke-Bonita road and the Cedar Camp road. Reportedly discovered in 1900, shafts and an open-cut expose 1 to 4 ft. veins of barite, containing small amounts of green fluorspar and copper oxides. Host rock for the ores is a fractured volcanic agglomerate. An assay of ores made by the U. S. Bureau of Mines is 71.1% $BaSO_4$, 6.4% CaF_2, and 1.3% $CaCO_3$.

Graham Prospect - Located in sec. 20, T8S R22E, at elevation 4900, about 2 miles southeast of the Marcotte Group. Small veins, 6 inches to 12 inches of barite are exposed in a location pit, with sparse fluorspar and copper oxides in a Pre-cambrian granite. An assay of typical ore is reported as 77.8% $BaSO_4$, and 4.9% CaF_2.

Barium King Prospect - Five claims are located in sec. 19, T4S R20E and sec. 24, T4S R20E, about 5 miles west of Turnbull Mtn. The property is accessible from old U. S. Hwy. 70 by turning south on a dirt road, 13 miles east of Coolidge Dam, traveling on the dirt road 9 miles to the House Ranch buildings, then take truck trail for 2.8 miles to claims on west side of Mitchell Canyon. Fine-grained barite-fluorspar veins, up to 18 feet wide, occur in a brecciated trachyte. Additional exploration of the property will require the removal of considerable overburden. U. S. Bureau of Mines reported assays of 62-65% $BaSO_4$, and 11-12% CaF_2. Metallurgical tests indicate that a good grade of barite, and that acid grade fluorspar concentrates could be recovered by flotation methods.

Coronado Group - Located in the vicinity of the old Copper Reef Mine, in secs. 28 and 29, T4S R19E, accessible by a graded to poor dirt road from old U.S.Hwy. 70. Barite, quartz, and fluorspar mineralization occurs in a limestone, along its bedding planes.

GREENLEE COUNTY

Mines, prospects and occurrences are located in Figure 5 (page 22), all in the Steeple Rock District, near the Arizona-New Mexico border.

Initial production began in 1918, with significant shipments in 1936-44, and the last production recorded in 1953. Total Greenlee County production is estimated at 7,500 tons.

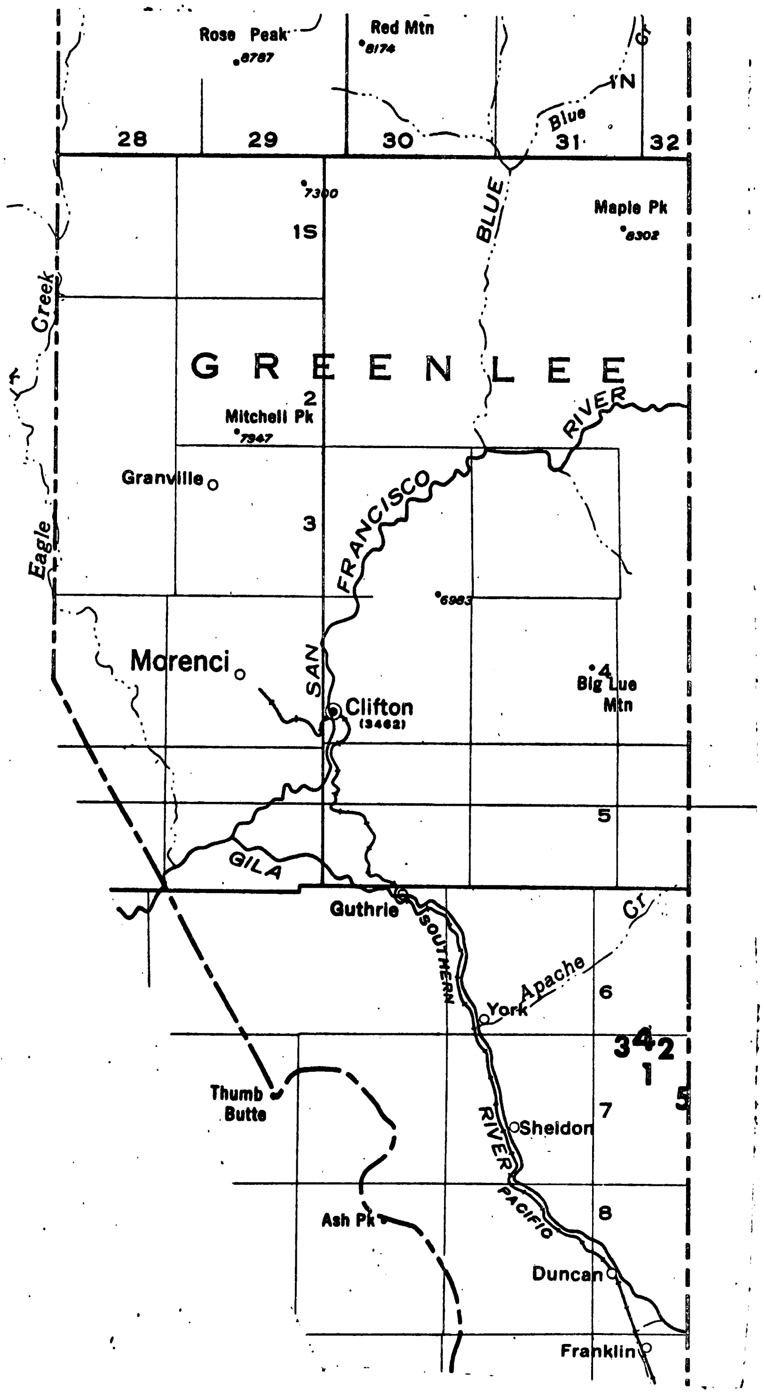
POLLY ANN MINE (Also known as Forbis Mine)

Located in the western foothills of the Mule Creek Mtns., in the NE-1/4 sec. 9, T7S R32E, about 14 miles northeast of Duncan. To reach the mine, take Arizona Hwy. 75 north of Duncan, crossing the Gila River, for a distance of 1.7 miles, then turn right (north) on a dirt road leading up a sandy wash a distance of 8.8 miles to Goat Camp; then take jeep road to left, past Luckie Mine workings, to the mine about 3 miles from Goat Camp.

The mine area consists of 3 shafts, several open cuts, and underground connecting drifts. The deepest shaft is about 200 feet and was flooded at the time of inspection.

The Polly Ann is the largest mine in the district and appears to have the best grade of ore.

Fluorspar occurs as fissure veins in a shear fault. The owner reports that the ore is mostly pale to deep green, coarse-grained crystalline, as shoots, 4 to 6 feet wide by 50 ft. long and 50 ft. high. Some of the ore on the dump is columnar, banded and medium grained crystalline textured. Host rock for the ore is a rhyolite tuff, intruded by a porphyritic andesite. Nearby is a bleached area of rhyolite rocks, indicative of hydrothermal alteration. On the surface, the veins extend for a distance of 4000 to 5000 feet, in an easterly direction,



GREENLEE COUNTY FLUORSPAR MINES

1. Polly Ann Mine.
2. Luckie No. 1 and 2 Mines.
3. Danie[illegible] Camp Mine.
4. Fourth of July Mine.
5. Phillips Mine.

Figure 5.

over to the Luckie Mine workings. Average grade of the ore shipped was 65% CaF_2, with 25 to 30% SiO_2. No metallic sulfides were noted.

LUCKIE NO. 1 and NO. 2 MINES

Located in the SE-1/4 sec. 3, and NW-1/4 sec. 10, T7S R32 E, about one airline mile east of the Polly Ann Mine. Elevation of the mine is approximately 4600. It was one of the four largest producers of the district. The ore is said to average 65% CaF_2. This grade was attained by crushing and screening at the mine.

Development works consist of a glory hole and a vertical shaft. Fluorspar occurs as fissure veins in an andesite porphyry and rhyolite tuff. The veins, 2 to 3 ft. wide consist of mixed fluorite and coarse quartz. Exposed ore is of lower grade than mined at the Polly Ann. The fluorite is medium-grained crystalline ore and is pale green in color.

On Luckie No. 1, the vein system is exposed as low quartz ridges, containing pockets of fluorspar. Surface widths of the ore vary from 4" to 2'6", and underground, they reportedly are 4.5 ft. wide. Dip of the veins is 40^o to 60^o S. For Luckie No. 2, the average width of ore mined was 4 feet. Much of the fluorspar post dates faulting, with both quartz and fluorspar cementing a breccia. Slicken-slides are common, but give no evidence of the general direction or amount of displacement along the faults. The occurrence of brecciated fluorspar indicates post-mineral movement along the fault.

Average grade of the ore is about 40 to 50% CaF_2, with silica 35 to 40%, and 5% calcite. Other minerals present are limonite, psilomelane containing tungsten and barite. The sequence of mineral formation was probably quartz, followed by fluorite, or simultaneously with it. In addition, some of the well-developed fluorspar cuts the quartz indicating that some of the fluorite was later than the quartz. Both the psilomelane and iron oxides are supergene minerals.

DANIELS CAMP MINE

Located in the NE-1/4 sec. 5, T7S R32E, about 1.5 airline miles northwest of the Polly Ann Mine at about elevation 4400. It is one of the four largest producers in the district.

Development works consist of one shaft and a large open cut from which most of the production was obtained. In the open cut, the fluorspar occurs as deep green to blue-green stringers in fractured andesite. Nearby is a markedly porphyritic andesite dike. Fluorspar stringers mixed with barren rock extend over an 8 to 10 ft. width.

FOURTH OF JULY MINE (also known as Ellis Shaft)

Located in the NE-1/4 sec. 4, T7S R32E, about 1 mile due east of Daniels Camp Mine at elevation 4600. It is one of the four largest producers in the district.

Mining at the Fourth of July Mine started in 1937 and continued until 1942, when about 1600 tons containing 60 to 65% CaF_2 and 25 to 30% SiO_2 were shipped.

Development work consists of a 150 ft. shaft, 500 ft. of drifting and two small open cuts. Fluorspar occurs in rhyolite porphyry that is faulted and notably porphyritic. Southwest of the shaft is a hydrothermally altered rhyolite tuff. The veins contain dense milky to reddish-brown quartz, grey calcite, and colorless to green fluorspar. Secondary coatings of psilomelane are present and much of the ore is interlaced with reddish-brown iron-stained quartz veinlets. Commonly, the fluorspar-rich part of the vein is a mixture of brecciated quartz and fluorspar. The U. S. Bureau of Mines report a vein system of 2500 feet, but only small sections contain fluorspar. The width of the fluorspar averages 3 to 4 feet in the mine, which contains two separate veins on the 102 and 148 foot levels.

PHILLIPS MINE (also known as Goat Camp Mine)

Located in the NW-1/4 sec. 15, T7S R32E, about 1/2 mile from the New Mexico state line.

The property was not visited, however the exploration work reportedly consists of a 20 ft. deep trench.

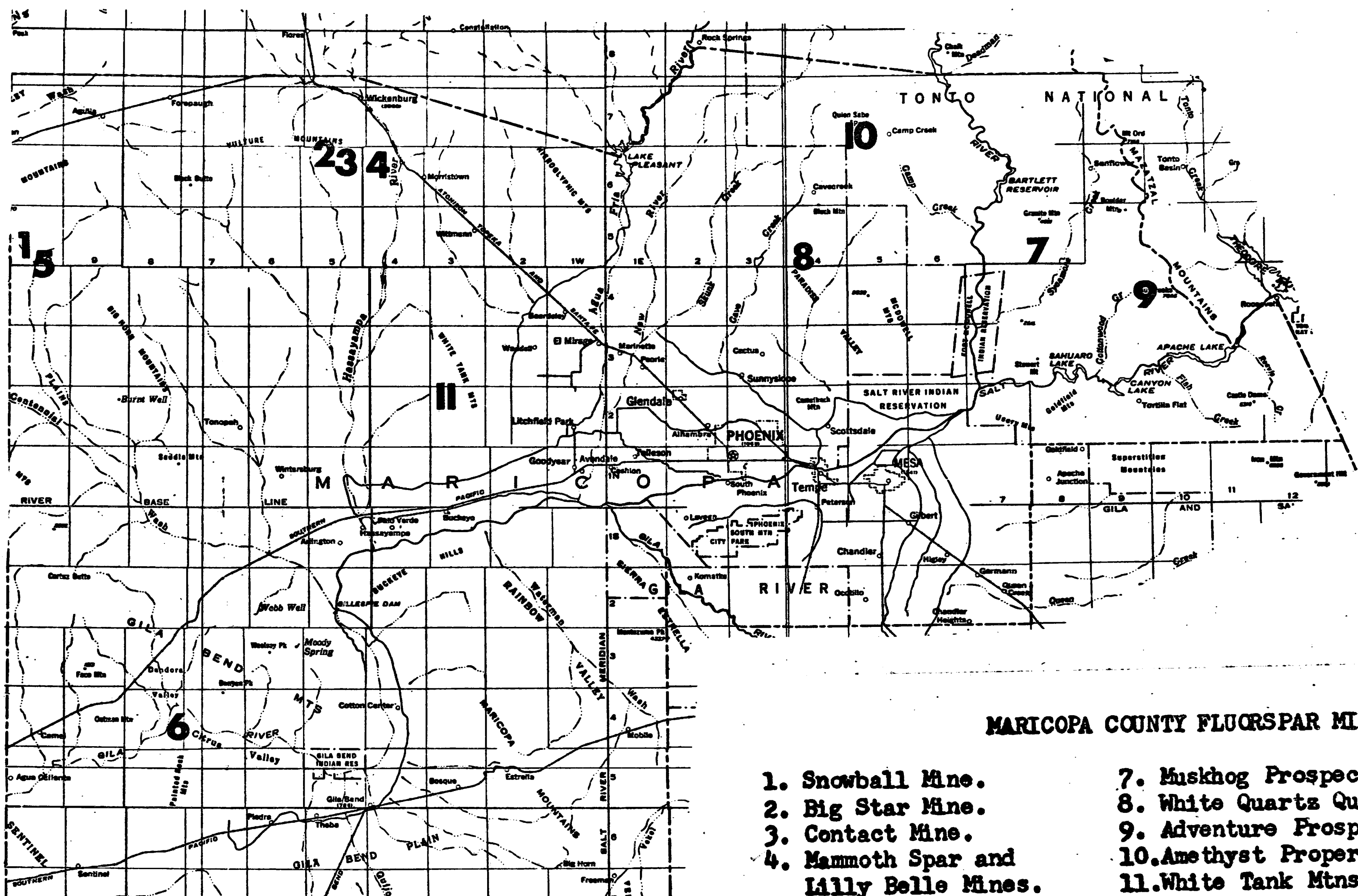
MARICOPA COUNTY

The Snowball Mine in the Harquahala Mtns., south of Aguila, and the Vulture Mtn. area near Wickenburg, account for the county's production. Mines, prospects, and occurrences are located in Figure 6 (page 26).

SNOWBALL MINE

Located about 23 miles southeast of Salome, on the south end of the Harquahala Mtns., in secs. 28 and 29, T5N R10W at elevation 1600. Access to the property is from U. S. Hwy. 60-70, at Salome, thence 13 miles southeast on the Hassayampa Road, and thence 10 miles northeast of a mine access road. An alternative route is to drive south from Aguila, thence 10.5 miles over an unimproved desert road.

It has been reported that fluorspar was first discovered in 1943, and an exploration program of trenching, surveying, drilling, and sampling was undertaken by the U. S. Bureau of Mines in 1949. Small shipments were made in 1957 and 1958, for use as a flux in the cement industry.



MARICOPA COUNTY FLUORSPAR MINES.

1. Snowball Mine.
2. Big Star Mine.
3. Contact Mine.
4. Mammoth Spar and Lilly Belle Mines.
5. Princess Ann Deposit.
6. Rowley Mine
7. Muskhog Prospect.
8. White Quartz Quarry.
9. Adventure Prospect.
10. Amethyst Property.
11. White Tank Mtns.

Figure 6.

Development work consists of several open cuts, and two shafts, each about 100 ft. in depth. Fluorspar occurs as lenses and fissure fillings, 1.5 to 2 ft. wide on the surface, over a distance of about 3000 feet. Mineralization occurs in a high-angle thrust fault, of a Paleozoic limestone that is cut by felsite dikes. The fault strikes N 70°W, and dips about 50°NE. The fluorspar lenses are high grade, light blue in color and fine to medium grained. Primary impurities are quartz, and white and black calcite. Minor gangue minerals are limonite, barite, hematite and manganese.

At the bottom of the shaft, a 3.5 ft. wide fluorspar vein averages 75% CaF_2, and in the open cut, a 10 ft. wide zone of fluorspar mineralization assayed 36% CaF_2, 35% SiO_2 and 18% $CaCO_3$.

BIG STAR MINE (also known as Big Spar Mine)

Located in the Vulture Mtns., about 5 miles southwest of Wickenburg in the NE-1/4, sec. 4, T6N R5W. To reach the property take the Vulture Mine Road (about 1 mile west of Wickenburg) from U. S. Hwy. 70, travel 3.2 miles south, turn left on dirt road for 2.7 miles to mine.

Development work consists of a 50 ft. shaft, remains of a jigging plant, and numerous open cuts. Small shipments were reported in 1939, 1943-45, 1948, and about 60 carloads of metspar in 1953.

Fluorspar occurs as 3 to 5 ft. wide veins in a faulted red andesite. Nearby is a granitic porphyry intrusion. The ore is light green, coarse crystalline in texture, and averages about 50% CaF_2, intimately mixed with silica. A 2 ft. vein can be traced on the surface for 1400 ft. and strikes east-west, dipping 60° to 70°S. Several small veins are exposed, parallel to the main vein, in the open cut adjacent to the shaft. By jigging and selective mining, ore averaging

60% CaF_2 was produced for shipment as metspar.

CONTACT MINE

Located in the SW-1/4 sec. 2, T6N R5W, about 1-1/2 miles southeast of the Big Spar property. Development work consists of several open cuts, exposing 1/2 to 1 ft. wide veins of fluorspar in a red andesite. Average grade of the ore is higher than an average grade from the Big Spar Mine and reportedly was 60% CaF_2, with fine to medium grained silica as an impurity.

MAMMOTH SPAR MINE (also known as Lucky Strike Mine)

Located in the NW-1/4 sec. 7, T6N R4W, about 2 miles southeast of the Contact Mine. The property was not visited, however, the owner reports that about 100 tons of 63% CaF_2 were shipped in 1953.

LILLY BELLE MINE (also known as Jumbo Claim)

Located in the S-1/2 sec. 7, T6N R4W, about 3/4 mile south of the Mammoth Spar Mine. The fluorspar occurs as veins in granite-trachyte-diorite. Nearby are two pegmatite veins that outcrop on the surface. The lower vein is 6 ft. wide, striking east-west, and dipping 55° south; whereas the upper vein is 5 ft. wide and dips 45° south. Each vein has been explored by an open cut, and each contains 2 ft. of high grade spar, estimated to be 55 to 60% CaF_2, with the balance mostly silica. In 1952, about 50 tons of metspar were reported to have been shipped.

PRINCESS ANN (Fay L) DEPOSIT

Located on the northwest tip of the Big Horn Mtns. in sec. 34, T5N R10W, at approximately elevation 1900. The property is located about 20 miles southwest of Aguila. Barite and fluorite occur in 10 to 20 ft. wide veins in a volcanic conglomerate. Overlying the conglomerate nearby is a basaltic flow through which the barite-fluorite mineralization does not penetrate. It was reported that

300 tons of barite were shipped from the property. A representative sample, taken and assayed by the U. S. Bureau of Mines ran 15.6% CaF_2, 53% $BaSO_4$, and 1.7% $CaCO_3$. Metallurgical tests indicate that acid grade fluorspar concentrates and a good grade of barite could be made by flotation methods.

WHITE ROCK (Blue Bird) CLAIMS

Located about 1 mile east of the Princess Ann deposit in sec. 35, T5N R10W, at approximately elevation 2000. Barite-fluorite mineralization occurs in a fractured basalt, as stringers and veins varying from 1 inch to 2 feet wide. A typical ore sample taken by the U. S. Bureau of Mines assayed 7.7% CaF_2, 86% $BaSO_4$, and 3.4% $CaCO_3$.

ROWLEY MINE

This property consists of 6 patented claims, on the west flank of the Painted Rock Mtns., in the NE-1/4 sec. 25, T4S R8W. Access to this property from Gila Bend (at intersection of Arizona Hwy. 84 and Interstate Hwy 8) travel west on Interstate Hwy. 8 for 14.5 miles, turn right on the Painted Rock Dam road for 12.6 miles, then right on dirt road to the mine for about 1 mile. The development work consists of an inclined shaft and a vertical shaft, from which wulfenite and base metals were mined from 1909 to 1923. Barite with minor amounts of fluorspar occur in a faulted andesite. A sample assayed by the U. S. Bureau of Mines was reported at 3.8% CaF_2, 64% $BaSO_4$, 3.6% Pb, 0.1% Cu, and 0.8 ounces Ag per ton.

MUSKHOG PROSPECT

Located in the SW-1/4 T5N R8E, about 5 miles south of Granite Mtn. Access to the property is from the Beeline Hwy. An open cut exposes a 3 ft. wide, high grade fluorspar vein in a Pre-cambrian granite. The ore is pale to deep green, dark purple, and coarse-grained crystalline.

The following fluorspar occurrences were reported by the Arizona Department of Mineral Resources, but were not visited:

White Quartz Quarry - Fluorite occurrence reported on Pinnacle Peak, sec. 32, T5N R5E.

Adventure Prospect - Located near Four Peaks, approx. T4N R9E.

Amethyst Property - Located in the Cave Creek District in sec. 31, T7N R6E.

Davis Property - Reported to be 30 miles north of Mesa, near Verde River, approx. T6N R7W.

Texas Queen Property - Located 11 miles southwest of Morristown in the San Domingo District in T5N R5W.

White Tank Mtns. - Fluorspar reported in sec. 5(?) T2N R3W.

MOHAVE COUNTY

The following fluorspar occurrences have been reported but were not examined.

Blue Daisy Prospect - Located 4 miles east of Hackberry in T23N R13W, 4 ft. vein of blue-green fluorspar reported in faulted limestone.

Black Mtns. - Approx. T20N R20W, white, pale green, and purple fluorspar reported in quartz veins with gold mineralization, in Oatman District, at the Times, Hardy and Moss Mines.

Red Hills Prospect - Located in sec. 7 T11N R13W in Artillery Mtns., about 6 miles northwest of Alamo. Lavender fluorite reported with barite and copper oxides in limestone and felsite breccia.

Boriana Mine - Fluorite reported in tungsten-bearing quartz veins of granitic rocks, as veinlets. Located in Hualpai Mtns., 16 miles east of Yucca in NW-1/4 T18N R15W.

PIMA COUNTY

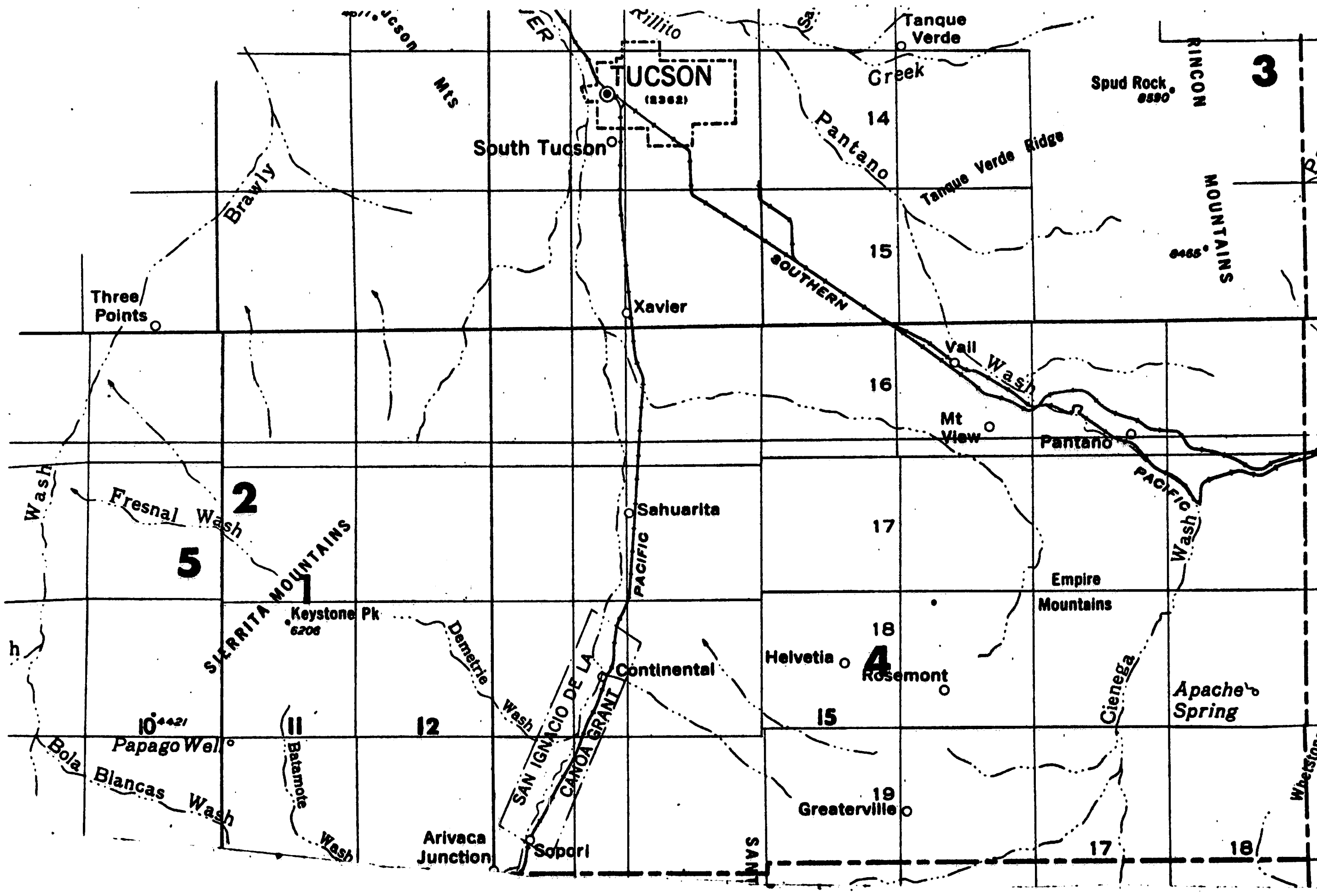
Production from Pima County has been small, from two properties in the Sierrita Mtns., southwest of Tucson. Figure 7 (page 32) shows the approximate location of prospects and occurrences.

NEPTUNE MINE (also known as Fluxore Mine)

Located in the Sierrita Mtns. approx. sec. 34, T17S R11E, about 25 airline miles southwest of Tucson. To visit the property, take a dirt road, leading southeast from Arizona Hwy. 286 about 0.5 miles south of Three Points (Robles Jct.), up Soto Wash for about 11 miles, then turn right up Fresnal Canyon for 4 miles to the mine. Development work consists of a shaft, two adits and prospect pits. Fluorspar occurs as 2 to 5 ft. wide veins, with ore shoots about 25 ft. long by 25 ft. deep in veins along a fault that separates a schist from granite. Nearby are aplite porphyry dikes that strike northwest to southeast. The exposed veins strike N 10°W and N 60°W. and dip nearly vertical. Small shipments were intermittent in 1918-20 and the 1940s. The fluorspar is both green and dark purple, coarse grained crystalline and free of sulfides. It is high-grade, averaging 70 to 80% CaF_2, with 12 to 25% SiO_2.

GUNSIGHT MTN. MINE

Located on the north side of the Gunsight Mtns. in secs. 7 and 8, T17S R11E, at about elevation 3500. Access to the property is from Robles Jct., go south on State Hwy. 286 about 3-1/2 miles, then southeast on dirt road for 9 miles, turning north on dirt road to northwest flank of the mountain for about 2 miles to the mine. Workings consist of 2 adits, a 30 ft. shaft, and an open cut.



PIMA COUNTY FLUORSPAR MINES AND PROSPECTS

1. **Neptune Mine.**
2. **Gunsight Mtn. Mine**
3. **Driscoll Mtn. Prospect.**
4. **New York Mine.**
5. **Black Dike Group.**

Figure 7.

A 3 ft. fluorspar vein was followed by driving a drift along a fault separating granite from quartz-biotite schist. Most of the fluorspar is pale green, medium to coarse grained crystalline, averaging 60 to 70% CaF_2. Small shipments of metspar were made.

DRISCOLL MTN. PROSPECT

Located in the NE-1/4, T14S R18E along the eastern margin of the Rincon Mtn., about 22 miles north of Interstate Hwy. 10. Coarse grained crystalline green fluorspar, 3 to 4 ft. wide is exposed in a prospect pit. Host rock for the spar is a faulted Devonian or Mississippian limestone. The fluorspar is estimated at 70% CaF_2.

NEW YORK MINE

Located in the Helvetia District, of the Santa Rita Mtns., approximately sec. 24, T18S R16E. Minor fluorite and quartz veinlets are reported to occur with argentiferous lead. The property was not visited.

MAMMOTH MINE

Located in the W-1/2 sec. 4, T12S R8E, about 2 miles northwest of Silver Bell. Quantities of green fluorspar are reported to occur with barite and lead, in a silver-lead exploration pit. Host rock for the fluorspar is a Paleozoic limestone at a contact with intruded porphyry.

BLACK DIKE GROUP

Located in secs. 23, 24, 25 and 26, T17S R10E on the west flank of the Sierrita Mtns. Fine-grained purple fluorspar is disseminated in a greenstone schistose rock, with chalcopyrite, epidote, and sulfide minerals. Nearby is a ridge of micaceous schist, stained by iron and manganese oxides. In a contact metamorphic zone that is richest with sulfide minerals and fluorite is a black pitchblende.

SURE FIRE NO. 1 CLAIM

Located in sec. 15, T13S R18E about 30 miles east-northeast of Tucson near Espiritu Canyon. Purple fluorite is found in schist and gneissic granite. Four shallow prospect pits have been dug, exposing small veinlets of fluorite associated with quartz, calcite and the uranium minerals uranophane and autunite.

WHITE PRINCE CLAIM

Located on the west flank of the Quijotoa Mtns. in approx. sec. 17 T15S R2E of the Papago Indian Reservation at elevation 3300. The property is about 5 miles southwest of Quijotoa (Covered Wells). The claims were located for barite which is in a metamorphosed limestone in contact with Tertiary andesite, containing minor amounts of fluorspar. A sample taken by the U. S. Bureau of Mines assayed 2.6% CaF_2, 61% $BaSO_4$, and 24% $CaCO_3$.

PINAL COUNTY

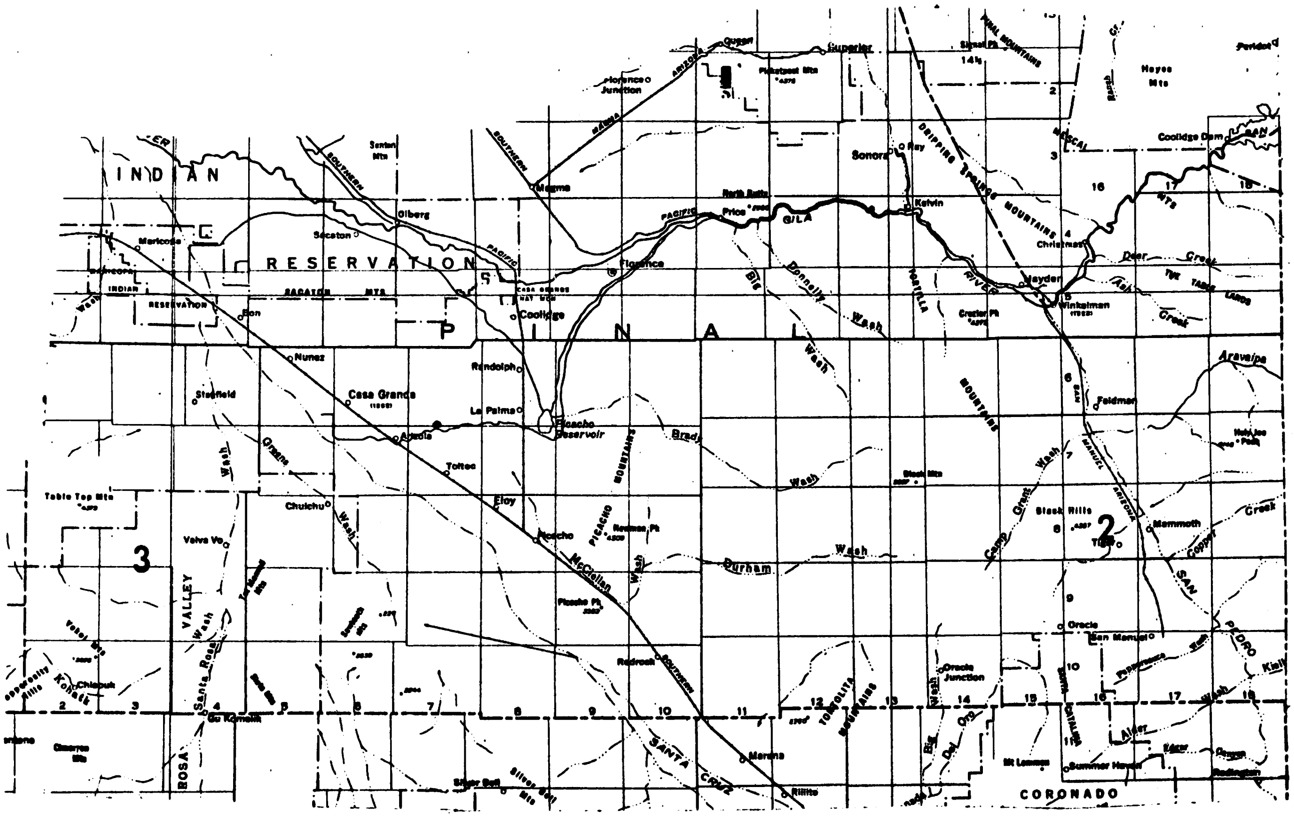
Four fluorspar occurrences are reported at the locations shown in Figure 8, (page 35).

GONZALES PASS DEPOSIT

Located in sec. 16, T2S R11E about 1/2 mile south of Gonzales Pass. Property can be reached by traveling easterly from Florence Jct., for 4.9 miles then 2.2 miles southeast on truck road to workings. Several pits dug in a schist expose barite veins with minor fluorspar.

MAMMOTH MINE

Located in approx. sec. 26, T8S R16E about 1/4 mile north of Tiger mining camp. Microscopic fluorite crystals occur in veins in rhyolite and quartz monzonite



PINAL COUNTY FLUORSPAR PROSPECTS

1. **Gonzales Pass Deposit.**
2. **Mammoth** Mine
3. **Vekol Mtns.**
4. Near Oracle (not shown on map)

FIGURE 8.

associated with pyrite, quartz, copper, gold, barite, galena and sphalerite.

VEKOL MTNS.

Fluorspar reported 7 miles south-southwest of Vaiva Vo, Papago Indian Reservation.

Near Oracle

Green and purple fluorspar reported in Pre-cambrian granite, in T9S R15E.

SANTA CRUZ COUNTY

Fluorspar occurrences are reported at two locations.

ALTA MINE

Located in the Patagonia Mtns. in sec. 3, T23S R16E. The mine shaft is in a quartz diorite and rhyolite. The ore mined was silver-bearing galena in a gangue of quartz and reddish fluorite.

ANNIE LAURIE CLAIMS

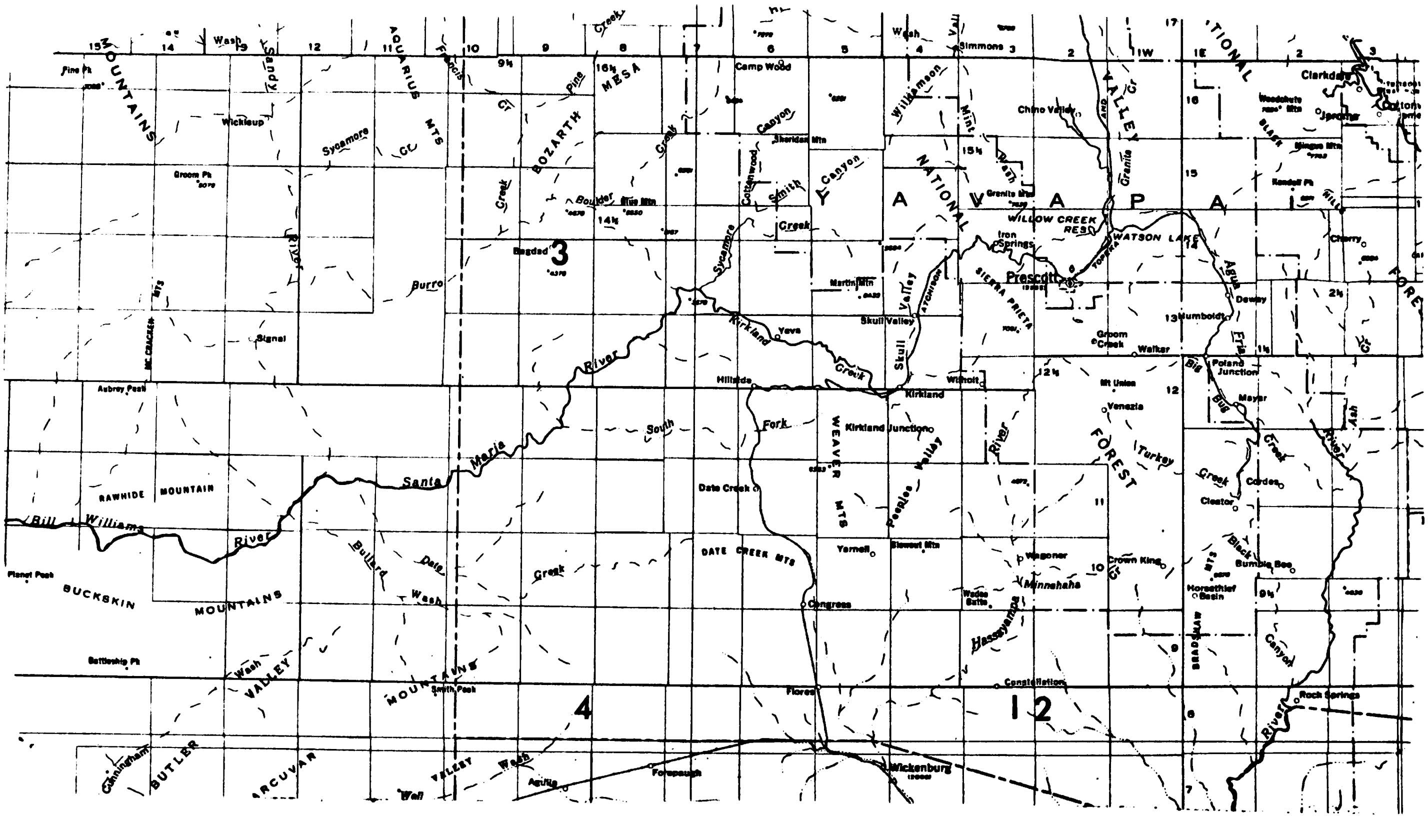
Located about 25 miles west of Nogales, and 3 miles south of the abandoned Ruby mining camp, in the SE-1/4 sec. 1, T23S R11E. The claims cover a uranium-lead-zinc prospect in granite, near intrusive porphyritic andesitic masses. Minor amounts of purple fluorite form blebs and stringers in a calcite gangue with sphalerite, galena, chalcopyrite, pyrite and uranium minerals.

YAVAPAI COUNTY

No production has been recorded from Yavapai County. Prospects and occurrences are located in Figure 9 (page 37), and the following data is available, although none of the properties were visited.

ABE LINCOLN MINE

Located in the SE-1/4 sec. 11, T8N R3W, in the north end of the Wickenburg



Yavapai County Fluorspar Prospects

1. **Abe Lincoln Mine.**
2. **Swallow Mine.**
3. **Bagdad Area.**
4. **Harris Group.**

Figure 9.

Mtns. about 14 miles northeast of Wickenburg. Development work for copper consists of 2 shafts, 2 adits, with connecting drifts and crosscuts. Small amounts of purple fluorite occur in a narrow vein with calcite, copper oxides and secondary uranium mineralization. Host rock is a granite intruded by trachyte porphyry dikes.

SWALLOW MINE

Located in sec. 7, T8N R2W about 4 miles northeast of Constellation in the Castle Creek District. Fluorspar occurs as gangue in a vein with copper oxides, specularite, quartz and calcite. Host rocks are granite and schistose rocks.

CONGRESS JUNCTION AREA

Large fluorite crystals are reported in pegmatite dikes in T9N R5W.

LEVIATHAN MINE AREA

Reported to be in the McCloud Mtns. northwest of Hillside in T13N R7W. Fluorspar veins reported in a faulted granite.

SPRINGFIELD GROUP

Located about 2-1/2 miles west of Crown King in the Pine Grove District of the Bradshaw Mtns. in the N-1/2 T10N R1W. Stringers of purple fluorite reported in a quartz diorite, with quartz and pyrite in granodiorite host rock intruded by porphyry dikes.

BAGDAD AREA

Reported to be in T14N R9W area east of Lawler Peak. Purple and white fluorite in quartz veins with bismutite, and in pegmatite dikes.

HARRIS GROUP

Located in sec. 12, T8N R9W, in the eastern end of Harcuvar Mtns. Access is from Aguila, by traveling 10 miles northwest of Aguila on Alamo Road, then west on a dirt road to the mine. Workings include several open stopes, shafts and an open cut. The property was worked for manganese. The manganese ore veins with minor fluorite, calcite, barite and galena, occur in a red andesite.

LUCKY JACK PROPERTY

Reported to be in approximate T8N R3W, about 8 miles northeast of Wickenburg.

MAY PROPERTY

Reported to be 30 miles west of Prescott.

YUMA COUNTY

Arizona's first production of fluorspar came in 1902 from the Castle Dome district as a by-product from lead-silver mining. Total production from 1902 to 1953 was estimated at about 4000 tons. Figure 10 (page 41) shows the locations of mines and prospects.

CASTLE DOME MINES

The Castle Dome District located along the western base of the Castle Dome Mtns. is at about elevation 1500, about 4 airline miles southwest of Castle Dome Peak, and 35 miles northeast of Yuma. Major workings are in secs. 25 and 36, T4S R19W. To reach the mines, take U. S. Hwy. 95 north toward Quartzsite for 33 miles, then take a graded road to the right (northeast) for a distance of 9.7 miles to the mine.

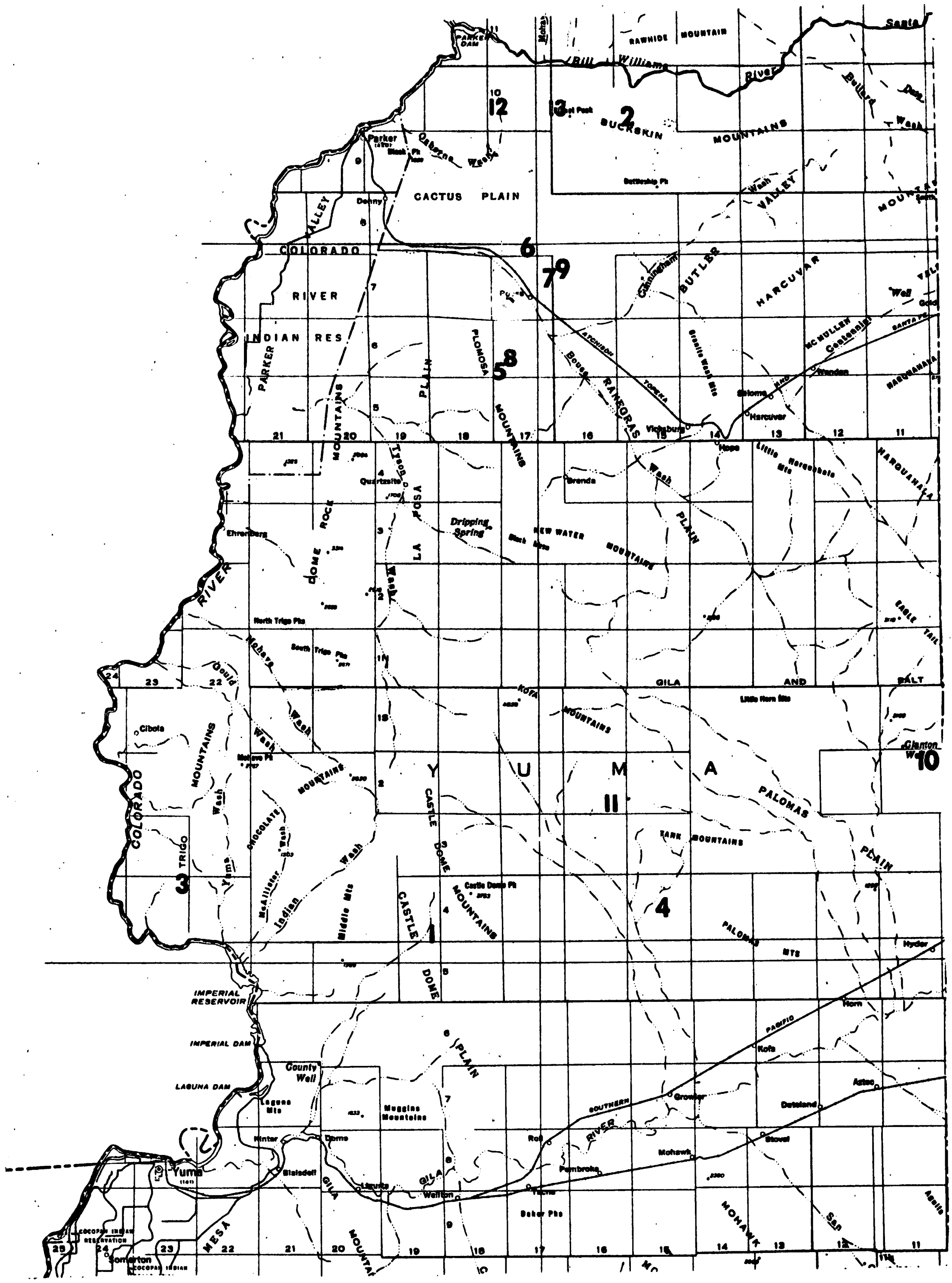
From 1902 to 1920 most of the production was shipped to Riverside, California where it was used as a flux in making cement clinker. Subsequent shipments were as metspar chiefly from the Senora lead mine in the 1940s and the last recorded production was in 1953, when 1600 tons of metspar were produced from 10,400 tons of tailings. The processing of fluorspar entailed hand-sorting, tabling and jigging with the fluorspar produced as a by-product of high grade lead and silver ores.

There are many mines in the district, but fluorspar production has been largely from the Big Dome, Rialto, Senora, Little Dome, and De Luce claims. Fluorspar mineralization occurs in lead-silver ores, as veins in diorite porphyry and Cretaceous shale. Some of the fluorspar veins can be traced on the surface for 3000 to 4000 feet. The widest veins and also the richest were found where diorite porphyry forms both of the vein walls. The wall rocks show pronounced alteration by silification. Veins generally are less than 5 feet wide, but some attain widths of 10 feet. A former owner reports that few veins were productive below the 250 level.

The veins consist mainly of green, purple and rose colored fluorspar that is coarse-grained crystalline, with some excellent specimens of cube crystals with etched edges. Other minerals found are crystalline calcite, bladed to massive barite, minor quartz, and irregular or sheet-like masses of galena and silver. Outcrops of the veins are traceable as colorless or pale green streaks of crystalline fluorspar, calcite and barite.

The Senora claims are in the S-1/2 sec. 36, T4S R19W and the workings consist of 3 shafts. Underground is a 3 ft. vein of galena and fluorite that was mined. It dips steeply eastward in a fault zone with a strike of N 30^{o}W. On the surface, the host rocks are steeply dipping dense grey shales, alternating with dikes of diorite and rhyolite porphyry and below the 250 level, the host rock is reported to be a rhyolite porphyry. The fluorspar is varicolored, pale green, purple, with rose colored predominating.

Adjoining the Senora claim on the northeast is the Little Dome claim, where the geology is similar to the Senora claim, with galena-fluorite veins occurring in a fault zone, adjacent to rhyolite porphyry dikes. Galena-fluorite



YUMA COUNTY FLUORSPAR MINES AND PROSPECTS

1. Castle Dome Mines
2. Mammoth, Copper Glance and Chicago Properties
3. Silver King Claim
4. Nottbusch Mine
5. Red Chief Deposit
6. Black Mtn. Group
7. White Christmas Group
8. Burro Barite No. 1
9. Happy Day No. 1.
10. Yellow BRest Prospect
11. King of Arizona Mine area.
12. Osbourne Wash Prospect.
13. Planet Peak Prospect

Figure 10.

veins, 4 to 7 ft. wide are reported at the 125 level. A parallel vein, some 10 ft. south of the main vein, shows 2-1/2 ft. of crystalline green fluorite, with minor amounts of lead.

Northeast of the Little Dome Claim, is the Big Dome Claim, which was an early producer of fluorspar prior to 1918. Four shafts, an adit, and open pits constitute the workings in shale at the contact with a diorite porphyry. The tailings dump indicates **that** considerable fluorspar was present in the veins that were mined.

The Hull or Rialto claims are in the northwest portion of the district in the N-1/2 sec. 25, T4S R19W. The main fluorspar-galena veins are in a dense bedded grey shale, cut by diorite porphyry dikes. The workings were believed to be in operation in 1902, and there are remains of a jigging-tabling mill, used to sort the fluorspar from lead-silver ores. A representative ore sample from tailings, taken and assayed by the U. S. Bureau of Mines averaged 44% CaF_2, 18% SiO_2, 19% $CaCO_3$, 0.8% Pb, 3.7% Zn, 1.4% Fe. Metallurgical tests indicate that by jigging and tabling a product of 73% CaF_2, metspar grade could be achieved. Subsequent flotation of a re-ground gravity concentrate yielded a concentrate of 89% CaF_2, which is less than acid grade fluorspar requirements.

The De Luce claims are located in the W-1/2 sec. 36, T4S R19W. The vein outcrops along a fissure in shale with a rhyolite porphyry dike near the footwall. At the surface it appears to be 3 ft. wide, high in galena content, and with fluorite, calcite and barite. One sample tested by the U. S. Bureau of Mines ran 11% CaF_2, 43 % SiO_2, 14% $CaCO_3$, 3.3% Pb, 2.0% Zn and 2.8% Fe. Combined gravity and selection flotation tests by the U. S. Bureau of Mines resulted in a concentrate of 91% CaF_2.

Considerable fluorspar remains in the Castle Dome District, and metspar grade can be made by jigging and tabling; however, the U. S. Bureau of Mines tests indicate that the ores are not amenable to flotation methods to produce an acid grade concentrate.

MAMMOTH, COPPER GLANCE AND CHICAGO PROPERTIES

Located in the Buckskin Mtns. approx. sec. 29, T10N R15W, near the abandoned Swansea mining camp. Minor amounts of fluorite, barite and quartz are found in a gneiss-schist complex with copper oxides and silicates. Some fluorite mineral specimens are uncommon in that the crystals are a bluish-green 1/4 to 1/2 inch octahedrons.

The following prospects of barite-flourspar mineralization are reported:

SILVER KING CLAIM

Located in the Trigo Mtns., at an elevation of 850, about 7 miles from the Colorado River in sec. 1, T4S R23W. It is located in the Silver District, and can be reached by the following route: From the junction of U. S. Hwy 95 and Interstate 8 in Yuma, travel 24.2 miles north on U. S. Hwy 95, turn left at windmill on dirt road, continuing 27 miles past the Red Cloud Mine, then turn on jeep trail for 1.7 miles to the workings. Clear to light green fluorspar occurs in a vein with quartz, calcite, iron oxides, white barite and wulfenite in fractured andesite. An adit with drifts exposes a 5 to 7 ft. wide barite-fluorspar vein, containing 49% CaF_2 and 11% $BaSO_4$.

NOTTBUSCH MINE (also called Silver Prince)

Located in the extreme southeast corner of the Kofa Wildlife Refuge at approximate elevation 2500. It is in the northern Neversweat Mtns., in sec. 15, T4S R15W. Development work consist of an inclined shaft, worked for lead and silver values. Barite-fluorspar mineralization occurs in a schist, intruded by rhyolite and andesite dikes. Prospect pits near the shaft expose a 3 ft. zone of barite, yellow-amber fluorite, and argentiferous galena. Reportedly, silver was shipped in 1908 and 1944.

RED CHIEF DEPOSIT

Located in the Plomosa Mtns. at elevation 1300, about midway between Quartzsite and Bouse. The property is in sec. 31, T6N R17W, and can be reached by traveling 8.6 miles south of Bouse, on the Quartzsite Road, then turning right (west) on a dirt road for 1/2 mile to the workings. Barite-fluorite veins occur in fissures in a fractured volcanic agglomerate. The veins vary from 2.5 to 4.5 ft. wide, averaging 31% CaF_2, 39% $BaSO_4$, and 7% $CaCO_3$. Metallurgical tests by the U. S. Bureau of Mines indicate that acid grade fluorspar could be produced by flotation, along with a good grade of barite.

BLACK MTN. GROUP

Located 5 miles north of Bouse in sec. 34, T8N R17W, at elevation 1000. Barite-fluorite in fissure veins 2 to 4 ft. wide are exposed in a faulted Mesozoic volcanic agglomerate, with iron and copper oxides. A composite sample assayed 14% CaF_2, 75% $BaSO_4$, and 5% $CaCO_3$. Flotation tests by the U. S. Bureau of Mines achieved a concentrate grade of 94% CaF_2 and 96% $BaSO_4$.

WHITE CHRISTMAS GROUP

Located in low rolling hills of volcanic breccia, about 4 miles from Bouse at about elevation 1000. The property is in sec. 12, T7N R17W. Several open cuts expose 2 ft. wide barite-fluorite veins.

BURRO BARITE NO. 1 CLAIM

Located 9 miles southwest of Bouse on the Quartzsite road, in sec. 29, T6N R17W, about 3/4 mile north of the Red Chief deposit. An open cut exposes a 4 ft. wide vein of light green fluorite, white to red barite, and crystalline quartz in a volcanic agglomerate.

HAPPY DAY NO. 1 CLAIM

Located in sec. 7, T7N R16W about 5 miles from Bouse. Near a shallow shaft an 18-inch to 2 ft. vein of barite-fluorite is exposed in an open cut, in a black volcanic agglomerate host rock.

PAY DAY CLAIM

Located on the west side of sec. 29, T7N R17W about 3-1/2 airline miles from Bouse. It is accessible from the Bouse-Quartzsite road, traveling 1.2 miles south from Bouse, then turn right for 1.5 miles, and next, turn left for 0.6 miles to the workings. Two parallel 2 ft. wide barite-fluorite veins are exposed in a 10 ft. shaft. The veins also contain iron and manganese oxides.

Other prospects reported but not visited were:

YELLOW BREAST PROSPECT

Located in the area of Clanton's Well, approximately sec. 2, T2S R11W - green fluorite, galena, wulfenite and quartz veins in a schist.

KING OF ARIZONA MINE AREA

Located in the Kofa Mtns., in the SW-1/4 T2S R16W, about 1 mile north of King of Arizona Mine. Fluorite, galena and calcite occur in a vein, of faulted schist near a monzonite porphyry dike.

OSBOURNE WASH PROSPECT

Located about 14 airline miles east-northeast of Parker, in sec. 19, T10N R17W - fluorite veinlets reported in a faulted basalt.

PLANET PEAK PROSPECT

Located about 2 miles northwest of Planet Peak in approx. sec. 29, T10N R17W. Narrow pale green fluorspar veins are reported in a fault zone, separating a Pre-cambrian granite-schist and a limestone, cut by aplite and pegmatite dikes.

FLUORSPAR PROPERTY

Reported to be in T9N R13W about 20 miles north of Wenden. Veins reported in a sheared granite-gneiss.

OUTLOOK, PRICES AND TARIFFS

World steel production is expanding rapidly as is the aluminum industry. Even greater growth rates are forecast for some sectors of the chemical industry. There is no satisfactory substitute for fluorspar either as a metallurgical flux or in the manufacture of hydrofluoric acid, an essential raw material used in the aluminum industry and by the chemical industry for the manufacture of fluoro-carbons for aerosols, plastics and refrigerants.

In 1969, fluorspar consumption was 1,330,000 tons, of which only 185,000 tons were produced in the United States. The balance was imported from Mexico, Italy, Spain and South Africa. The estimated United States consumption in 1975 will be 3,500,000 tons, requiring the mining of some 10,000,000 tons of crude ore per year.

Increased demands have resulted in an increase in fluorspar prices, and increased exploration and mine development. New reserves must be found to meet the anticipated demand.

The United States tariff schedules contain the following:

Imports	Duty
Fluorspar, containing over 97% calcium fluoride	\$ 2.10 per long ton.
Fluorspar, containing not over 97% calcium fluoride	\$ 8.40 per long ton

In 1966 the average price of metspar, FOB the Illinois-Kentucky area was \$38 per ton. It increased in July 1971 to \$60 per ton. Carloads of acid grade were being sold in 1966 for \$58 per ton and are currently \$85 per ton.

United States fluorspar prices quoted in the Engineering and Mining Journal of July 1971 were as follows:

Fluorspar: net ton; f.o.b. Ill., Ky.; CaF_2 content, bulk	
Metallurgical:	
Pellets, 70% effective CaF_2	\$ 60.00
Ceramic: calcite and silica variable, CaF_2	
88-90%	\$ 75.00
95-96%	\$ 80.00
97%	\$ 85.00
In 100-lb paper bags, extra	\$ 6.00
Acid: dry basis, 97% CaF_2	
Carloads	\$ 85.00
Less than carloads	\$ 85.00
Bags, extra	\$ 6.00
Pellets, 90% effective	\$ 68.00
Wet Filter cake, 8-10% moisture, sold dry content subtract approx.	\$ 2.50
Dry acid concentrates, f.o.b. Wilmington, 97% CaF_2, st.	\$ 82.50
European wet filter cake 8-10% moisture, sold dry content, duty pd,st,c.i.f. Wilmington/Philadelphia term contracts (spot material \$5-10 higher)	\$ 69-70

Mexican: st, f.o.b. metallurgical effective CaF_2

	f.o.b. vessel Tampico	f.o.b. cars Mex. border
70%	\$48.33-50.33	\$47.33-\$49.33
Acid 97%+, Eagle Pass, bulk, nt		\$ 62-67

EXPLORATION ASSISTANCE

Under Public Law 85-701 the U. S. Geological Survey through its Office of Mineral Exploration provides financial assistance in the exploration of fluorspar reserves. Approved projects are eligible to receive financial assistance in the form of a federal contribution of 50 percent of the total allowable cost of exploration work, repayable in production royalties.

A depletion rate of 22% for domestic fluorspar production is allowable for income tax purposes, subject to limitation of 50 percent of net income from the property.

EVALUATION OF DEPOSITS

Factors to be considered in evaluating fluorspar deposits are similar to most metallic minerals, and should include the following:

A. Geographic Factors.

1. Transportation costs.
2. Exploration costs.
3. Mining development and milling costs.
4. Labor cost and availability.

B. Geologic Factors.

1. Size and shape of deposit.
2. Reserves.
3. Mineralogy of deposit - grade, principal impurities, valuable by-products, and the amenability of the ore to beneficiation.

C. Economic and Environmental Factors.

1. Marketing cost.
2. Environmental and political acceptability.
3. Acquisition costs, royality payments, taxes, duties and legal costs.

GUIDES FOR EXPLORATION AND DEVELOPMENT

As a guide to prospecting and developing new deposits, the following information may be useful:

(1) Structure is an important factor in the emplacement of fluorspar. There is strong evidence that fluorine solutions ascended along fissures; and therefore shear-fault structures are favorable locations for ore shoots and veins.

(2) Fluorine solutions are also believed to have emanated from magmatic sources. Areas far from intrusive outcrops may have rhyolite, granite, diorite, or andesite porphyry dikes which are indicative of deep-seated igneous intrusions.

(3) Favorable host rocks for vein type deposits, are faulted granites, andesites, rhyolites. Replacement deposits may possibly be found in limestones and dolomites, beneath an impervious caprock.

(4) Metallics commonly found in association with fluorspar are lead with silver. Other metallics less common are sphalerite and manganese and tungsten minerals. Commonly associated non-metallics are calcite, quartz and barite.

(5) Fissure veins are likely to dip very steeply and the veins commonly pinch and swell.

(6) Since fluorspar resists chemical weathering, float material will likely be found near its source.

(7) Metallurgical users require that fluorspar be in lump or pelletized form. Since silica is a common impurity, metspar can be produced from few deposits without selective mining or processing.

(8) Fluorspar is sold and valued according to its effective calcium fluoride

content, equivalent to the assayed CaF_2 content in percent, less 2.5 percent for each 1.0 percent of assayed silica content.

Therefore, assays should be made at an early stage to determine if the ore grade is of commercial value.

(9) Some fluorspar deposits are of commercial value because of salable by-products, such as lead, silver, barite, and beryllium, and therefore the importance of valuable by-products should be considered.

(10) Metallurgical tests, to determine if acid grade concentrates can be made should be conducted at an early stage. Certain impurities may be locked in and both difficult and expensive to remove.

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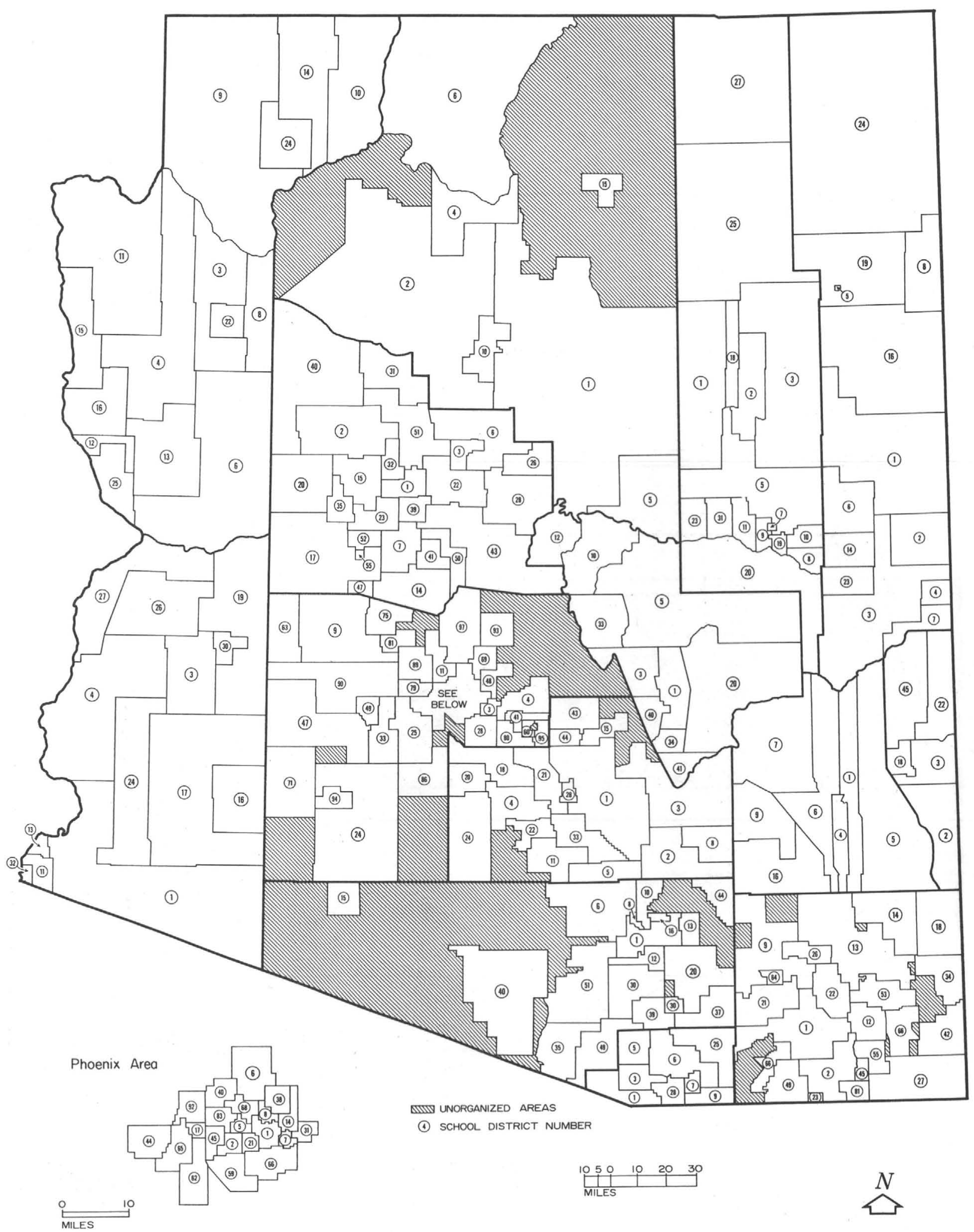
AN ARIZONA ECONOMIC AND HISTORIC ATLAS

ELEMENTARY SCHOOL DISTRICTS



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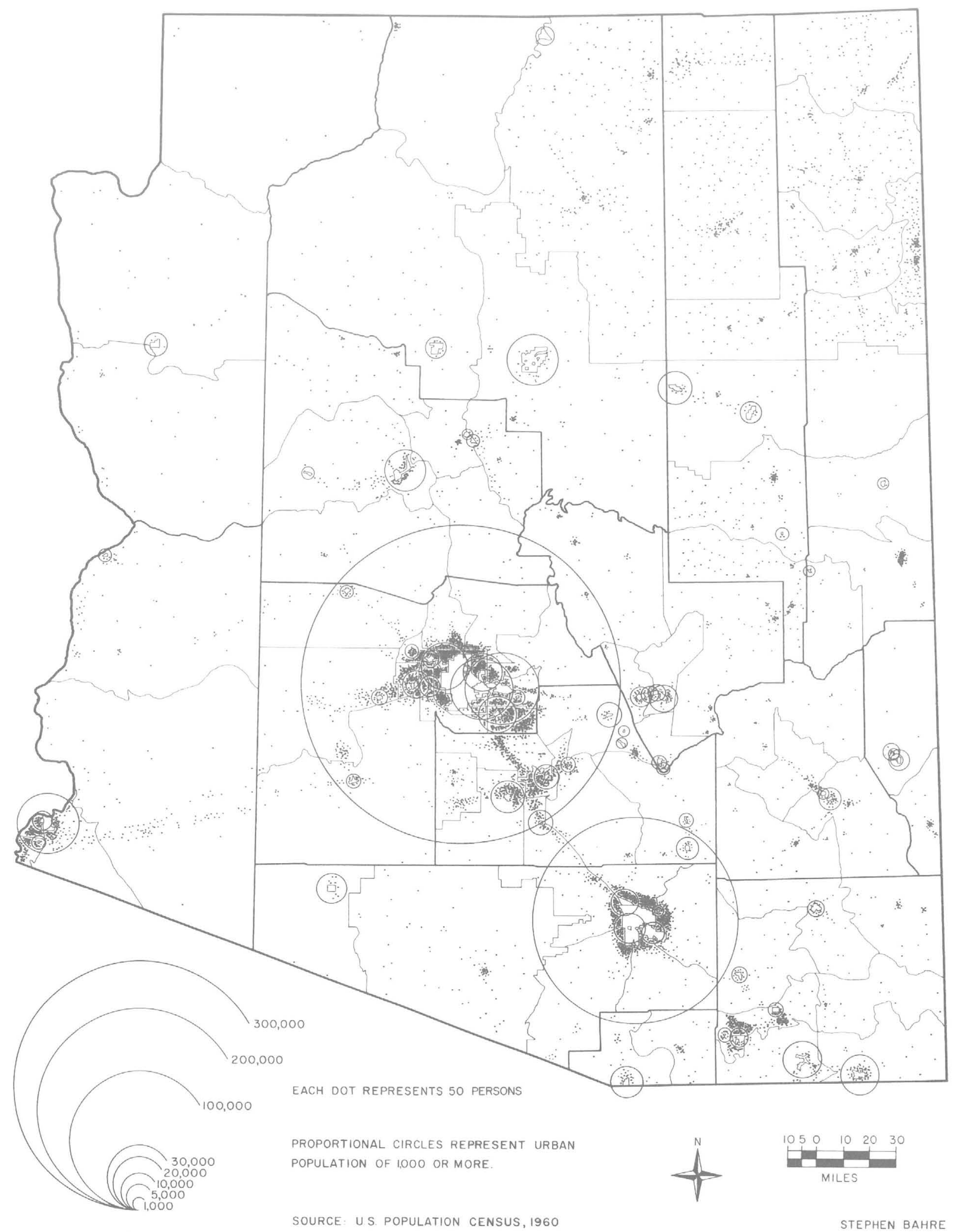

A SUMMARY OF THE GEOLOGIC AND METALLOGENIC HISTORY OF ARIZONA AND NEW MEXICO

(From "Ore Deposits of the Western States", Edited by B.S. Butler)

The basement rocks of Arizona and New Mwexico are a complex of deformed and recrystallized schists and gneisses, mostly of pre-Cambrian age. The schists have been formed from sediments, volcanic tuffs and flows, and some intrusives. These have been divided into various units by different investigators in different areas, though their relations with each other are poorly known.

VISHNU SCHIST

In the Grand Canyon of Arizona the schist is called the Vishnu schist by Walcott; eight subdivisions of this unit are recognized by Noble and Hunter. These are mostly hornblende and granite gneiss, mica schist, amphibolite, metadiorite, and massive basic intrusives, with some injected granite and pegmatite.

YAVAPAI SCHIST

Jaggar and Palache have assigned the name Yavapai schist to a series of metamorphic rocks in the Bradshaw Mountains. These are mostly phyllites, slates, mica schists, and chlorite schists, locally metamorphosed to gneiss, hornfels, and epidote and hornblende schist. Included are bands of quartzite, conglomerate, and limestone. Although most of these rocks appear to be of sedimentary origin, at least some of the chlorite schists prove to be altered andesitic volcanics. The conglomerate and sandstone series has an estimated thickness of 5000 to 7000 feet.

PINAL SCHIST

In the Pinal Mountains near Globe, Arizona there occurs a quartz-muscovite

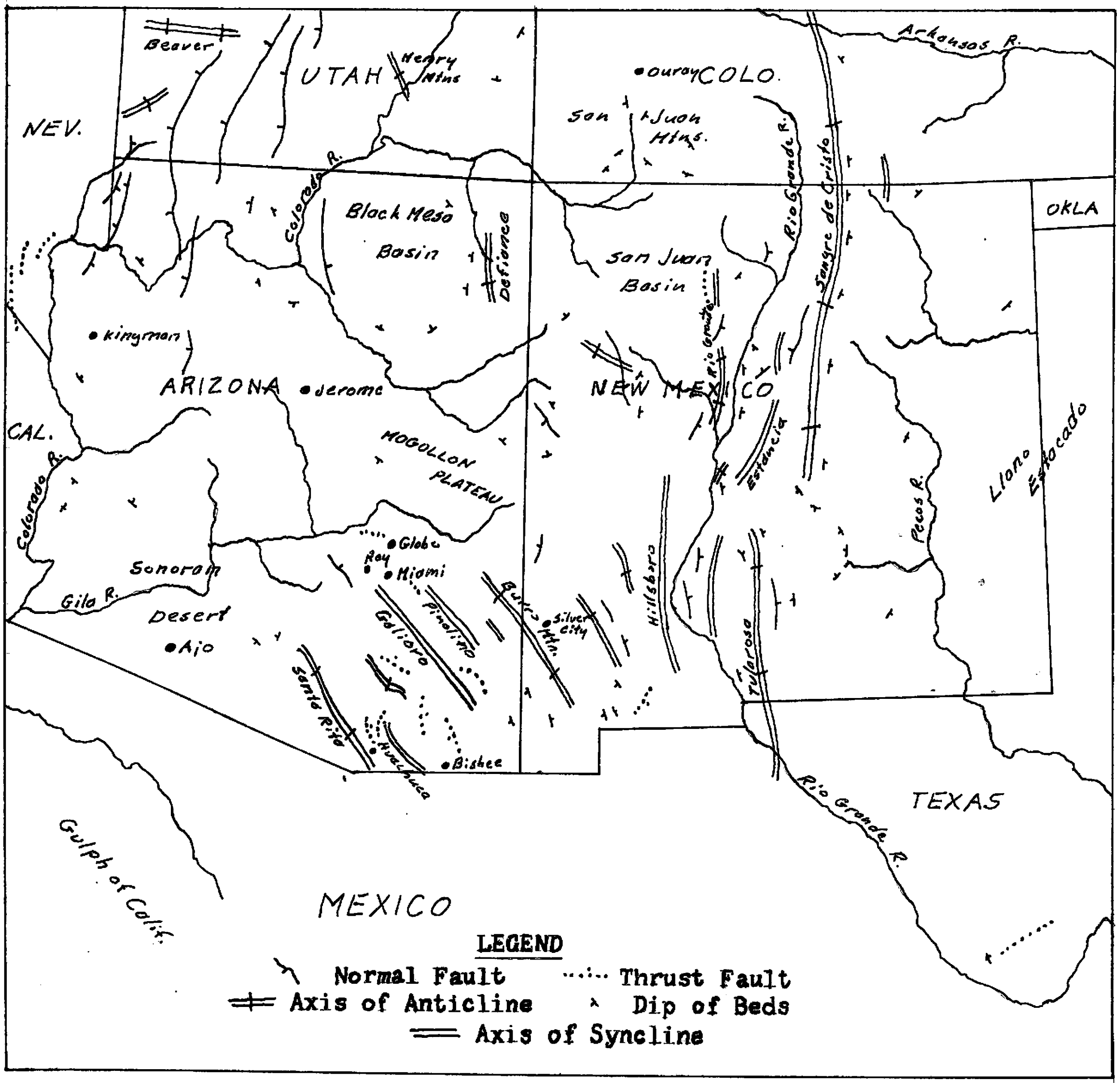
NEV.
UTAH
COLO.
OKLA
ARIZONA
NEW MEXICO
CAL.
TEXAS
MEXICO
Beaver
Henry Mtns
Ouray
San Juan Mtns.
Arkansas R.
Colorado R.
Black Mesa Basin
Defiance
San Juan Basin
Rio Grande R.
Sangre de Cristo
Kingman
Jerome
MOGOLLON PLATEAU
Estancia
Pecos R.
Llano Estacado
Colorado R.
Sonoran Desert
Gila R.
Ajo
Globe
Ray
Miami
Pinaleño
Galiuro
Silver City
Hillsboro
Tularosa
Santa Rita
Huachuca
Bisbee
Rio Grande R.
Gulph of Calif.
LEGEND
Normal Fault
Thrust Fault
Axis of Anticline
Dip of Beds
Axis of Syncline

Figure 1

schist which grades into quartzites and conglomerates. Where the schist has been intruded by bodies of quartz diorite it has been altered to andalusite and sillimanite schist. This schist has been called the Pinal schist by F.L. Ransome. The name has been extended by Ransome to the crystalline schists of Bisbee and by Lindgren to the schist at Morenci.

In the Mazatzal Mountains is a belt of quartz-sericite schist, phyllite, brown slate, and quartzite, which may be a part of the Pinal schist. These beds are folded and, barring duplication by faulting, are at least 10000 feet thick.

GREENSTONE COMPLEX

South and southwest of Jerome, Arizona is a series of andesitic flows and tuffs. Toward the top are thin-bedded quartzites and argillites. The top consists of rhyolite and latite flows and tuffs. There is a discordance between the lower and upper beds due either to folding and erosion before the rhyolite or to thrusting of the rhyolite over the andesite.

MAZATZAL QUARTZITE

The larger part of the northern half of the Mazatzal Mountains is made up of a massive quartzite which rests on a schist. A similar quartzite is found at Natural Bridge and in the northwest part of the Jerome quadrangle. At Natural Bridge it is overlain by a basal Camrian sandstone. It ranges in thickness from 1150 feet at Natural Bridge to 2500 feet a few miles north.

GRAND CANYON SERIES

Lying on the Vishnu schist in the Grand Canyon is a series of sedimentary rocks with a combined thickness of about 12000 feet. They are predominantly sandstones, quartzites, and shales. These rocks are unconformably overlain by Cambrian sandstone. The lower part, or Unkar formation, is mostly sandstone and quartzite. The upper part, or Chuar, is mostly shale with interbedded limestone.

PALEOZOIC AND LATER ROCKS

The middle Cambrian seas advanced from California and Mexico and spread north and east, covering Arizona and southern New Mexico, remaining until lower Ordovician time. The sea withdrew in middle Ordovician time and the area was uplifted without folding.

In the upper Devonian the sea again returned from the south and west and advanced toward the persistent positive area in northern New Mexico. This positive was present all through the Paleozoic, as evidenced by the overlaps and thinning of beds through the whole Paleozoic section in this area.

Lower Mississippian fossiliferous limestone was deposited over most of Arizona and the southern half of New Mexico, but few upper Mississippian rocks are known to occur, due either to erosion or non-deposition. The sea again spread over the region in the lower Pennsylvanian, but again withdrew in the upper Pennsylvanian, due to rapid uplift in northern New Mexico and southern Colorado.

In New Mexico and northern Arizona lower Permian redbeds were deposited while marine limestone was laid down in west Texas. The Kaibab limestone of middle Permian age was then deposited over a large area, followed by continental sediments laid down along the margin of the retreating upper Permian seas.

At the end of the Permian there was some minor uplift and faulting, but little of the intense deformation which marked the end of the Paleozoic elsewhere. The sea invaded northwestern Arizona in the lower Triassic but was driven back in the upper Triassic by the first significant orogenic activity here since pre-Cambrian time. This may have been an early eastern reaction to the Nevadan revolution taking place farther west.

During Nevadan times northern Arizona, southern Utah, and northern New Mexico were for the most part receiving continental sediments from the southeast. By Dakota-Colorado time the Nevadian mountains were worn down to the extent that marine sediments were again deposited as far west as central Arizona.

Lavas and volcanic breccias interbedded with the marine Dakota sandstones and shales give the first indication of the Cretaceous Laramide revolution. The area was uplifted, folded, thrusted, and later intruded, and the sea was driven all the way to the edge of the continent. The country was eroded as soon as it was lifted above sea level, and by Eocene time was reduced to a peneplain. This extensive peneplain lasted well into the Oligocene. It is overlain by a thick series of intermediate and acid volcanics of Miocene-Pliocene age.

The volcanic and sedimentary deposits of Pliocene and older rocks have since been folded and thrusted. The folds are spatially related to the pre-Pennsylvanian and Permian-Cretaceous geosynclines and are probably a composite result of late Cretaceous and late Tertiary compression around the Colorado plateau.

ORE DEPOSITS

The more important ore deposits occur during four periods of orogenic activity. These are: Pre-Cambrian, Nevadian, Laramide, and Late Tertiary. The most important of these is the Laramide orogeny. Next in importance is the pre-Cambrian, then the late Tertiary, and finally, the Nevadian. The importance of the Nevadian, however, depends on the interpretation of the age of the Bisbee deposits.

AGE OF ORE DEPOSITS IN NEW MEXICO AND ARIZONA

PRECAMBRIAN	NEVADIAN	LARAMIDE	LATE TERT.
Jerome-Prescott	Bisbee ?	Magma	Mogollon
Pecos	Patagonia ?	Globe	Steeple Rock
	Red Bed	Miami	Lordsburg ?
	Copper ?	Ray	Stanley Butte
		Christmas	Oatman ?
		Morenci	Ajo ?
		Tombstone ?	Silver Bell ?
		Twin Buttes	
		Magdelina	
		Santa Rita-Fierro	
		Pinos Altos	
		Tyrone	
		85 Mine ?	

PRE-CAMBRIAN DEPOSITS

Two districts have important pre-Cambrian ore deposits. The first is the Jerome-Prescott area where copper occurs in a deformed and eroded greenstone schist. The second is the Pecos, N.M. lead-zinc deposits. These occur in pre-Cambrian schists and igneous rocks, and are overlain by Pennsylvanian limestone and shale. The ore was introduced by pre-Cambrian pegmatites which do not cut the Pennsylvanian strata.

NEVADIAN DEPOSITS

Until recently, the Bisbee deposits were considered to be Nevadian in age, but this is now being questioned (as of the date of this paper 1933). They may be post-Nevadian in age. If such is the case then there are no important ore deposits of Nevadian age in Arizona or New Mexico. From some evidence ore deposition may have occurred both in Nevadian time and again later.

LARAMIDE DEPOSITS

Most of the important deposits of this age seem to be the result of late Cretaceous volcanism, folding, intrusion, and metallization. They are overlain with great unconformity by more acidic middle and late Tertiary volcanics. These deposits are generally associated with monzonitic intrusions.

LATE TERTIARY DEPOSITS

The Miocene-Pliocene volcanics of Arizona and New Mexico are cut by mineralized fault veins, the most important of which are at Mogollon and Stanley Butte. The ore deposits at Ajo and Silver Bell have been considered as late Tertiary in age, since they cut acidic volcanic rocks. But any dating closer than post-Carboniferous is uncertain.

Notes on Earth Fissures in Southern Arizona

By G. M. Robinson and D. E. Peterson

GEOLOGICAL SURVEY CIRCULAR 466

Washington 1962

United States Department of the Interior

STEWART L. UDALL, SECRETARY

Geological Survey

THOMAS B. NOLAN, DIRECTOR

Free on application to the U.S. Geological Survey, Washington 25, D. C.

During the summer of 1961 the junior author surveyed the general area of Picacho by gravity meter and certain Bouguer gravity anomaly highs were observed. These are apparent highs but they can be related to the amount of rock mass present between the meter station and the mean sea level datum. Significantly, the location and trends of the earth fissures in the Picacho-Eloy basin are in general linear conformity with the gravity anomaly highs. This would appear to support the hypothesis advanced by Heindl and Feth (1955) that some fissures are tensional breaks that may result from differential settlement along the edge of a concealed (buried) pediment.

SELLS

An earth fissure 1/2 to 3/4 mile long was first observed in the early 1950's by personnel of the Bureau of Indian Affairs. The fissure is about 12 miles southwest of Sells near (east of) the Indian settlement of Chukut Kuk (pl. 1), in an area where irrigation farming, using ground water, has not been extensively practiced. A photograph (fig. 8) taken on February 8, 1962, from a low-flying light plane shows the straight east-west fissure trace intersecting at right angles with a wash tributary to Chukut Kuk Wash.

CONCLUSION

Observing the development, with respect to time, of earth fissures like those described in these brief notes affords an excellent opportunity to document the rates of certain geomorphic processes. In the Black Canyon area, for example, periodic detailed mapping of the local fissure area, using photogrammetric techniques, will reveal the rates and manner in which the landform changes and talus or debris accumulates. In valley-floor areas the occurrence of fissures in alluvial materials may present another useful key in the continuing search for improved understanding of the natural and man-induced mechanisms of sediment compaction and earth subsidence. Corollary thereto are changes in the landform, the surface drainage pattern, and the movement of sediment to streams.

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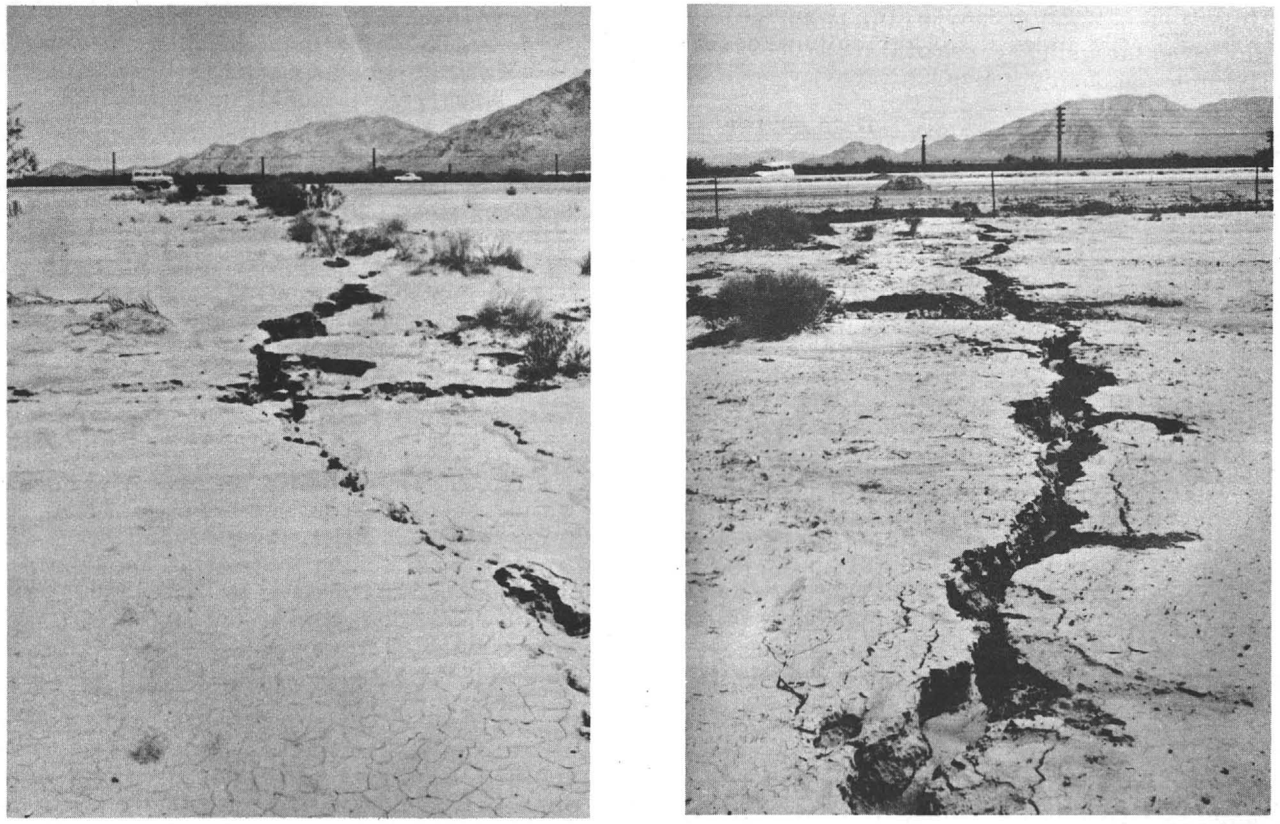


A B

Figure 7.—Views looking northeast at fissures crossing Arizona Highway 84 near Picacho Mountains. A, Fissure 3 miles southeast of town of Picacho; 2 days previous width appeared less than half an inch; torrential rain on previous day revealed this opening; note vegetal growth along fissure. B, Fissure 1 mile southeast of Picacho. Photographs taken on August 6, 1961, by D.E. Peterson.

Arizona Highway 84 at the distant Picacho Mountains. A second photograph (fig. 7B) shows a similar fissure about 1 mile southeast of Picacho. Again the view is northeastward across Highway 84 with the Picacho Mountains in the distance. Note the absence (figs. 7A and B) of differential vertical or horizontal movement along the two fissures. The openings are characterized by clean breaks and near-vertical walls.

Numerous other earth fissures have been observed from time to time in the general area of Picacho. Those examined as recently as 1961 are shown in the large circled area on plate 1. Some fissures intersect Picacho Reservoir (pl. 1) and in 1961 a retaining embankment overlying a fissure failed. Although the reservoir is only occasionally used to collect surplus water, the Bureau of Indian Affairs, responsible for its operation, is debating whether or not to discontinue its maintenance.

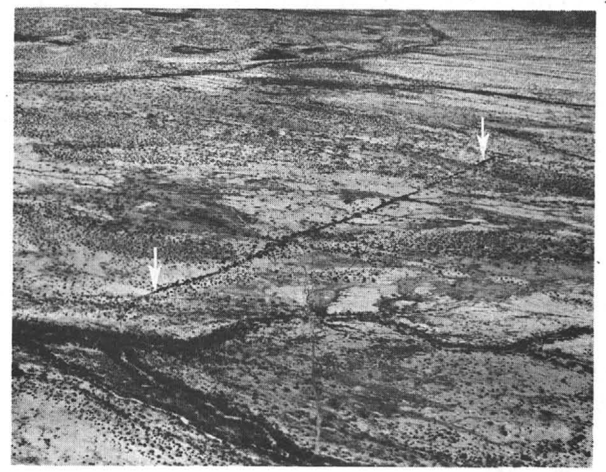


Figure 8.—Aerial view looking northeast at east-west trending fissure near Sells. Fissure intersects, nearly at right angles, a wash that is tributary to Chukut 'Kuk Wash. Photographed on February 8, 1962, by H.T. Chapman and A.E. Robinson.

CONTENTS

ILLUSTRATIONS

following data on ground-water pumpage furnish a partial index to the agricultural development:

Year	Pumpage (acre-feet)	Data source
1937---	64,000	Smith, 1940, p. 26.
1940---	172,000	U.S. Geol. Survey, 1940-61.
1948---	360,000	Do.
1952---	300,000	Do.
1960---	330,000	Do.

The ground-water production has been accompanied by a steady water-table decline throughout the area. Present water levels range from 100 to nearly 200 feet below an assumed static level for 1930. Until the late 1940's the center of the cone of depression in the water table remained slightly west of Eloy. Subsequently the cone center has migrated steadily eastward in consort with the development of new irrigated acreage and the consequent production from new irrigation wells.

First-order leveling and subsequent checks, by the U.S. Coast and Geodetic Survey, of bench marks along Arizona Highway 84 yield extremely valuable subsidence data. The surveys span the 55-year period from 1905 to 1960 and show (fig. 6) how markedly subsidence rates have increased in the valley alluvium, especially in the Eloy-Picacho region. Of particular interest is the fact that the data show some land-surface subsidence centered around Eloy over the period from 1905 to 1934, before extensive ground-water development. However, the process seems to have been greatly accelerated, probably beginning in 1936, by the effects of persistently increasing ground-water pumpage and application of the water to the steadily increased acreage placed under cultivation. The correlation between subsidence rate and ground-water development is strengthened by noting (fig. 6) how the point of maximum subsidence migrated southeastward with time. This roughly correlates with the similar shift in the deepest part of the cone of depression in the water table. Maximum subsidence along the profile is now approaching 4 feet.

Also shown in figure 6 are the points at which several observed earth fissures intersect the profile along Arizona Highway 84. As might be expected, the fissures are near the outer limits of the subsidence profiles where the earth material could have been subjected to tensile stresses.

The fissure shown at the extreme right in figure 6, at a point on Highway 84 about 3 miles southeast of Picacho, is the one described by Leonard (1929) as having first opened in September 1927. Subsequent filling and reopening of this and other fissures in the general area are described by Heindl and Feth (1955). Leonard's description mentions the fissure length as one-fourth mile; it is now at least 8 miles long. Part of the fissure appears in a photograph (fig. 7A) taken on August 6, 1961, looking northeast across

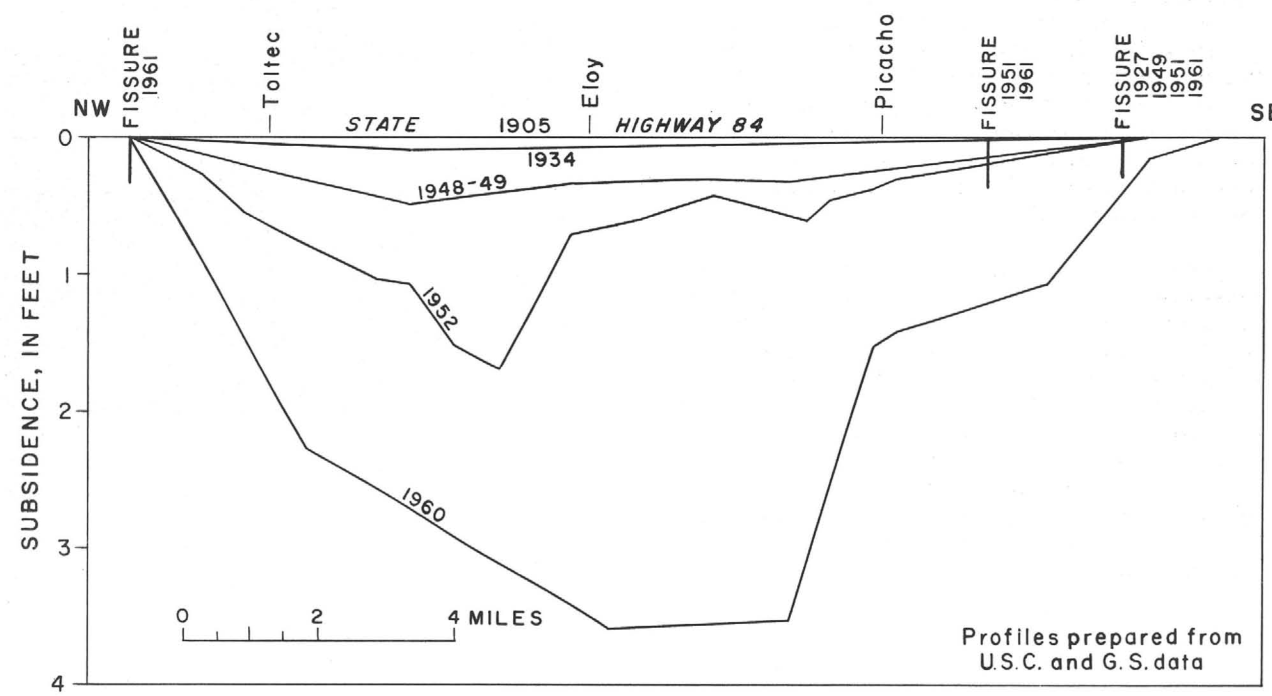
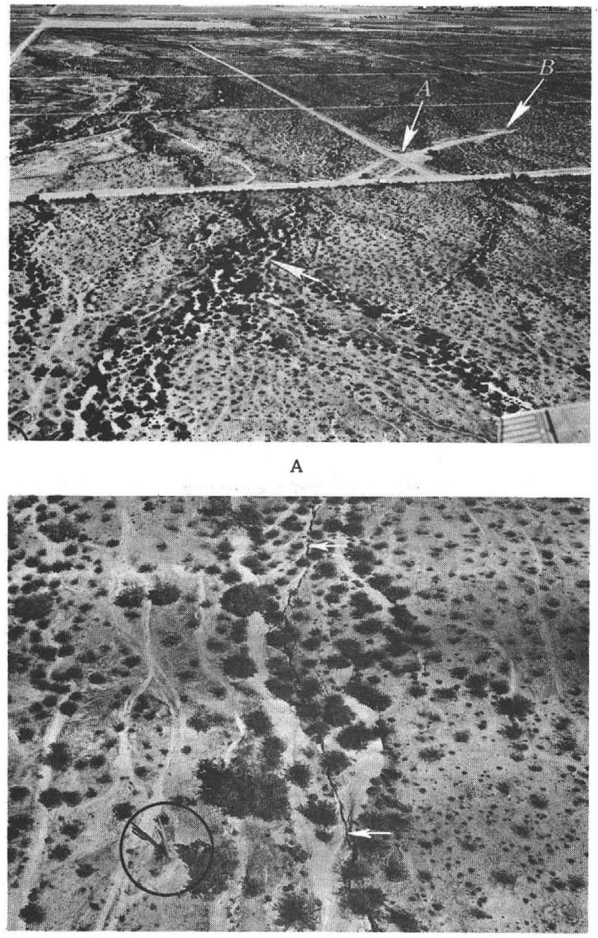


Figure 6.—Changes in land-surface elevation in the Eloy-Picacho area, Pinal County, Arizona.



A

B

Figure 4.—Aerial views looking north at fissure near Chandler Heights. A, General view of the area with arrows denoting fissure trace. B, Closer view of fissure trace with same saguaro cactus circled. Photographs taken on February 10, 1962, by H. T. Chapman and A. E. Robinson.

LUKE AIR FORCE BASE

Earth fissures were first observed in the fall of 1959 in a 300-acre well-field area 1¼ miles east of Luke Air Force Base which is about 15 miles northwest of Phoenix (pl. 1). The well field has yielded substantial quantities of water for irrigation since 1936, with annual pumpage ranging between 4,000 and 8,000 acre-feet. The well-field area itself, in which the fissures occur, has never been in cultivation. To shallow depths, at least, the soil consists of caliche. Surrounding the well field are cultivated fields and additional wells for irrigation. The longest fissure extends for a distance of about 1 mile in a northwest-southeast direction.

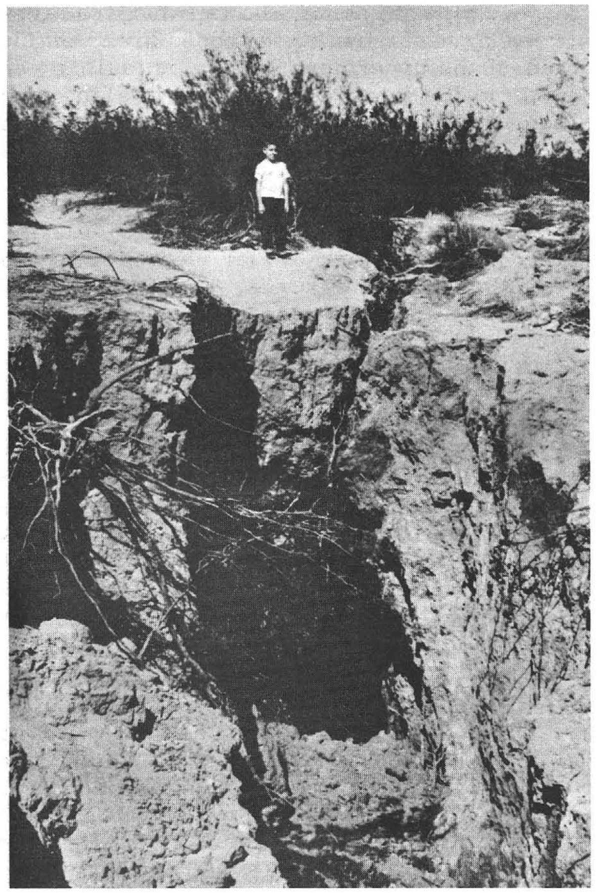


Figure 5.—Magnitude of fissure opening near Chandler Heights, viewed from site marked by arrow A in figure 4A. Photographed on September 16, 1961, by D. E. Peterson.

PICACHO

Heretofore the limited notes and observations on earth fissures in Arizona, published in technical journals, have focused attention principally on the Picacho portion of the general Picacho-Eloy-Casa Grande area (pl. 1). The valley or basin floor is characterized by a northwesterly sloping plane that ranges in elevation from 1,750 feet (mean sea-level datum) near Picacho Peak and the Picacho Mountains to 1,400 feet near the Casa Grande Mountains. These mountains rise abruptly from the basin floor, effectively bounding it on the east and west. Agricultural development in the basin has been extensive.

Ground-water production for irrigation began near Eloy in 1936 because of the favorable market for cotton. A steady increase in irrigated acreage continued until after the war, at which time a sharp rise was noted. The

Notes on Earth Fissures in Southern Arizona

By G. M. Robinson and D. E. Peterson

ABSTRACT

This report describes earth fissures at six sites in southern Arizona. These notes are preliminary to a more extensive study and detailed analysis being prepared by hydrologists in the Water Resources Division. Earth fissures were first recorded in Arizona in 1927, and have been noticed with increasing frequency since 1949. Fissures at Black Canyon, Bowie, Chandler Heights, Luke Air Force Base, Picacho, and Sells are discussed and illustrated with photographs.

INTRODUCTION

A recent short paper by Pashley (1961) called attention to large cracks or fissures that have appeared from time to time in valley alluvium in southern Arizona. Pashley's discussion was confined, however, to a brief review of several earlier accounts of earth fissures in the Picacho area, to his own observations during 1958-60 on fissures near Casa Grande, and to his hypothesis for their origin. No comprehensive paper has yet appeared that discusses the occurrence and formation of fissures throughout the State.

Although certain local residents are well aware that earth fissures have been developing for many years in several areas in the southern part of the State, earth scientists may not have been generally aware of the specific areas in which these phenomena have been, and still are, forming. Data are being collected by hydrologists in the Water Resources Division but the collection, interpretation, and analysis are not yet complete. Nevertheless it seems timely to present these notes on earth-fissuring activity in six distinct local areas, so that patterns and orientation may be viewed regionally as well as in local reference to the exposed rock masses and the general geologic environment. Subsequent reports will present more data and the conclusions that may be drawn therefrom.

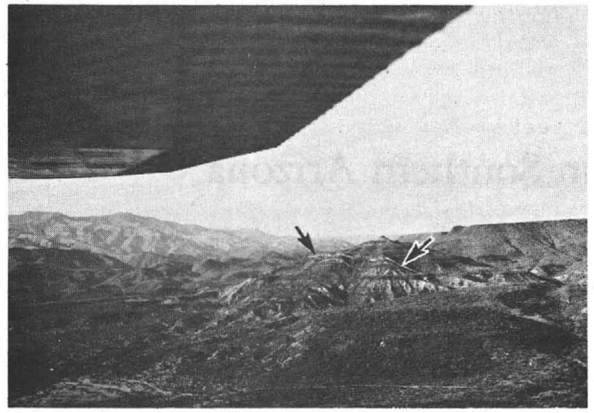
The first earth fissure recorded in Arizona was discovered in September 1927, about 3 miles southeast of Picacho (pl. 1), and was described in some detail by Leonard (1929). Similar cracks recurred in that area in 1935 and 1949. Since 1949 reports of earth fissuring have been made with increasing frequency from widely separated areas throughout the southern part of the State.

Of special interest is the fact that until February 1962 all reports concerned fissuring in valley alluvium. On February 1, 1962, however, local residents in the Black Canyon area north of Phoenix (pl. 1) reported new earth cracks or fissures; these occurred in a basalt and semiconsolidated sedimentary rock section exposed on a relatively steep dissected slope. Local investigation revealed that similar fissuring and slumping of the earth materials in this area had obviously taken place on previously unrecorded occasions.

Presented in the following paragraphs are a few details on earth fissuring in the selected areas, arranged in alphabetical order. Fissure locations, patterns, and orientation may be observed on plate 1 and in the photographs and subsidence profile included in figures 1 through 8.

BLACK CANYON

Earth fissures have formed in a volcanic rock area about 45 miles north of Phoenix on the east side of Arizona Highway 69, approximately 2 miles northeast of the junction of Squaw Creek with the Aqua Fria River. The fissures traverse a section of volcanic and semiconsolidated sedimentary rocks near the north edge of a small valley. Virtually no ground water is developed in the valley.



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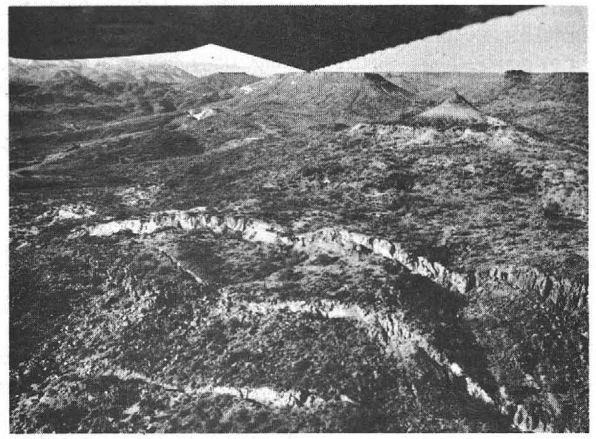


B

Figure 1. —Aerial views looking north at fissures near Black Canyon; A, distant view; B, closer view. Light-colored areas indicate the recent exposures. Photographed on February 1, 1962, by H. T. Chapman and A. E. Robinson.

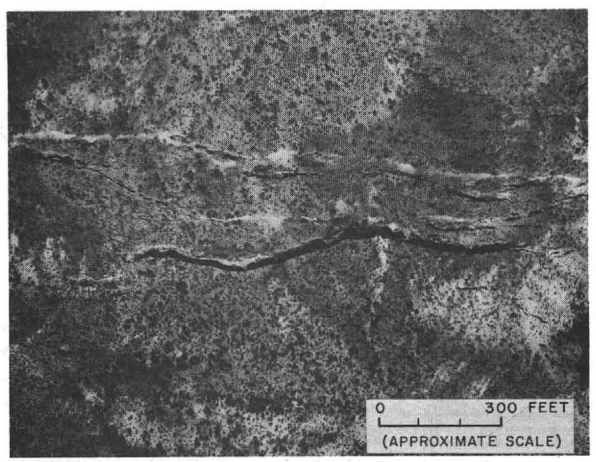
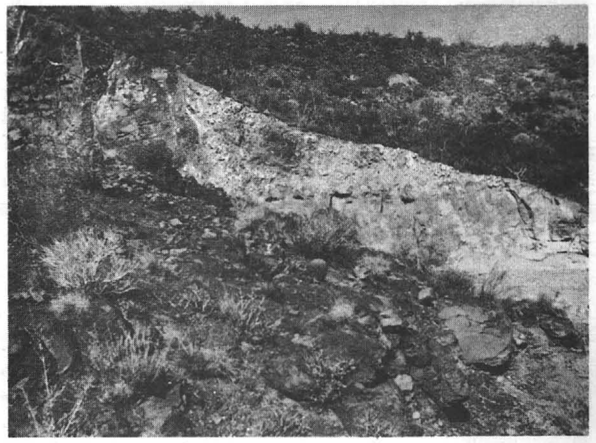
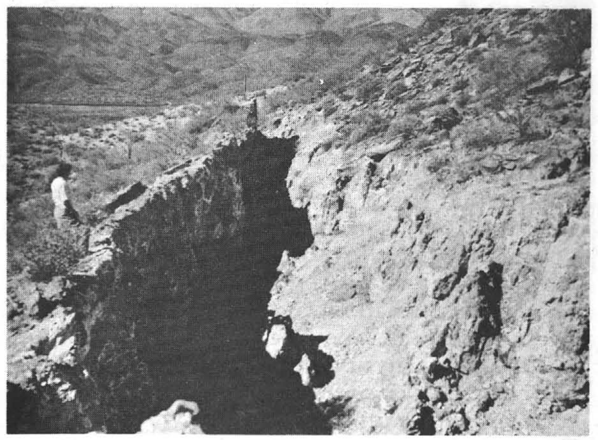


Figure 2. —Aerial photograph from altitude of 4, 000 feet showing principal fissures near Black Canyon. Photographed on March 26, 1962, by H. T. Chapman.

The sequence, in time, of the fissure development is not known. Aerial photographs of the general area, taken from an altitude of about 11,000 feet in 1936, clearly show the east-west traces of earlier fissures developed in conjunction with faulting. On February 1, 1962, however, Phoenix newspapers reported the discovery by local residents of new earth movement in the fissure area. The exact time of occurrence seems to have gone unnoticed but air and ground inspection confirmed that the movement was indeed new and that it had been substantial. A photograph (fig. 1A) taken on February 1, 1962, from a



A



B

Figure 3. —Ground views of uppermost and lowermost principal fissures near Black Canyon. A, View looking north at vertical displacement near east end of slippage fault produced by upper fissure. B, View looking west at size of opening near western end of lower fissure. Photographs taken on February 3, 1962, by H. T. Chapman.

low-flying light plane, shows (white trace between arrows) freshly exposed areas on the face of the uppermost fissure or fault in relation to the local relief. The vertical interval from the valley floor (approximate elevation 2,100 feet, mean sea level) to the small cone-shaped hill that rises to the distant skyline (right of center) is between 600 and 700 feet. A similar photograph (fig. 1B) on the same date gives a closer aerial view of this and adjoining major fissures. The cone-shaped hill is again a convenient reference marker. A vertical aerial photograph (fig. 2) taken from an altitude of about 4,000 feet (mean sea level) identifies the major fissure pattern. The fresher and lighter appearing areas, along the northernmost fissure in the photograph, identify the new exposures associated with the most recent earth movement. The duller and darker areas denote exposures dating back to earlier movements. These details, as well as the vertical movement (about 10 to 15 feet) at this particular fissure, show to advantage in figure 3A, as photographed on February 3, 1962. The black band (fig. 2) along the lower or southernmost principal fissure is the shadow that the sharply defined southern rim casts into the opening. The opening size can be judged from figure 3B, photographed on February 3, 1962, from a ground vantage point on the fissure rim at about the western quarter point with respect to its length as indicated in figure 2.

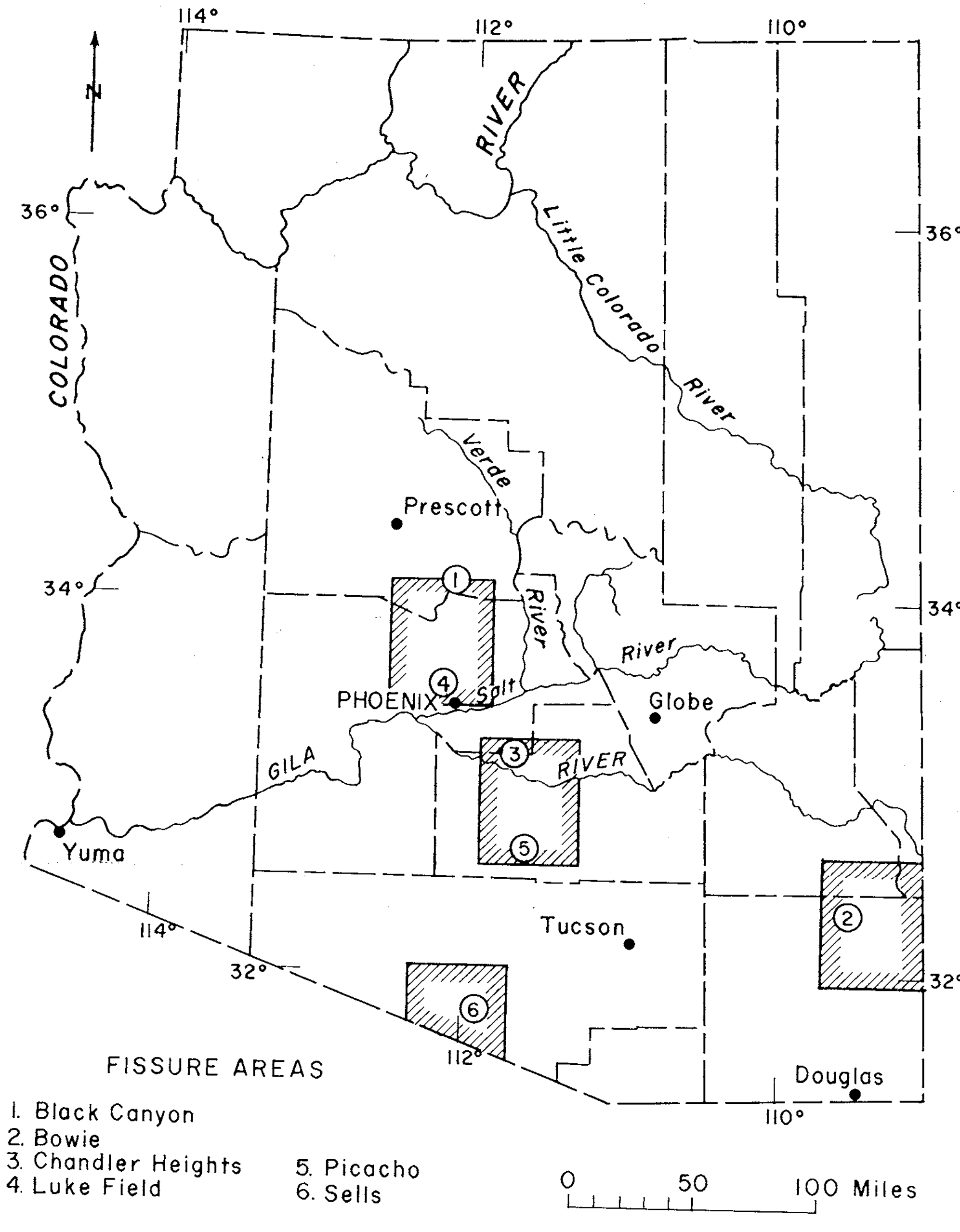
Figure 2 is one of a series of six overlapping aerial photographs which when viewed stereoscopically give dramatic evidence of the substantial earth movement. At each opening the earth or rock material appears to have failed in tension or to have been literally pulled apart. The photographs show no significant differential horizontal movement along the fissures. Elongate islands or blocks of material, created when fissures intersected one another, in some instances settled or slumped as grabens. Examples are found by carefully studying stereoscopically various pairs of fissures.

BOWIE

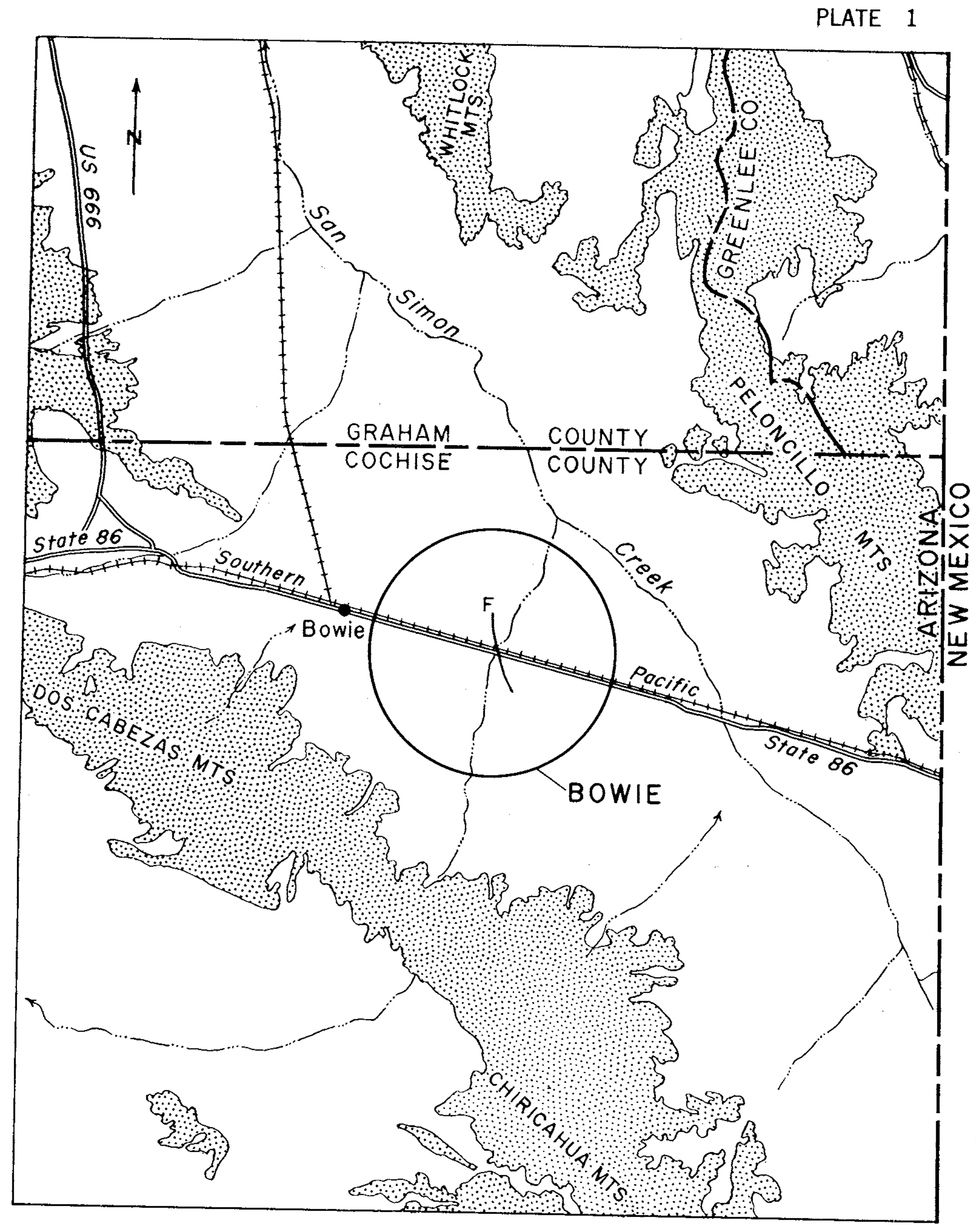
Approximately 6 miles east of Bowie on State Highway 86 an earth fissure crosses both the highway and the Southern Pacific Railroad. The fissure is in the center of a broad alluvial valley, north of the Dos Cabezas Mountains, and extends about 1 mile northward and about 1 mile south-southeastward from the highway (pl. 1). The use of ground water for irrigation has lowered water levels in the Bowie area more than 100 feet since 1950 (U.S. Geological Survey, 1940-61). The fissure site is near the common perimeter between two centers of heavy pumping, namely, the Bowie and San Simon areas. Compaction of the sediments in these two areas, accompanying the water-table decline, could gradually have built up tensile stresses in the peripheral area common to the two centers of pumping, leading to ultimate rupture of the earth material in the form of the observed fissure.

CHANDLER HEIGHTS

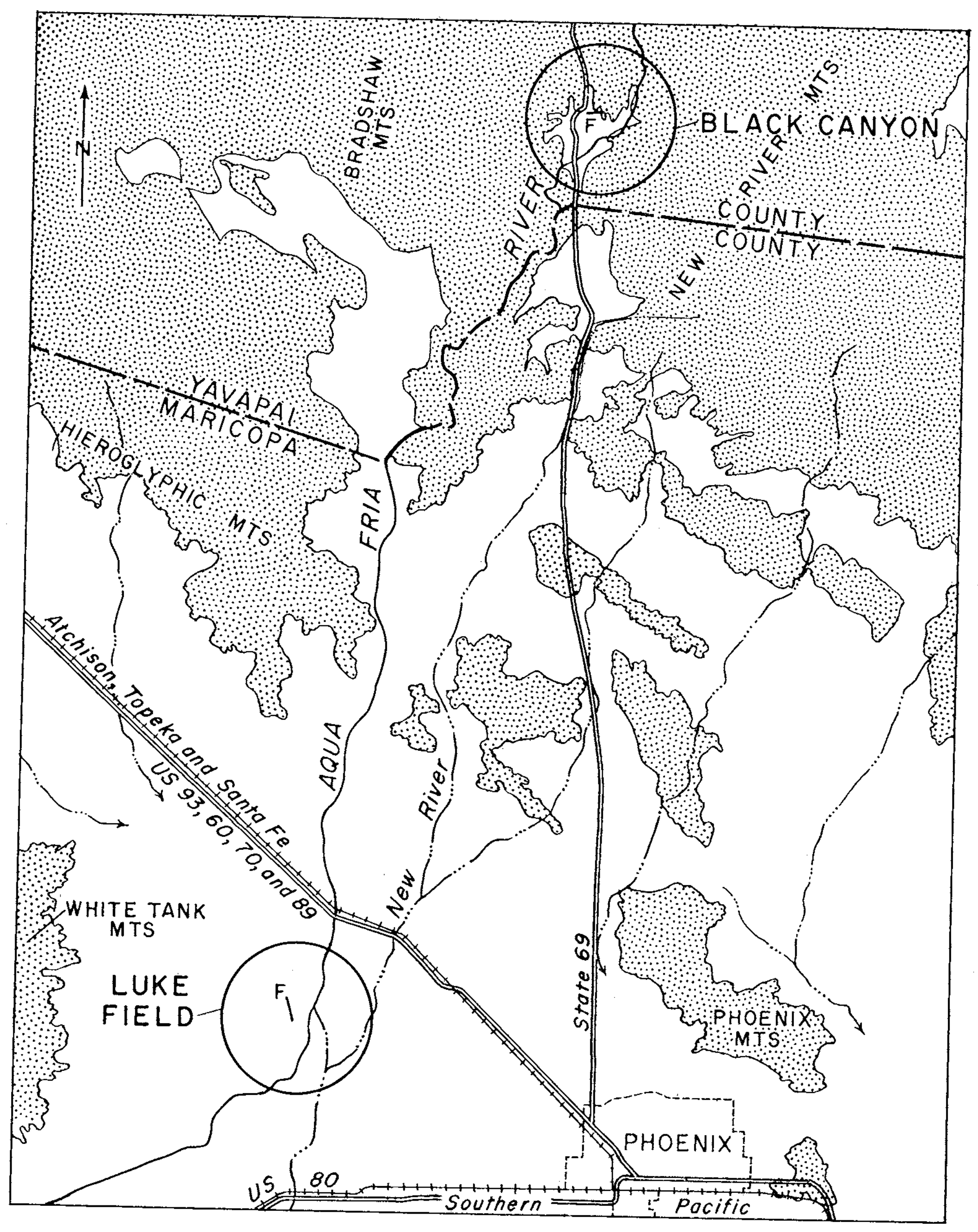
Close to the northernmost flank of Santan Mountain, approximately 30 miles southeast of Phoenix and 12 miles southeast of Chandler, local residents report that earth fissures have occurred on several occasions. The fissures are oriented roughly parallel to the nearest exposed segment of the mountain mass (pl. 1). The trace of a spectacular opening that formed in 1961 is marked on photographs (figs. 4A and B), which were taken from the air on February 10, 1962, to show the fissure site and part of the surrounding area. The lower left part of figure 4A is viewed closer up in figure 4B to show more clearly some details of the fissure trace. The circled saguaro cactus, about 30 feet tall, is also partly circled in the lower left corner of figure 4A. Irrigated land is visible to the north (fig. 4A) of the fissure site but the principal irrigated acreage and area of ground-water withdrawal lies to the northwest. The white scar bracketed by arrows A and B marks the interval in which the fissure terminated. The area was reworked by earth-moving equipment to fill the fissure. The magnitude of the fissure opening is graphically revealed in figure 5, as photographed on September 16, 1961, from a ground site near arrow A (fig. 4A). These photographs suggest that again the earth material has simply pulled apart. No differential horizontal movement can be seen along the fissure and no differential vertical movement is apparent. Where islands or blocks of material have been left standing in the larger openings some crumbling and slumping have occurred.



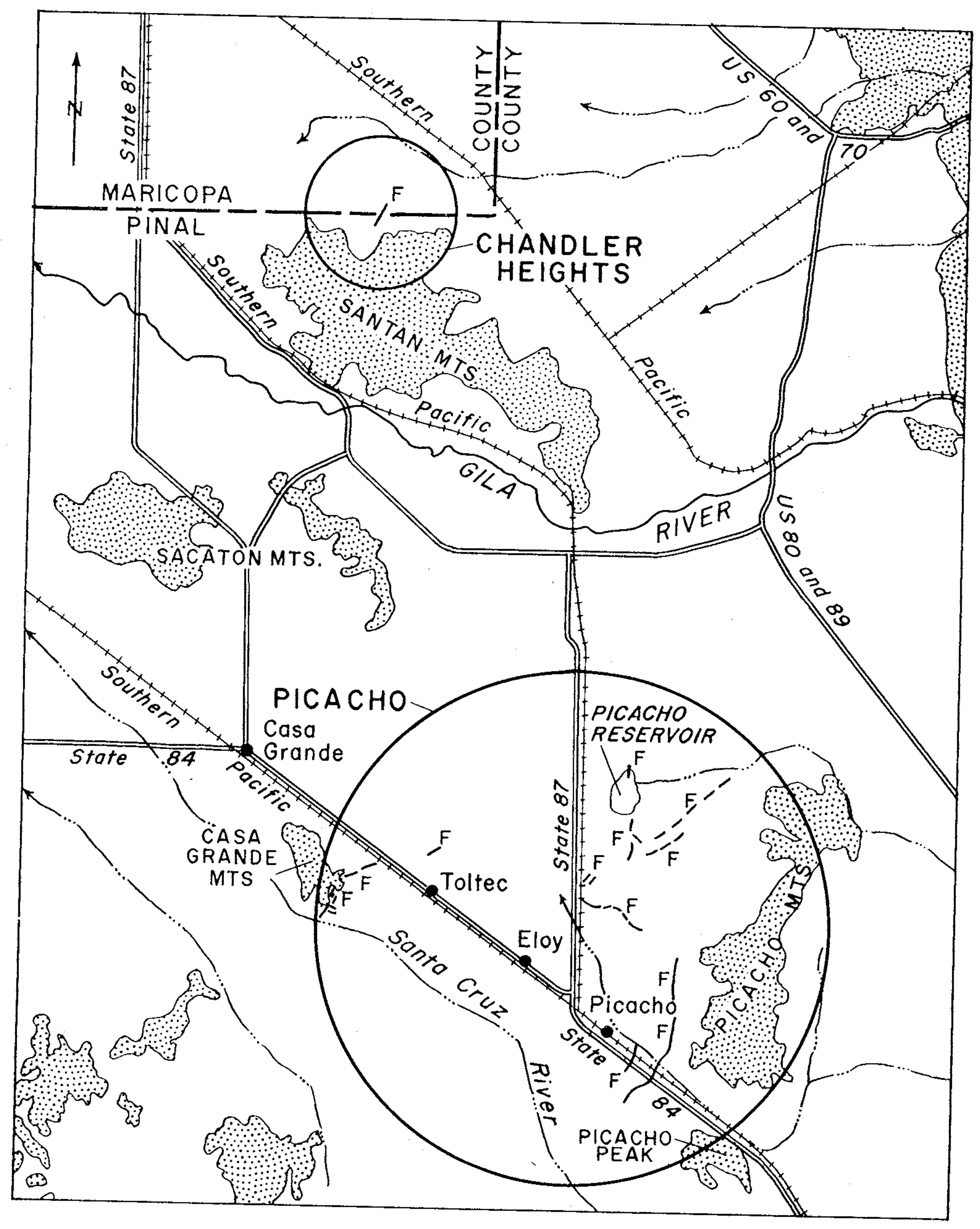
INDEX MAP



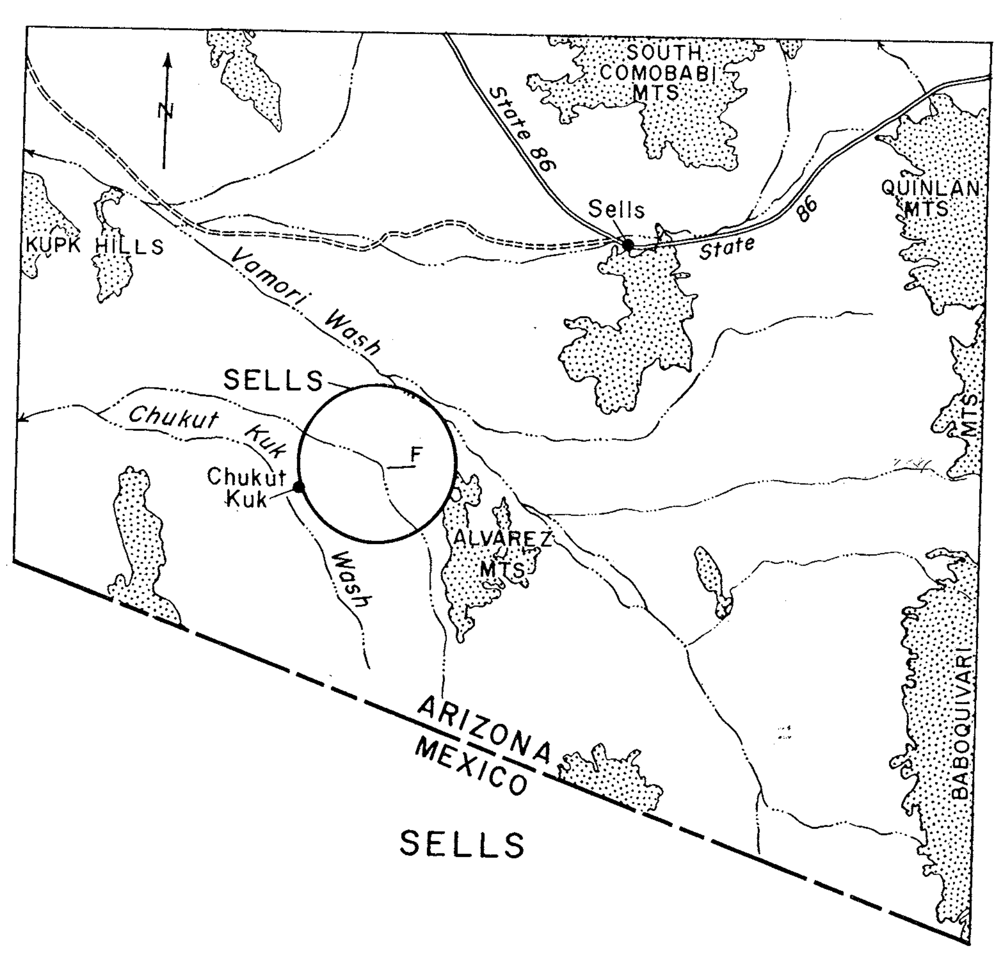
BOWIE



BLACK CANYON AND LUKE FIELD

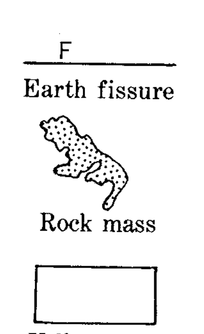


CHANDLER HEIGHTS AND PICACHO



SELLS

EXPLANATION



INDEX AND LOCAL AREA MAPS SHOWING EARTH-FISSURE OCCURRENCE IN SOUTHERN ARIZONA RELATIVE TO VALLEY FLOOR AND EXPOSED ROCK MASSES

10 0 10 20 MILES

INVENTORY OF ARIZONA LANDS

As of June 30, 1970

ARIZONA DEPARTMENT OF MINERAL RESOURCES

John H. Jett, Director F. P. Knight, Consultant

Mineral Building, Fairgrounds

Phoenix, 85007

May, 1971

BOARD OF GOVERNORS

INVENTORY OF ARIZONA LANDS AS OF JUNE 30, 1970

The following tables and other information summarizing the distribution of Arizona's lands as of June 30, 1970 and the state's revenues therefrom in fiscal 1969-1970, have been compiled by the Arizona Department of Mineral Resources from reports of the General Services Administration and the State Land Commissioner:

Of the 72,680,320 acres of land area in Arizona, the Federal Government as of June 30, 1970 owned or controlled 51,959,976 acres, or 71.49% of the total. Included were 19,623,399 acres of "trust properties" of which all except a small fraction were Indian tribal lands. The federally owned lands amounted to 44.49% of the land area of the state, while the federal trust lands amounted to 27.00%. 39 percent of the 50.3 million acres of trust properties under federal control in the United States, are in Arizona. New Mexico is next highest with 13.6 percent. There were 9,593,589 acres of Arizona trust lands in the hands of the State Land Department as of June 30, 1970, or 13.20% of the state's total land area. The remaining 11,126,755 acres, or 15.31%, consisted of lands privately owned or belonging to State, County and City Agencies other than the Land Department. These data are shown in Table I.

Table II shows the distribution of federally owned land in Arizona by predominant usage. The largest acreages are used for grazing, and for forest and wildlife. Each Category has nearly 13 million acres. Military areas use a little over 3.5 million acres; reclamation, irrigation, flood control and power development total about 1.5 million; and parks and historic sites 1.6 million acres.

As of June 30, 1970, Arizona had 22.21 million acres of public lands unsurveyed, the largest percentage (30.5) of unsurveyed lands in any of the United

States, except Alaska. Only 8 percent of the public lands outside of Alaska are unsurveyed, all of it being in the eleven western states.

STATE LANDS

The total of lands granted by the federal government to the state or acquired otherwise by the state in the past, is 10,849,932 acres (See Table IV). Of this total, 8,334,950 acres were grant lands for the support of common schools; university, college and other institutional grants amounted to 2,451,295 acres; and 63,687 acres were acquired by the state through special grants, purchases, exchanges, and accretions.

Up to June 30, 1970 the state has patented and/or deeded 894,598 acres of its trust lands and has placed 148,331 acres under sales contracts; indemnity base lands amounting to 199,334 acres in, and 9,090 acres outside of the National Forest, either have not been selected, or have been selected and not approved; and 5,884 acres have been of uncertain ownership. Deduction of these lands leaves 9,593,589 acres of trust lands held available for lease by the State Land Department as of June 30, 1970. The surface of all except 52,036 acres of the available lands was leased, and sub-surface leases in 1970 aggregated 2,013,957 acres - 52 percent higher than in 1969.

Table VIII shows acreages of State Land Department leases and receipts therefrom. The largest surface acreage was covered by grazing leases - over 9 million acres in 1970. Agriculture occupied only 2.25 million acres but paid almost twice as much rental. 1.8 million acres, or 90% of the acreage of sub-surface leases, were in oil and gas leases. Mineral leases, with only 55,000 acres, paid only a tenth as much rental in 1970, but its total of rentals plus royalties was about ten times greater than that of the oil and gas leases. The oil and gas area was 60 percent greater than in 1969.

Table IX shows the sub-surface acreage of prospecting permits, mineral, and oil and gas leases in each county. Pinal County had the biggest acreage of prospecting permits and mineral leases, as it did in 1969. Pima again was next in both categories, but its acreage of mineral leases dropped 4 per cent while Pinal's increased 11 per cent, and its acreage of prospecting permits dropped slightly while Pinal's increased 34 per cent. Notable increases in sub-surface acreages of permits and mineral leases also occurred in Maricopa County. Prospecting permit acreages were in all counties except Apache, Coconino, and Santa Cruz although Navajo had only 20. Mineral leases were in all counties except Santa Cruz. There were state oil and gas leases in all counties except Gila and Greenlee, with Cochise having the largest acreage, as in 1969; however, large increases occurred in Pima and Pinal, which replaced Apache and Navajo in second and third places, oil and gas lease acreage decreasing in the last two.

Tables V, VI, and VII, give summaries of the areas of: surface and subsurface leases, Land Department receipts from all sources, and lease royalties received, in 1969 and 1970. Were it not for the large increase in mineral royalties, 1970 would have shown a drop in receipts instead of a gain of 22 per cent. The royalty increase to $4,532,505 however, was abnormal due to higher copper production sold at higher prices and to bringing royalty accounts current. The Land Commissioner's report for fiscal 1970 gave expectation of royalties of $2 to 2.5 million in fiscal 1971-1972, or about half of the 1970 total.

Table X gives annual subsurface lease receipts by type of lease for the period 1960 through 1970. The enormous growth in mineral royalties in the period, started with development of ores on state lands following the earlier discovery and development of copper ores on adjacent lands in the Pima Mining district south of Tucson.

Table V shows that all except 52,036 acres of the 9,593,589 acres of state trust lands was covered on June 30, 1970 by surface leases. It therefore is obvious that the 2,013,957 acres of sub-surface leases nearly all, if not wholly, underlied surface leases. The increase of 690,884 acres of sub-surface leases was due largely to removal of the statutory acreage limitation for oil and gas leases, and their jump of 683,863 acres in 1970. The area of prospecting permits increased 3.4 percent, 188 permits being issued in the year.

Table VI shows a decline of federal government remittances from $831,077 in 1969 to $73,252 in 1970. These remittances are portions of federal revenues from lands within the states. According to the Bureau of Land Management's report, "Public Land Statistics, 1970" federal receipts from mineral leases, licenses, and permits on public lands of the United States in 1970 totalled $132,781,799, of which $347,808 came from Arizona lands. 94 per cent of the nation's total came from oil and gas leases, as did 88 per cent of Arizona's total. The revenue from Arizona public lands was from leases under the Mineral Leasing Act of 1920. 37.5 per cent of such revenue reverts to the states, excepting Alaska, which gets 90 per cent.

ARIZONA MINERAL LANDS

At first glance, large areas in Arizona appear to comprise vacant, unappropriated and unreserved public lands open to unrestricted prospecting and the location of mining claims; but many areas are not open, and the actual status of a particular area may be quite complex. It is suggested that one obtain a copy of this department's booklet, "Laws and Regulations Governing Mineral Rights in Arizona" as a guide to proper procedure in locating claims or acquiring lease or other mineral rights.

The booklet also explains the rights of a mineral locator, under the mining law, especially since the enactment of The Multiple Surface Use Act of 1955 which prohibited any use of subsequently located unpatented mining claims other than for the purposes of prospecting, mining, or processing operations and uses reasonably incident thereto. The necessity of a mineral discovery before a claim can become valid is also fully discussed.

TABLE I

DISTRIBUTION OF ARIZONA LANDS

As of June 30, 1970

	Acres	% of Total
Federally Owned Lands (1)	32,336,577	44.49
Trust Properties in Custody of the Federal Government, almost entirely Indian tribal lands (1)	19,623,399	27.00
State of Arizona (Trust Lands) (2)	9,593,589	13.20
Other Lands (3)	11,126,755	15.31
Total Land Area (4)	72,680,320	100.00

(1) Source: Inventory Report on Real Property Owned by the United States Throughout the World as of June 30, 1970; prepared by General Services Administration.

(2) Source: 58th Annual Report of the State Land Department for July 1, 1969, through June 30, 1970. Figure does not include 199,334 acres within and 8,196 acres outside of the National Forests for which indemnity lands have not been received.

(3) Patented and owned by individuals and corporations, or deeded to state and local government agencies other than the State Land Department. Determined by difference.

(4) "Source: Bureau of the Census Publication GE-20, No. 1, May 1970 - Table 1, Area Measurement Reports," as given by the U.S. Dept. of the Interior in "Public Land Statistics - 1970," p. 138.

TABLE II

FEDERAL LAND WITHIN ARIZONA, BY PREDOMINANT USAGE

	ACRES* June 30, 1969	ACRES* June 30, 1970	1970 % of Total
Agricultural	75.9	75.9	.00
Grazing	12,995,261.3	12,601,702.8	38.97
Forest & Wildlife	12,963,704.2	12,970,578.2	40.11
Parks & Historic Sites	1,591,016.8	1,597,769.2	4.94
Office Building Locations	39.2	55.5	.00
Military (except airfields)	3,501,421.9	3,504,003.9	10.84
Airfields	16,699.6	16,524.6	.05
Power Development & Distribution	539,639.4	609,422.6	1.88
Reclamation & Irrigation	935,436.6	931,463.3	2.88
Flood Control & Navigation	40,449.1	43,133.7	.13
Vacant	394.3	394.3	.00
Institutional	1,570.6	1,569.5	.01
Housing	53.6	54.6	.00
Storage	28,398.4	28,401.4	.09
Industrial	2,313.0	2,185.0	.01
Research & Development	28,229.2	28,229.2	.09
Other Land	1,086.4	1,013.3	.00
TOTAL	32,645,789.5	32,336,577.0	100.00

* Source: Inventory Report on Real Property Owned by the United States Throughout the World as of June 30, 1970; prepared by General Services Administration.

TABLE III

AREA OF SURVEYED AND UNSURVEYED LANDS IN ARIZONA, 1786-1970

SURVEYED	UNSURVEYED	% UNSURVEYED
50,518,118	22,162,202	30.49

Source: U.S. Department of the Interior, Public Land Statistics - 1970

TABLE IV

ARIZONA TRUST LANDS GRANTED AND/OR ACQUIRED

As of June 30, 1970

Source: 58th Annual Report of the State Land Commissioner

		Acres
School Grants 1/		8,334,950
Univ., College and Other Institutional Grants 2/		2,451,295
Farm Loan Lands 3/		22,238
Special Grants: Airfields 4/	7,310	
Other	3,778	11,088
Net gain from exchanges and accretions		30,361
Total Trust Lands Granted and/or Acquired		10,849,932
LESS:		
Lands Patented, Deeded, or Committed	894,598	
Lands under sale contracts	148,331	
Indemnity Base Lands not received		
In National Forests	199,334	
Outside National Forests	8,196	
Lands of undetermined ownership	5,776	
Other Adjustments	108	1,256,343
Total State of Arizona Trust Lands 6-30-70		9,593,589

1/ Grants for the Support of Common Schools. The Enabling Act of June 20, 1910, granted to the State of Arizona specific lands for the support of the "Common Schools", namely sections 2, 16, 32 and 36 in every township, upon being surveyed, provided the lands were not otherwise entered upon, sold, reserved, or otherwise appropriated at the date of this Act, and excepting all or any part thereof classified mineral in character. This restraint from taking title to lands mineral in character, remained in force until changed by the Act of January 25, 1927. Where the lands in sections granted to the State have been preempted, sold, or otherwise disposed of, the State has been given the right of lieu selection from open lands of the public domain. Deficiencies of school lands in fractional townships have been adjusted in accordance with provisions of the Enabling Act.

2/ University, Colleges and Other Institutional Grants. By an Act of February 18, 1881, the Territory of Arizona was granted 72 sections of the unappropriated public lands within the said Territory, to be immediately selected, withdrawn from sale, and located under the direction of the Secretary of the Interior, with the approval of the President of the United States, for the use and support of a University in said Territory when admitted as a State into the Union. In addition to the grants mentioned above, the Enabling Act also made specific acreage grants for the support of various institutions of the state.

3/ Farm Loan Lands. After a Farm Loan Program was enacted by the State Legislature, March 14, 1944, the State was able to acquire 22,238 acres of public lands.

4/ Special Grants. From the time of statehood, Arizona has acquired parcels of land by special grants and quit-claim deeds. Other than the grant of Papago Park for recreational purposes and a few lessor acquisitions, the special grant lands were airfields that had been declared surplus by the War Assets Administration, plus some lands separately granted.

TABLE V

SUMMARY OF LEASED AREAS OF ARIZONA TRUST LANDS

	As of June 30th 1969	1970	Increase (Decrease) %
Surface Only:			
Aggregate area of leases	9,411,949	9,565,965	1.6
Less areas which coincide	23,956	24,412	1.9
Area covered by one or more leases	9,387,993	9,541,553	1.6
Area not leased	147,803	52,036	(64.8)
Total Trust Lands	9,535,796	9,593,589	0.1
Sub-surface Only:			
Area leased	1,323,073	2,013,957	52.2
Area not leased	7,658,582	7,029,033	(8.2)
Total available for lease	8,981,655	9,042,990	0.1

TABLE VI

SUMMARY OF STATE LAND DEPARTMENT RECEIPTS FROM ALL SOURCES

	1969 Fiscal	1970	Increase (Decrease) %
Leasing Rentals, Penalties & Interest	$ 3,190,920	$ 3,523,131	10.4
Leasing Royalties and fees	1,432,730	4,688,869	227.3
Land Sales, Principal	3,045,852	2,436,553	(20.0)
Land Sales, Interest	1,302,859	1,430,702	9.8
Federal Government Remittances	831,077	73,252	(91.2)
Other	242,774	65,019	(73.2)
Total	$10,046,213	$12,217,526	21.6

TABLE VII

LEASE ROYALTIES RECEIVED

Lease	1969 Fiscal	1970	Increase (Decrease) %
Mineral	$ 886,914	4,492,339	406.5
Mineral Materials 1/	367,517	89,923	(75.5)
Helium	83,525	8,478	(89.8)
Commercial water	28,804	25,738	(10.6)
Other	1,149		(100.0)
Totals	$ 1,367,909	4,616,478 2/	237.5

1/ Mostly road material for state highways.
2/ Adjusted. Accounts brought current.

Source: 57th and 58th Annual Reports of the State Land Commissioner.

TABLE VIII

ACREAGES OF STATE LAND DEPARTMENT LEASES AND RECEIPTS THEREFROM

Fiscal Year Ending June 30th	1969		1970	
	Acres	Receipts Rental	Acres	Receipts Rental
Surface Leases				
Agriculture	225,680	$1,027,191	215,214	$1,229,875
Grazing	8,931,372	620,253	9,089,354	642,126
Commercial	74,934	435,230	77,850	455,553
Homesites	188	1,190	188	814
Rights of Way	77,589	622,689	79,847	276,912
Special Use Permits	------	7,948	691	1,968
U.S. Contracts	102,185	14,986	102,821	201,174
Total Surface	9,411,948	$2,729,487	9,565,965	$2,808,422
Sub-surface Leases				
Minerals & Mineral Mat'ls.	51,266	$ 39,956	55,132	46,046
Prospecting Permits	94,169	119,952	97,323	148,716
Oil & Gas	1,131,395	284,360	1,815,258	456,579
U.S. Contracts	46,243	-------	46,244	46,244
Total Subsurface	1,323,073	$ 444,268	2,013,957	$ 697,585
Total Rental Receipts		$3,173,755		$3,506,007
		Other		
Leasing Fees		$ 64,821		$ 72,391
Royalties		$1,367,909		$4,616,478
Total Rental Rcts, Fees & Royalties		$4,541,665		$8,194,876
Penalties and interest, not included above		$ 17,165		$ 17,125

Rental Receipts Per Acre

(Leasing fees and royalties excluded)

	1969	1970
Average, Surface and Subsurface	$0.2956	$0.3028
Grazing	$0.0694	$0.0501
Minerals & Min's Mat'ls	$0.7794	$0.8352
Oil & Gas	$0.2513	$0.2515

Lease rental per acre per year on mineral claims is 75 cents, and on Oil & Gas leases is 25 cents.

Source: 57th and 58th Annual Reports of the State Land Commissioner.

TABLE IX

SUB-SURFACE ACREAGE UNDER LEASE BY COUNTY BY TYPE OF LEASE

1970

County	Prospecting Permits	Mineral Materials	Mineral	Oil & Gas	U.S. Contracts	GRAND TOTAL
Apache		195	80	247,137		247,412
Cochise	12,180	764	1,740	423,113		437,797
Coconino		254	807	23,306		24,367
Gila	640		620			1,260
Graham	6,885	40	2,884	11,057		20,866
Greenlee	354	43	331			728
Maricopa	3,439	1,094	4,134	236,598		245,265
Mohave	1,361	451	838	19,120		21,770
Navajo	20	355	576	104,494		105,445
Pima	18,384	980	12,383	280,683		312,430
Pinal	48,864	487	20,892	222,187		292,430
Santa Cruz		75		80		155
Yavapai	1,935	553	3,606	27,958		34,052
Yuma	3,261	638	313	219,525	46,243	269,980
Total 1970	97,323	5,929	49,204	1,815,258	46,243	2,013,957
Total 1969	94,169	4,606	46,660	1,131,395	46,243	1,323,073

TABLE X

SUBSURFACE LEASING RECEIPTS BY TYPE OF LEASE 1/

	A			B		
	Rental and Royalty Receipts			All Subsurface Lease Receipts		
Year	Prospecting Permits	Mineral Materials 2/	and Mineral 2/	Rental	Royalties 3/	Total
1960	$ none	$127,735		$474,025	$ 50,504	$ 524,529
1961	none	100,319		448,825	59,750	508,575
1962	71,676	257,538		476,462	221,143	697,605
1963	36,626	44,882 4/		430,054	270,341	700,395
1964	193,681	34,608 4/		547,863	138,623	686,486
1965	159,035	34,696 4/		534,731	121,984	656,715
1966	85,265	35,256 4/		346,036	155,922	501,958
1967	113,483	655,843		338,737	782,064	1,120,801
1968	166,731	$430,146	$886,922	412,114	1,280,734	1,692,848
1969	119,952	371,025	923,492	445,059	1,339,105	1,784,164
1970	148,716	96,138	4,532,505	699,125	4,590,770	5,289,895

1/ Includes rental receipts, penalties and interest, and royalties.
2/ Does not include oil and gas, helium, or U.S. Contracts.
3/ Prior to 1967, water royalties are included.
4/ Rental receipts, penalties and interest, only. Mineral royalty not separately reported.