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Mineral Deposits of Western Grant County, New Mexico

by Elliot Gillerman

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Abstract

Grant County has produced more than a billion dollars worth of metals and minerals since 1880. Most of this has come from the eastern part of the county, but important amounts of copper, gold, silver, fluorspar, and turquoise were mined from the western half. Lesser amounts of zinc, lead, and manganese and small amounts of tungsten, uranium, perlite, and ricolite have also been produced. Concentrations of other commodities present include nickel, cobalt, bismuth, molybdenum, and rare earths.

Mineral deposits occur in the Precambrian igneous and metamorphic rocks and in the Tertiary volcanic rocks that occupy most of the western part of the county. They are associated with northwest and northeast-to-east fractures and with intruded stocks and plugs. Major districts are at the intersection of the structural trends.

The largest and most productive mineral deposits are in the Big Burro Mountains. The supergene-enriched copper deposits at Tyrone have accounted for most of the copper produced, and the outlook for future production is excellent. Copper also occurs elsewhere in the mountains, and numerous deposits have been exploited. Fluorspar and turquoise have been mined, and large amounts of fluorspar still remain. In the White Signal subdistrict, gold, copper, and uranium deposits are numerous. Mining here essentially has been confined to the oxidized zone, and only small amounts of gold, radium, and uranium have been produced.

In the Steeple Rock district, gold and silver were the major commodities produced in the early days of mining, but in recent years lead, zinc, and copper have been extracted in significant amounts. In the Bullard Peak district, silver was produced from veins that contained native silver, nickel, cobalt, and uranium.

Other major districts include Gold Hill (gold, silver, fluorspar), Gila (fluorspar), Redrock (silver, copper, fluorspar, manganese), Malone (gold, silver), Little Burro Mountains (gold, silver, copper, lead, zinc, manganese), and Soldiers' Farewell (fluorspar, perlite).

Excluding perlite, diatomite, clay, and dimension stone, most of the mineral deposits are hydrothermal in origin, but oxidation and supergene enrichment have been important in concentrating the low-grade ores into deposits of economic worth. A few small deposits in the Redrock area were formed by metamorphic processes. Rare-earth-bearing pegmatites are in the Big Burro Mountains and Gold Hill.

Introduction

Grant County has produced more than a billion dollars worth of metallic and nonmetallic mineral products since 1880. Excluding oil, gas, and potash, this is more than 80 per cent of all mineral commodities produced in the state of New Mexico. Copper, zinc, lead, gold, silver, molybdenum, iron, manganiferous iron ore, fluorspar, and turquoise have been the major commodities produced. Numerous others, including uranium, manganese, building stone, clay, tungsten, vanadium, and bismuth, have been of minor importance.

Grant County is the most intensely mineralized area in the state and since Spanish colonial days has supported a mining industry. Mining is, and always has been, a most important segment of its economy. In 1960, activity and interest in mineral production and in the exploration for new mineral deposits were still intense. Prospects for the continued dominance of the mineral industry in the economic structure of the area and the dominance of Grant County as a leading factor in the mineral industry of New Mexico seem to be assured.

Despite the large quantities of minerals extracted from the hills of Grant County, large tonnages undoubtedly remain. This study was undertaken to encourage the search for new mineral deposits. The background and basic information provided, it is hoped, will aid and assist future exploration and exploitation of mineral commodities in the county.

PURPOSE AND SCOPE

The mineral deposits of western Grant County were studied as part of a program undertaken by the State Bureau of Mines and Mineral Resources to provide basic information on and document mineral deposits and resources of the various counties of New Mexico. Grant County is the most intensely mineralized in New Mexico and, excluding oil, gas, and potash, has accounted for the major portion of the mineral wealth of the state. Mines and prospects are numerous, totaling several times that of any other county. Because of this, and to facilitate and expedite completion and publication of this report, the county was divided into a western and an eastern half. Work was concentrated first in the western half, and this report includes only studies of the geology and mineral deposits of the western half of Grant County. A report on the eastern half is scheduled to follow.

This report aims, first, to present pertinent information on the geology of the western part of the county and on individual mineral districts and mineral deposits. Basic facts of mineralogy, mineral associations, ore genesis, ore controls, and localization are discussed. Second, the report aims to present an over-all picture of all mineral resources of western Grant County. Past production and history are given and future possibilities are outlined. All mineral resources, those currently economical, those potentially economical, and even those which appear to have no economic potential, are discussed, on the premise that a thorough analysis and documentation of known facts are instrumental to the future development of the mineral resources of this part of the county.

Attention in this report is concentrated on the geology and mineral deposits of the Big Burro Mountains. This has been the most productive area in the past and is believed by the author to hold the most promise for the future. Except for the Tyrone and White Signal districts, the area has received little previous attention. Many of the other areas have been the subject of relatively recent or forthcoming reports.

METHODS OF INVESTIGATION

Field work for the study was done during the summers of 1959, 1960, and 1961. In addition, information gathered by the author during the previous fifteen years while working on mineral deposits in the area was utilized. Information gathered by others and appearing in published reports was freely drawn upon, particularly if it pertained to deposits which were not accessible during the field work and which were accessible to the various authors when their studies were made. In many instances, the reader is referred to these earlier reports for more complete descriptions and analyses than are presented here. Most of the deposits were not being worked from 1959 through 1961, and many that had not been worked for years were caved and inaccessible. Much pertinent data, which would have aided in understanding the particular deposit, given a more complete understanding of the mineral resources and geology of the entire area, and in all respects made this report more informative and valuable, were perforce unobtainable. Information relative to such areas, however, was obtained from past and present owners of many of the properties and from others. This proved to be of great value to the study, particularly if the information could be, at least in part, reliably verified.

ACKNOWLEDGMENTS

Appreciation has been expressed personally to many of the individuals who have been of assistance in this study, and the opportunity is taken here to thank the many others whom it has not been possible to reach.

Financial assistance for this study was provided by the New Mexico Bureau of Mines and Mineral Resources, which also furnished all aerial photos, field transportation, equipment, and the necessary base maps. Grateful thanks are expressed to Mr. Alvin J. Thompson, director of the Bureau, for this help and co-operation and, through him, to the many individuals of the Bureau staff for their aid and assistance in typing, drafting, and editing of the manuscript and for other help.

I am also grateful for the many courtesies and the able help and assistance given by the various mine owners and former owners, and for their allowing free access to their properties. The Phelps Dodge Corporation was extremely helpful in making information on the Tyrone area available from its files, and Mr. Hyman Kelly, agent for the company at Tyrone, was most co-operative. Mr. Charles Russell freely gave of his time to personally guide me to many deposits which otherwise I may never have seen, and he also furnished information on old and now inaccessible deposits. Messrs. L. L. Osmer, Jr., Albert A. Leach, Fayette Rice, Robert P. Thompson, and Sherman Harper did likewise. Messrs. C. R. Altman, C. O. Prevost, and Ira L. Wright furnished much information, and Mr. Livingstone Utter was extremely helpful in making available for inspection many old records and maps of the Steeple Rock area. To these and to all the other residents of Tyrone, White Signal, Silver City, and other parts of Grant County who may have assisted me in any way, I herewith express my thanks.

Numerous individuals assisted in the field work and in the preparation of the report. Assistance in mapping of individual deposits is acknowledged in credits on the separate maps and figures. Paul Saueracker drafted many of the illustrations. Wolfgang Elston made many helpful suggestions and comments, and his assistance in the Gold Hill and Steeple Rock areas was particularly appreciated.

The help of many others, not specifically mentioned, is also acknowledged.

PREVIOUS WORK

The earliest account of many of the mines in the district is given by Fayette A. Jones in a report prepared for the World's Fair held in St. Louis in 1904. This publication, *New Mexico Mines and Minerals*, includes descriptions of and production data for many mines and is the only reference for some of them. Graton (Lindgren, Graton, and Gordon, 1910) and Paige (1916) were two early workers who included the geology and mineral deposits of western Grant County within larger regional studies in New Mexico and in the Silver City area, respectively. Paige (1911) also studied the mineral deposits of the Burro Mountains. Zalinski (1907, 1908), Paige (1912), and Sterrett (1908, 1909, 1911, 1912) described the turquoise deposits near Tyrone, and Somers (1916) and Paige (1922) gave excellent accounts of the Tyrone copper deposits. These reports are the major contributions to geological and mineral resource studies prior to 1945. In addition, there are a number of shorter and less inclusive studies, including those of Johnston on fluorspar (1928), A. A. and F. I. Leach on uranium and radium (1920, 1927, 1928), and Lang (1906), Reid (1902), Wade (1907), and others on copper at Tyrone, and various private reports.

Since 1945, detailed studies have been made by Rothrock (Rothrock, Johnson, and Hahn, 1946) and Gillerman (1952) on fluorspar; Gillerman and Whitebread (1956) on the uranium-nickel-cobalt-native silver deposits of the Black Hawk district; Gillerman (in preparation) on the White Signal district; Hewitt (1959) predominantly on the Precambrian rocks of the northern Burro Mountains; Ballmann (1960) on the volcanics of the Knight Peak area; Edwards (1961) in the Little Burro Mountains; Wargo (1958, 1959b) on the volcanic rocks southwest of Cliff; and Griggs (in press) on the Steeple Rock district. Shorter and less inclusive studies have been made by Elston (1956, 1960a, 1960b) on the Virden and Steeple Rock areas, Pradhan and Singh (1960) on the manganese deposits southwest of Redrock, Weber and Willard (1959) on the Cliff area, and Granger and Bauer (1950, 1952) on some of the uranium deposits in the White Signal area.

LOCATION

Grant County is in southwestern New Mexico, adjacent to the state of Arizona, and includes an area of 3970 square miles. Its maximum dimensions are 85 miles east and west and 90 miles north and south. It is bounded by Catron County on the north, Sierra County on the east, Luna and Hidalgo counties on the south, and Hidalgo County and the state of Arizona on the west. Silver City, the county seat and largest town, is almost in the center of the county. According to the 1960 census, Grant County had a population of 18,700 and Silver City a population of 6972. Other principal towns in the county are Hurley, Santa Rita, Bayard, Central, Pinos Altos, Gila, Cliff, Redrock, and Hachita.

Silver City is on a branch line of the Santa Fe Railway. Two lines of the Southern Pacific Railway cross the southern part of the county. U.S. Highway 260 extends northwestward across the county through Silver City. New Mexico State Highway 180 extends southwestward across the county through Silver City. U.S. Highway 70-80 crosses the southern part of the county.

The area included in this report is shown in Figure 1. The line between the western and eastern parts of the county is drawn to consider differences in geology and character of mineral deposits and also to take advantage of natural topographic divisions. The dividing line extends from a point on the Grant County–Catron County line one and a half

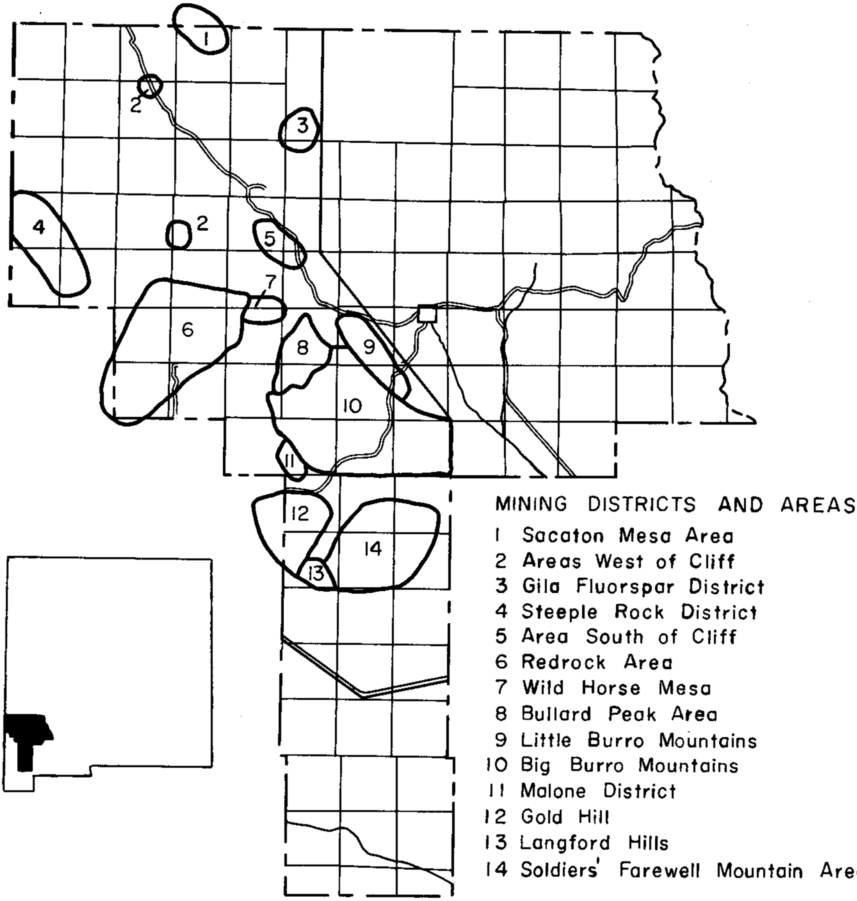


Figure 1

GRANT COUNTY, SHOWING AREA INCLUDED IN THIS REPORT AND MINING DISTRICTS AND AREAS SEPARATELY DESCRIBED

miles east of the 108°30′ meridian of west longitude, due south for 36 miles to the northeast corner of sec. 3, T. 17 S., R. 16 W., thence diagonally southeast 23 miles to a point one quarter of a mile due east of the northeast corner of T. 20 S., R. 14 W., thence due south 6 miles to the Grant County–Luna County line at the point where the county line turns south. The area east of this dividing line as here defined is excluded from discussion in this study.

The extreme southern part of Grant County is also excluded. The southern limit of the study is drawn at U.S. Highway 70-80, which crosses the southern part of the county between 22 and 28 miles north of the southern county line. This excludes the area in the vicinity of Hachita, the Hachita mining district, and the Little Hatchet Mountains. For a description of the mineral deposits in the vicinity of Hachita, see Lasky (1947) and Zeller (in press).

Silver City is not within the western part of the county as here defined, but it is less than five miles east of the dividing line. Redrock, Cliff, Gila, Mule Creek, Buckhorn, White Signal, and Virden are communities within the area.

TOPOGRAPHY AND DRAINAGE

Western Grant County includes part of the Basin and Range and the Colorado Plateau provinces. Northwest-trending mountain ranges separated by gravel-filled basins, characteristic of the Basin and Range Province, occupy the southern part of the county. The Big Burro Mountains are the most prominent of these ranges. The Little Burro Mountains, Knight Peak Range, and Gold Hill–Langford Hills are smaller and are subsidiary to the Big Burro Mountains. The northern part of the county is occupied by a dissected lava plateau, part of the southern edge of the Colorado Plateau province.

The highest point in western Grant County is in the extreme northeastern part of the area when the southern extremities of the Mogollon Mountains reach an elevation of 8650 feet above sea level. Four to eight miles to the north, in Catron County, the higher peaks of the Mogollon range are more than 10,500 feet above sea level. The lowest point is where the Gila River crosses the western boundary, at an elevation of 4000 feet. In general, the gravel-filled basins lie between 4000 and 6000 feet above sea level; the Big Burro Mountains and the other parallel ranges of the south are between 5000 and 7000 feet above sea level, except for the central peaks of the Big Burro Mountains which rise to 8000 feet above sea level. The lava plateau in the north is 5000 to 7000 feet above sea level, except in the Mogollon Mountains. The Continental Divide crosses the area, traversing the crests of the Little Burro and Big Burro mountains.

The Gila River crosses the northern and western parts of the county. Northwest of the Continental Divide, all streams drain into the Gila River. Major tributaries entering the Gila River from the high lava country to the north are Mogollon and Duck creeks. Mangas Creek is the major tributary from the south. Southwest of the Divide, the drainage is into the Lordsburg and Hachita interior basins. Southeast of the Divide, the drainage is into the Mimbres interior basin.

Except for the Gila River, all streams are intermittent and flow only during short intervals after the summer rains or in the spring when the snow melts in the high country to the northeast.

CLIMATE AND VEGETATION

Southwestern New Mexico has a continental, semiarid to semidesert climate. Average temperatures at Tyrone and near Silver City are 72°F in the summer and 36°F in the winter, but daily variations may be 60°F in parts of the area. Temperatures in the semideserts of the southern part of the county are considerably higher, and in the summer, temperatures over 100°F are common. The yearly precipitation is about 16 inches of rainfall around Silver City and Tyrone. Most of the rainfall comes in July, August, and September as widely scattered thundershowers. Precipitation is heavier in the mountains, and is as little as 10 inches annually in the southern part of the county. Snowfall is normally light except in the higher parts of the area.

The flora and fauna reflect the semiarid climate. The higher mountains are in the Canadian and Transition life zones (Corle, 1951, p. 344) but the gravel-filled basins are in the Upper Sonoran Zone. Ponderosa pine, scattered aspen, oak, spruce, and hardwoods occupy the highest areas. Piñon pines, juniper, and scrub oak cover much of the mountainous area and are scattered over the lower hills. Bear grass, yucca, cacti, and various desert grasses abound in the gravel basins and lower hills. Cottonwoods, and in places walnut, are present along the stream courses in the lower elevations.

History of Mining

Turquoise was mined by the Indians near Tyrone in the Big Burro Mountains prior to the coming of the Spaniards, and ancient excavations can still be seen. Old stone implements, fragments of pottery, and pieces of charcoal have been found in the old workings (Zalinski, 1907). Mining by the Spaniards in the Burro Mountains is also reported (Jones). Historically, the earliest mining in the county was at Santa Rita where in 1801 Spaniards mined and shipped copper to Chihuahua and Mexico City under contract to supply metal for Mexican coinage. An average of 4,000,000 pounds of copper a year was shipped (Lasky and Wootton, 1933).

In western Grant County, mining can be said to have begun when "Turquoise John" E. Coleman rediscovered turquoise in some old pits near Tyrone in the Burro Mountains in 1875 (Paige, 1922, p. 23, gives the date as 1879 but Zalinski, 1907, p. 465, gives 1875) and located claims on both copper and turquoise deposits. It appears, however, that Robert and John Metcalf had found both turqouise and copper in 1871, but because of the danger of Indians no further work was done until Coleman's discovery.

Following Coleman's discovery, numerous properties were developed in the years prior to 1910. The Alessandro, Burro Mountain, Chemung, and Savannah Copper companies and their predecessors developed extensive ore bodies. The Azure Mining Company and others mined turquoise. Elsewhere in the Burro Mountains and in the White Signal district, numerous deposits, mostly copper or gold, were discovered or mined. In the early 1880's, fluorspar was mined at the Burro Chief mine near Tyrone and at the Foster mine on the Gila for use as flux in smelters built at Oak Grove and Paschal in the Burro Mountains and at Silver City.

In 1880 and 1881, extensive prospecting resulted in the finding of gold, silver, lead, and copper in the Anderson, Clarks Peak, and Telegraph districts near Redrock, and in the Steeple Rock district in the extreme western part of the county. Also in 1881, high-grade silver was found at the Alhambra mine in the Black Hawk (Bullard Peak) district.

In 1884, gold was discovered at Gold Hill and Malone. Mining camps were established at Gold Hill, Malone, and Black Hawk, and more than 500 people lived at Gold Hill. Prominent among the prospectors and miners responsible for the early discoveries and their development were David Egelston, John Malone, J. A. Kirby, Judge Potter, J. W. Fleming, Lou Anderson, R. P. Thompson (who was still living in 1961), Theodore Carter, M. W. Porterfield, T. S. Parker, John E. Coleman, Robert Metcalf, John Metcalf, James Bullard, John Black, and others.

During the 1880's and 1890's, mining boomed, but the panic of 1893 and the drop in the price of silver caused many of the mines to close, some never to reopen. By 1900, little activity was going on in the area. In 1902, new discoveries of high-grade copper in the Tyrone district resulted in renewed activity in this district, and large-scale mining continued in this area until 1920. The towns of Leopold and Tyrone were mining centers, and in 1915, Tyrone was a town of about 5000 people. Small-scale mining activities continued in the White Signal district, Gold Hill, and elsewhere, but the Bullard Peak district was active only for a short period during 1917 and 1918, and major operations were never resumed in the Steeple Rock district.

In 1921, operations at Tyrone were closed and mining in the Burro Mountains virtually ended. The increase in the price of gold in the early 1930's stimulated production of this metal and a renewal of activity at Gold Hill, Gold Gulch, Malone, and in the White Signal district, but the high-grade ore soon played out and mining ceased.

In the late 1930's, the advent of World War II created a demand for fluorspar, and numerous properties were reopened and new ones found. Activity continued for about ten years, with the Burro Chief and Shrine mines as the major producers.

Since 1950, attempts have been made to revive activities in the Steeple Rock and Black Hawk (Bullard Peak) districts and at various places in the Burro Mountains and White Signal district, partly as a result of the interest in uranium. Extensive prospecting, especially in the White Signal district, was done. In addition, an intensive 10-year drilling program was carried on at Tyrone to prepare the low-grade ore body for future operation as an open-pit copper mine. This was completed in 1959. Activity in the Black Hawk district also terminated in 1959. In 1960 and 1961, mining activity in western Grant County was limited to a little prospecting, assessment work, and a few small operations.

PRODUCTION

No information is available as to the total mineral production of western Grant County. Total production, however, for all of Grant County for the five major commodities, gold, silver, copper, lead, and zinc ore, for the years 1904-1954 are given by Anderson (1957, p. 46). Production figures for these commodities for the years 1954 to 1961 have been compiled from the several volumes of the *Minerals Yearbook* (Parts III, 1955, 1956, 1957, 1958, 1959, 1960, 1961). The totals for the years 1904 to 1961 are as follows:

	1904-1954	1954-1961	Total
Gold (value)	$7,435,056	$526,575	$7,961,631
Silver (ounces)	14,133,471	958,720	15,092,191
Copper (pounds)	3,531,250,987	865,590,800	4,396,841,787
Lead (pounds)	202,550,468	27,032,300	229,582,768
Zinc (pounds)	1,440,107,008	220,452,476	1,660,559,484
Total value	$880,954,409	$323,882,943	$1,204,837,352

The value of the production of silver from the Black Hawk district is estimated to have been between $1,000,000 and $1,500,000 (Lindgren, Graton, and Gordon, p. 324; A. A. Leach, 1916). The value of turquoise produced from the Tyrone district was said by Zalinski (1907, p. 465) to be several million dollars. Leach (oral communication) stated that the value of the gold and silver produced from the Malone district was about $300,000. The total value of gold and silver from Gold Hill is reported to be several hundred thousand dollars.

Production figures are more reliable for the Steeple Rock and Tyrone districts. Production of gold and silver from the Steeple Rock district between 1932 and 1947 was valued at nearly $3,000,000; prior to 1897, it is estimated that $3,000,000 worth of gold and silver was produced (Anderson, p. 76). The value of the metals produced between 1897 and 1932 and from 1947 to 1961 was small. The total value of metals produced, therefore, was about $6,000,000, most of which was in gold and silver (table 1).

TABLE 1. PRODUCTION OF METALS IN THE STEEPLE ROCK DISTRICT, GRANT COUNTY, 1932-1947

YEAR	GOLD (ounces)	SILVER (ounces)	COPPER (pounds)	LEAD (pounds)	ZINC (pounds)	TOTAL VALUE
1932	13	780	—	—	—	$ 493
1933	2	94	—	—	—	64
1934	421	21,141	1,700	500	—	28,553
1935	407	19,490	2,200	—	—	28,414
1936	850	54,173	5,600	300	—	72,222
1937	5,552	200,863	57,550	68,175	55,000	364,258
1938	5,687	239,119	33,300	38,500	—	358,654
1939	4,487	237,030	13,000	19,000	—	320,183
1940	5,414	216,374	20,900	74,000	—	349,418
1941	6,685	252,509	53,200	226,000	—	432,697
1942	1,390	60,220	29,000	86,700	—	100,791
1943	250	20,870	202,800	683,000	703,500	177,158
1944	295	21,181	210,800	838,500	944,000	228,541
1945	963	25,494	232,200	1,079,500	1,156,400	309,004
1946	408	8,797	87,800	405,200	328,800	119,893
1947	203	3,765	33,700	193,000	133,250	66,822
1948-1954*	—	—	—	—	—	—
Totals	33,027	1,381,900	983,750	3,712,375	3,320,950	$2,957,165

* No production reported.

In the Tyrone district, 78,481,469 pounds of copper were produced between 1904 and 1929. This, plus some gold, silver, and lead, resulted in a total value for metals produced during these years of $16,725,236 (Lasky and Wootton, p. 50). Only small amounts of copper and other metals were produced between 1929 and 1961. Fluorspar produced from the Tyrone and adjacent areas in the Burro Mountains, mostly from the Burro Chief mine, between 1943 and 1948 totaled about 110,000 tons. There was also production both prior to 1943 and after 1948; total production of fluorspar is calculated at between 125,000 and 150,000 tons of ore (table 2).

TABLE 2. PRODUCTION OF METALS IN THE BURRO MOUNTAINS (TYRONE) DISTRICT, GRANT COUNTY, 1904-1929

YEAR	GOLD (value)	SILVER (ounces)	COPPER (pounds)	LEAD (pounds)	TOTAL VALUE
1904	$ —	—	973,231	—	$ 124,574
1905	—	—	1,804,416	—	281,489
1906	—	—	2,608,005	—	503,345
1907	—	—	2,163,810	—	432,762
1908	271	387	801,841	—	106,319
1909	284	2,160	1,160,838	—	152,316
1910	421	1,769	80,205	—	11,562
1911	558	3,623	28,089	—	5,989
1912	—	63	51,583	—	8,550
1913	2	19	15,155	—	2,362
1914	—	739	285,014	—	38,316
1915	—	3,558	1,406,286	—	247,904
1916	1,426	23,491	8,392,329	—	2,081,396
1917	5,354	41,523	14,574,355	—	4,018,368
1918	5,960	50,323	17,100,044	—	4,279,994
1919	2,129	16,275	6,101,102	—	1,155,162
1920	2,160	27,656	6,605,669	—	1,247,748
1921	2,357	18,184	4,496,124	—	600,541
1922	—	—	—	—	—
1923	21	724	2,374,163	—	349,617
1924	—	—	2,665,093	—	349,127
1925	—	664	1,890,662	—	268,935
1926	445	2,476	678,250	20,000	98,545
1927	873	4,993	250,687	—	36,544
1928	523	1,805	889,347	—	129,645
1929	1,158	3,724	1,085,131	—	194,126
Totals	$23,942	204,156	78,481,429	20,000	$16,725,236

Geology

Rocks of western Grant County are divisible into three major groups based upon age and petrologic character: Precambrian metamorphic and plutonic rocks, Late Cretaceous and Tertiary volcanic rocks, and Late Tertiary and Quaternary consolidated and unconsolidated gravels. Marine sedimentary rocks and small intrusive masses are of limited extent. The Precambrian rocks crop out mostly in the mountains in the southern part of the area and the volcanic rocks are widespread in the north. The gravels fill the intermontane basins (pl. 1).

Many of the boundaries that delimit the area of outcrop of these three major types are prominent northwest-trending zones of structural weakness.

Only a very brief analysis is here given of the petrographic character, distribution, genesis, age relations, and importance in the study of mineral deposits of the many rock types in the western part of the county. More detailed descriptions are included under the separate areas or districts. For still fuller descriptions, the reader is referred to publications by Hewitt, Gillerman (1952), Gillerman and Whitebread, Paige (1916, 1922), Somers, Edwards, Ballmann, Wargo (1959a, 1959b), and others.

METAMORPHIC ROCKS

Precambrian metamorphic rocks in western Grant County are divided into two series, the Bullard Peak and the Ash Creek (Hewitt, p. 9). The latter is confined to an area of less than two square miles, five miles north of Redrock. The former crops out extensively in the Redrock, Bullard Peak, and Gold Hill areas and is of limited extent elsewhere (pl. 1). The Ash Creek series is composed mostly of metasedimentary rocks, including phyllites, schists, hornfels, and serpentine-carbonate rocks. The Bullard Peak series consists of metasedimentary and metaigneous rocks including gneisses, schists, amphibolites, quartzites, and migmatites. The Bullard Peak series is the more intensely metamorphosed and is presumed by Hewitt to be the older. Both the Bullard Creek and Ash Creek series are intruded by the Burro Mountain granite and other plutonic rocks described below. In many places they occur as isolated masses, probably xenoliths or roof pendants, within the Burro Mountain batholith.

IGNEOUS ROCKS

Igneous rocks are the surface rocks over almost all the mountainous parts of western Grant County. They range in age from Precambrian to

Late Cenozoic, in composition from basic to acid, and in mode of origin from plutonic to volcanic and pyroclastic. For convenience in description, they are discussed under plutonic rocks of Precambrian age; dikes, stocks, and plugs, mostly of Mesozoic and Tertiary ages; and volcanic rocks of Cretaceous, Tertiary, and Quarternary ages. Only the more extensive rock types are mentioned in this section. Many of the more restricted units are described in the sections on the mineral deposits of separate areas.

Plutonic Rocks

All plutonic igneous rocks of Precambrian age are included as part of the Burro Mountain batholith complex. Burro Mountain granite constitutes the major exposed part of the batholith, but small, separate, isolated masses of anorthosite, metadiabase, diorite, syenite, and Shrine granite and larger masses of quartz diorite gneiss (tonalite) are included. These minor rock types are all older than the Burro Mountain granite and are intruded by it. They may represent early differentiates of the granitic magma or genetically unrelated separate intrusive rock units. Hewitt dates the anorthosite and metadiabase as the earliest of these rock units. Except for the quartz diorite gneiss (tonalite), the minor rock types of the batholith complex crop out over areas of less than half a square mile.

Quartz Diorite Gneiss (Tonalite)

Quartz diorite gneiss is described by Gillerman and Whitebread and by Hewitt under the name of *tonalite.* It is the dominant rock type in the Black Hawk district and is prominent in the area southwest of Bullard Peak. It intrudes rocks of the Bullard Peak series and is intruded by Burro Mountain granite, syenite, and minor plutonic rock units. Excluding the anorthosite and possibly the metadiabase, it is the oldest intrusive rock of the batholith complex.

The quartz diorite gneiss is a coarse-grained porphyritic rock with gneissoid texture. Oligoclase, biotite, and quartz are the major constituents; potash feldspar and hornblende are minor constituents; and zircon, magnetite, and apatite are accessory minerals. The oligoclase (An_{26-34}) comprises 40 to 50 per cent of the rock, occurring as anhedral grains with an average length of two centimeters and as euhedral crystals up to two inches long that stand out on the weathered rounded surface, giving the rock a knobby appearance. Biotite comprises 25 to 30 per cent and quartz 15 to 20 per cent of the rock. The gneissoid texture is due to the preferred orientation of biotite flakes and the parallel orientation of the long axes of the feldspar laths.

Burro Mountain Granite

Burro Mountain granite is the most extensively exposed Precambrian rock unit in western Grant County and is characterized by its heterogeneity. More than one type have been recognized, but no detailed petrographic or field studies have been made to analyze statistically and map the different variants. Local differences in color, texture, mineral composition, and degree of weathering and alteration have been recognized. Typically, the granite is light tan, orange, pink, or red, medium- to coarse-grained, and equigranular. Porphyritic and fine-grained varieties occur. Quartz constitutes 20 to 25 per cent of the rock, the remainder being mostly potash feldspar. Thinsection studies of samples from the Burro Mountains and south of White Signal show that most of the potash feldspar is microcline, but orthoclase is present in some places. Both microcline and orthoclase were observed in some specimens. Hewitt (p. 68) reports oligoclase (An_{31-26}) present in amounts of 12 to 29 per cent in the Redrock area, and Somers (p. 610), in referring to the granite near Tyrone, states that "in the granite as a whole plagioclase is usually more abundant than orthoclase." Biotite and hornblende are present in minor amounts; accessory minerals include sphene, zircon, tourmaline, apatite, magnetite, rutile, and ilmenite.

The effects of hydrothermal alteration and weathering are widespread in the granite. Feldspars are argillized, but near mineralized areas are more commonly sericitized or silicified. Biotite is altered to chlorite or sericite; hornblende to chlorite or epidote. Limonitic staining is common. The granite weathers readily to a soft crumbly rock and eventually to a gravelly soil, except where it has been silicified.

DIKES, STOCKS, AND PLUGS

Dikes, stocks, and plugs of various composition and age intrude the rocks of the Burro Mountain batholith.

Quartz Monzonite and Related Rocks

The Tyrone stock, the largest of the small plutonic masses, is intrusive into the batholith. It is exposed on the northeast side of the Big Burro Mountains, less than a mile southwest of Tyrone. The exposed part of the stock is elliptical, is four miles wide by five miles long, and trends northeast. Most of the stock is a homogeneous, light gray, medium-grained, equigranular or locally porphyritic quartz monzonite consisting of 15 to 20 per cent quartz, 20 to 25 per cent orthoclase, about 50 per cent oligoclase, up to 5 per cent biotite, and minor amounts of hornblende. Megascopic crystals of sphene are characteristic, and a few megascopic crystals of apatite are present. Magnetite, zircon, and allanite are other accessory minerals. In many places the rock is porphyritic, with prominent poikilitic orthoclase phenocrysts, some more than an inch in diameter. The poikilitic orthoclase crystals contain inclusions of quartz, plagioclase, feldspar, biotite, magnetite, apatite, and sphene. Many of the orthoclase crystals are zoned and/or show Carlsbad twinning. Euhedral crystals of quartz, in which positive and negative rhombohedrons are equally developed almost to the exclusion of the prism, are also common as phenocrysts and are a distinguishing criterion of the rock.

Along the northern and eastern edges of the stock are small bodies of rock that are similar to but distinct from the main quartz monzonite body. These may be segregations near the border of the main stock or they may represent separate intrusions. One type contains no sphene and only scattered biotite; another contains large plagioclase phenocrysts, hornblende, and no orthoclase; a third is deficient in quartz. This latter type occurs also in the southeastern part of the Little Burro Mountains.

Porphyritic dikes, petrographically similar to the stock and to its border phases, cut the surrounding granite and the stock. At least three distinct types have been recognized: granodiorite dikes, quartz monzonite porphyry dikes containing abundant chloritized biotite and sphene, and quartz monzonite porphyry dikes with small amounts of chloritized biotite and no sphene. The orthoclase and quartz phenocrysts in the quartz monzonite porphyry dikes are similar to those in the porphyritic phases of the main stock.

Monzonite Porphyry

The Twin Peak stock (photo 1) which crops out over two and one-half to three square miles about two miles northeast of Bullard Peak, consists of grayish white monzonite porphyry. Abundant white anhedral to subhedral phenocrysts of plagioclase up to 0.5 centimeter in diameter and needles of dark green hornblende up to 1.0 centimeter long constitute 20 to 25 per cent of the rock. The fine-grained matrix consists of feldspar with minor quartz, and accessory magnetite and apatite. The feldspar is mostly andesine (Ab_{60-62}), but some oligoclase is present. Dikes, apophyses of the stock, and irregular small intrusive masses are associated with the stock.

Rhyolite

Rhyolite forms plugs and dikes in the Big Burro Mountains, Gold Hill, Langford Hills, the Bullard Peak area, and elsewhere throughout the area of Precambrian exposures. A few rhyolite dikes intrude the volcanic rocks. Rhyolite is most abundant in the White Signal area, where several varieties have been distinguished.

The rhyolite plugs near White Signal form prominent hills that rise as much as 350 feet above the surrounding countryside (photo 2). Many

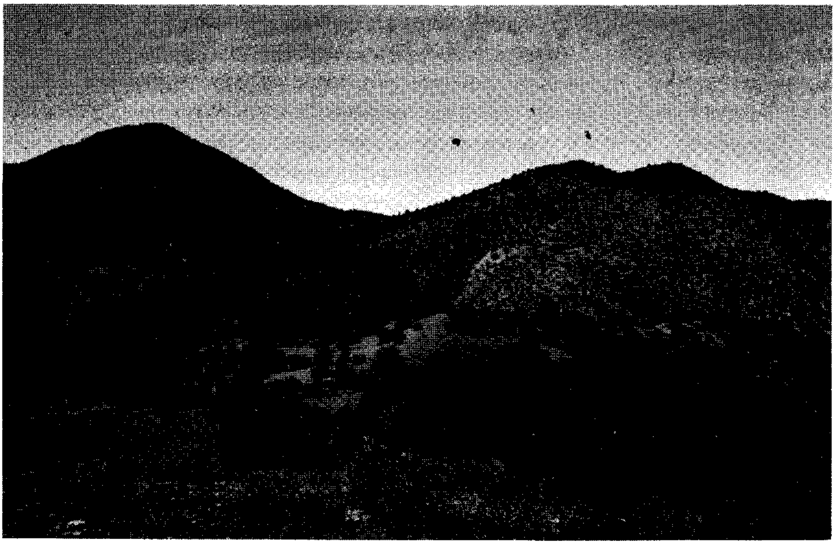


Photo 1

BULLARD PEAK (LEFT) AND TWIN PEAK MONZONITE STOCK (RIGHT) FROM NEAR THE BLACK HAWK MINE, BULLARD PEAK DISTRICT

Bullard Peak is a prominent landmark of the northern Big Burro Mountains.

of the dikes are also topographically prominent, standing up as a wall or holding up ridges. The rhyolite in the plugs is a light gray, fine-grained to aphanitic rock with a few small quartz and potash feldspar crystals. Many of the feldspars are argillized and appear as white spots in the rock. Limonitic stains and limonite-filled cavities are abundant. The rhyolite in many of the dikes in the vicinity of the plugs is similar to that of the plugs.

In the White Signal area north of the plugs, and elsewhere in the area of exposed Precambrian rocks, the rhyolite dikes are composed of a chalky white, aphanitic, compact rock with a few quartz, feldspar, or sericitized biotite phenocrysts.

Garnetiferous rhyolite occurs as dikes in the White Signal district in sections 11 and 14. The garnet occurs as reddish brown euhedral crystals

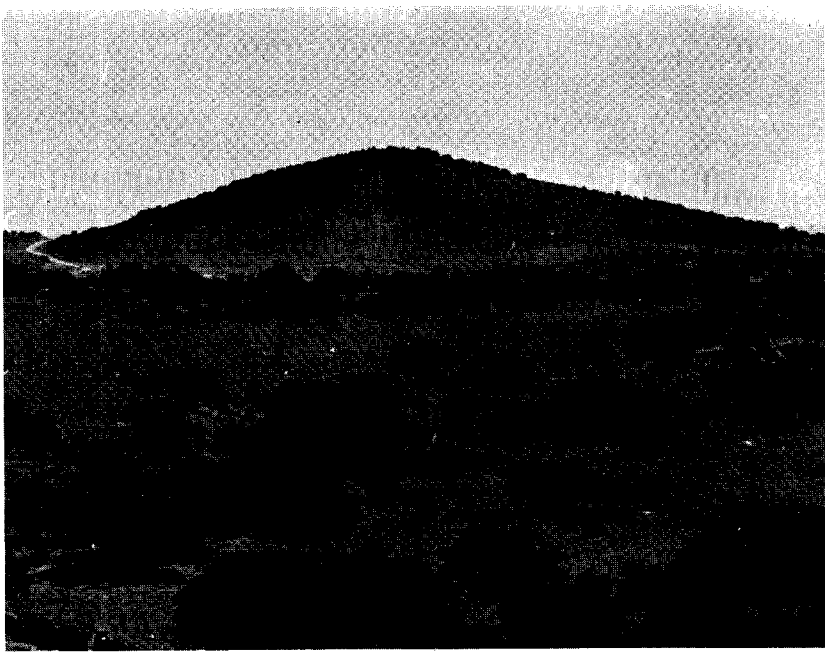


Photo 2

TULLOCK PEAK, A RHYOLITE PLUG RISING ABOVE THE SURROUNDING COUNTYSIDE, WHITE SIGNAL DISTRICT

up to two centimeters in diameter scattered throughout a gray aphanitic groundmass. With similar-sized quartz phenocrysts, the garnet constitutes about 5 per cent of the rock mass.

Diabase

Dikes and small intrusive masses of gabbroic and basaltic rocks are common in areas of Precambrian exposures. Many of these have a diabasic texture. In typical diabase, andesine (An_{34}) constitutes about 50 per cent of the rock, and pyroxene the rest, except for accessory magnetite and apatite. The diabase alters readily to chlorite, hydrous iron oxide, epidote, and clay minerals. The altered rock is soft and easily erodable; hence, outcrops of diabase are not common. The brown color of the soil overlying such dikes, however, is distinctive.

Photo 3

DATIL FORMATION, SHOWING THE NEARLY HORIZONTAL LAYERING OF LAVA FLOWS AND PYROCLASTIC MEMBERS

Looking north across the Gila River from near the Clum mine, Gila fluorspar district.

VOLCANIC ROCKS

Volcanic rocks cover most of the northern part of western Grant County (photo 3) and also crop out in the Little Burro Mountains, Big Burro Mountains, and southwest and south of the Big Burro Mountains. Mostly they are flows and pyroclastics of Tertiary age, with intercalated sediments in places and with associated dikes, sills, and plugs. Quaternary and Cretaceous volcanic rocks are present also. Andesite and rhyolite predominate, but basalt is prevalent in the Late Tertiary and Quaternary rocks.

The volcanic rocks have recently been mapped and studied in detail by Ballmann, Wargo (1958, 1959a, 1959b), and Edwards in the Knight Peak area (photo 4), Schoolhouse Mountain area (southwest of Cliff), and the Little Burro Mountains. In addition, Elston (1960a) mapped the volcanic rocks in the Redrock and Steeple Rock areas, and Weber and Willard in the Cliff area. Within each area, the sequence has been determined. Although differences exist, there is a basic sequence throughout the region (Callaghan, 1953; Wargo, 1959a,b). It is preferable, however, to describe the rocks in each area separately. This information is summarized in Table 3.

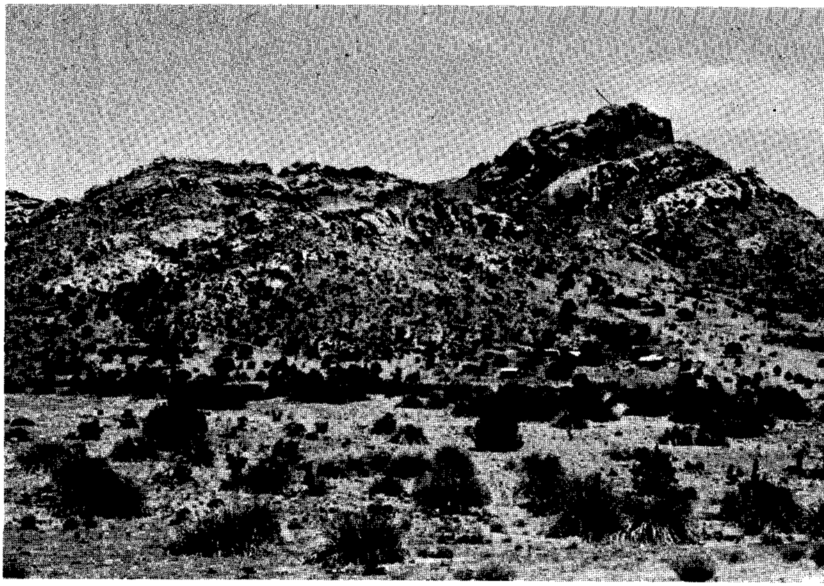


Photo 4

KNIGHT PEAK, FORMED OF EARLY RHYOLITE ROCKS (BALLMANN) OF THE KNIGHT PEAK VOLCANIC ROCKS

Looking southeast from near the Patanka mine, Malone district.

TABLE 3. VOLCANIC ROCKS IN WESTERN GRANT COUNTY

AGE	FORMATION	DESCRIPTION OF ROCKS
	Schoolhouse Mountain area (Wargo, 1959b)	
Quaternary	Basalt	dark gray, scoriaceous, olivine-bearing
Tertiary	Moonstone tuff	light gray, sanidine phenocrysts, vitric to crystal tuff
	Gamma Formation	purple and brown tuff breccia
	Cherokee Creek formation	red rhyolite tuffs, welded tuffs, and glass rocks
	McCauley Formation	pink and gray rhyolite, vitrophyre, and assorted breccias with interbedded shaly sandstones
	Mangas Creek Formation	rhyolite and andesite tuff and breccia
	Delta Formation	medium-grained, porphyritic gray, red, pink rhyolite and latite and purple latites
	Kerr Canyon Formation	mostly white and brown rhyolitic tuffs and breccia and some pink rhyolite porphyry
Tertiary or Cretaceous	Saddle Rock Canyon Formation	blue andesite or dense green andesite porphyry
	Knight Peak Range (Ballmann)	

TABLE 3. VOLCANIC ROCKS IN WESTERN GRANT COUNTY (Cont.)

AGE	FORMATION	DESCRIPTION OF ROCKS
Quaternary	Late andesite rocks	gray to purplish black andesite tuff
	Late dacite flows	gray to tan aphanitic dacite porphyry
	Late rhyolitic rocks	dense white to buff porphyritic aphanite
Tertiary	Middle rhyolitic rocks	gray, green, and white tuffs and tuff breccias
	Vitric rhyolite breccia	gray to pink volcanic breccia with rhyolitic and andesitic fragments
	Early andesite rocks	gray and purple andesite flows and gray to maroon, well-bedded, lithic andesite tuff
	Early rhyolitic rocks	porphyritic tuffs and flows of rhyolitic composition, agglomerate and perlite
	Little Burro Mountains (Edwards)	
Quaternary ?	Basalt	vesicular olivine basalt porphyry
Tertiary	Upper volcanic unit	tuffs and agglomerates, mostly of latite and quartz latite
	Middle volcanic unit	rhyolite, latite, and quartz latite tuffs
	Lower volcanic unit	andesite and andesite porphyry flows
	Mogollon Quadrangle (Weber and Willard)	
Tertiary	Upper rhyolite	flows, tuff and ash, vitric phases, interbedded with Gila Conglomerate
	Basalt and basaltic andesite	black and gray flows, flow breccias, vesicular amygdaloidal, interbedded with Gila Conglomerate and upper rhyolite
	Datil Formation	rhyolite sequence, flows, tuffs, and welded tuffs
	May be Datil or older	quartz latite and latite flows, flow breccias andesite and basalt, red and purple and black flows, pyroclastics, vesicular and amygdaloidal
	Virden Quadrangle (Elston, 1960a) (includes Steeple Rock area)	
Late Tertiary	Upper rhyolite	flows, tuffs, perlitic facies, interbedded with Gila Conglomerate
	Basalt and andesitic basalt	brown to black basalt, olivine basalt, and basaltic andesite interbedded with Gila Conglomerate
	Latite	purple, gray, or reddish porphyritic latite, may be a sill, grades up into basalt
Tertiary	Datil Formation	rhyolite flows, welded tuffs, and interbedded andesites and latite porphyry
Cretaceous	Andesite	flows, tuffs, and flow breccias, vesicular, amygdaloidal, and porphyritic (Steeple Rock area)
	Rhyolite	porphyritic rhyolite flows and welded tuffs (Steeple Rock area)
	Dacite	flows, tuffs, and flow breccias (steeple Rock area)

SEDIMENTARY ROCKS

CAMBRIAN, ORDOVICIAN, AND UNDIFFERENTIATED PALEOZOIC ROCKS

Small isolated outcrops of Bliss Sandstone, El Paso Dolomite, and undifferentiated Paleozoic rocks crop out south of the Big Burro Mountains. They rest unconformably on Burro Mountain granite or protrude through the gravels filling the basins. Their presence indicates that these areas were sites of marine deposition in early Paleozoic times.

CRETACEOUS

Upper Cretaceous marine and continental deposits, represented by the Beartooth Quartzite, Colorado Shale, and Virden Formation, crop out between the Precambrian rocks and the Tertiary volcanic rocks. They lie in a discontinuous band which extends from the Little Burro Mountains westward through the Bullard Peak, Wild Horse Mesa, and Redrock areas, to Steeple Rock. Nowhere is a complete section present, and the Beartooth Quartzite, Colorado Shale, or both may be absent. The Virden Formation is present only in the Steeple Rock area.

The Beartooth Quartzite caps hills, forms dip slopes, and outlines tilted fault blocks. It is mostly a fine- to medium-grained gray, thick-bedded, well-sorted orthoquartzite composed of rounded grains of quartz, mostly one millimeter or less in diameter, which are cemented by secondary fine-grained quartz and interlocking oriented quartz overgrowths. The quartzite is hard, breaks with a subconchoidal fracture, and is resistant to erosion. A basal conglomerate is present locally, and 2- to 12-inch-thick beds of sandy shale and thicker beds of sandstone are interbedded with 1- to 12-foot-thick beds of quartzite. In the Little Burro Mountains, Edwards (p. 18) measured a thickness of 117 feet; Hewitt (p. 79) reports a thickness of 60 feet north of Redrock. The variation in thickness and the discontinuity of outcrop pattern may be partly because of nondeposition and partly because of postdepositional erosion.

The Colorado Shale rests conformably upon the Beartooth Quartzite and is overlain by Tertiary volcanic rocks. It characteristically forms valleys or saddles between the more resistant rocks. Redrock Canyon in the Little Burro Mountains is an excellent example of a valley carved in the shale.

In the Wild Horse Mesa–Redrock area, the formation consists dominantly of thin- and thick-bedded, blue-black, carbonaceous shale with a few thin beds of arenaceous shale and some limestone. In the Little Burro Mountains, where only the lowermost part of the formation is present, brown, yellow, and gray fine- to medium-grained sandstones alternate with gray, blue-gray, brown, and black shales and sandy shales.

The shale and sandstone beds range in thickness from a few inches to several feet. Sandstone comprises 30 to 50 per cent of the formation.

In eastern Grant County, Paige (1916) reported a maximum thickness of 2000 feet. In the Little Burro Mountains, Edwards measured a maximum of only 156 feet, and Hewitt estimated a thickness of 1100 feet east of Clarks Peak northeast of Redrock.

Ammonites and pelecypods found by Edwards in the Little Burro Mountains indicate a Lower Turanian age (Keith Young, written communication, 1959).

The Virden Formation crops out in the foothills southwest of Steeple Rock Peak in the southeastern part of T. 17 S., R. 14 W., four or five miles south of the Carlisle mine. The formation was first described by Pradhan and Singh from exposures a mile or two southeast in Hidalgo County.

The formation rests unconformably on a thick series of andesitic, rhyolitic, and dacitic volcanic rocks in Grant County, but two miles southeast in Hidalgo County it unconformably overlies Colorado Shale. Rhyolite and latite of the Datil Formation overlie the Virden Formation. In the area southeast of Steeple Rock Peak, the formation dips 30° to 40° SE.

According to Pradhan and Singh, a minimum of 1000 feet of nonmarine tuffaceous sandstone, shale, fanglomerate, and conglomerate constitutes the formation. The fanglomerate and conglomerate contain rounded to angular boulders of the underlying dacite, andesite, and granite. Plant remains identified indicate a late Montanan or early Lancean age.

Tertiary and Quaternary

Gila Conglomerate

In western Grant County, consolidated and semiconsolidated conglomerates and interbedded sandstones, which postdate the outpouring of rhyolitic and latitic lavas referred to as the Datil Formation or its equivalents and which are of Late Tertiary and Early Quaternary age, are referred to as the *Gila Conglomerate*. The beds are mostly tilted, in places reposing at angles up to 65 degrees, and have been involved in Late Tertiary or Early Quaternary orogenic movements. In the lower part they are interbedded with basalt, basaltic andesite, and rhyolite lava flows, representing the last stages of Tertiary volcanism.

As thus used, the name *Gila Conglomerate* is consistent with usage of the name throughout southern Arizona and southwestern New Mexico for the extensive deposits of consolidated and semiconsolidated coarse detrital material that underlies many of the intermontane valleys. These deposits, first described by Gilbert (1875) from the valley of the upper Gila River, were originally dated as Early Quaternary, but recent work (Knechtel, 1936; Heindl, 1952, 1954) has shown that much of the material is Pliocene in age. Beds referred to as Gila Conglomerate throughout the area thus include material eroded from high-standing areas and deposited during Pleistocene, Pliocene, and possibly pre-Pliocene time in different intermontane basins, not necessarily contiguous, in a physical environment that was similar throughout the larger area of erosion and deposition.

In western Grant County, the Gila Conglomerate crops out within the graben bounded by the Malone and Taylor faults, lying between Knight Peak volcanic rocks and Burro Mountain granite. It is particularly well exposed in Gold Gulch and Pine Canyon. The outcrop area is overlapped to the southeast by later bolson deposits which fill the interior Mimbres basin. To the northwest, the outcrop area fans out to include most of Grant County west of the Burro Mountains and south of the area of extensive volcanic rocks. Gila Conglomerate also fills the wide valley extending northwestward from Silver City and occupied by Mangas Creek and Duck Creek. A westward extension of this area occupies much of northwestern Grant County in the vicinity of Mule Creek. Smaller areas of Gila Conglomerate are present along the Gila River. In many places, areas mapped as basalt or upper rhyolite include interbedded Gila Conglomerate and vice versa. Elsewhere it is difficult to distinguish Gila Conglomerate from younger gravels.

The thickness of the formation has a considerable range. Hewitt reports a maximum thickness of 200 feet exposed in the area south and southeast of Redrock. Ballmann reports a doubtful thickness of 5000 feet in Pine Canyon, less than two miles south of the area mapped by Hewitt. In Gold Gulch, south of Pine Canyon, a minimum thickness of 2000 to 2500 feet is postulated. Faulting may be responsible for a repetition of beds in these areas of great apparent thickness.

The Gila Conglomerate consists mostly of conglomerates containing locally derived boulders, cobbles, and pebbles of igneous and metamorphic rock set in a matrix of coarse sand, grit, and gravel. Thin sandstone layers and lenses are locally interbedded with the conglomerate. Lacustrine deposits and beds of volcanic ash are present in places.

The conglomerate is red, brown, gray, white, or tan, depending upon the color of the dominant rock fragments. It is poorly sorted. The fragments are angular to subrounded and range up to 12 feet in diameter; most are less than 4 inches. In Gold Gulch, the lower part of the formation is well consolidated and consists largely of granite fragments, many of them up to 6 feet in diameter.

Sandstone lenses are mostly semiconsolidated and consist of coarse, angular, sand-size particles of quartz, feldspar, or rock fragments, with a few subrounded pebbles. They grade laterally and vertically into conglomerate and are probably stream channel deposits.

Lacustrine deposits are prominent north of Buckhorn and are scattered elsewhere. They include thin- and thick-bedded white, gray, tan, and pink clays, siltstones, fine-grained sandstones, and beds of volcanic ash. White, fine-grained, friable, chalky diatomite, and diatomaceous clay occur through a thickness of at least 25 feet. The lacustrine deposits appear to be in the upper part of the formation.

Lateral and vertical variations in the character of the formation reflect differences in source of materials and in stability of source area and area of deposition. The formation consists essentially of debris derived from adjacent highlands and deposited at the foot of the mountains as fanglomerates which merged basinward to cover large areas. Ever changing stream channels and temporary lakes within the basin of deposition were the sites of alluvial and lacustrine deposits. Volcanic ash falls added to the sediments.

The Gila Conglomerate rests unconformably on pre-Tertiary and some Tertiary rock units but is conformable with late Tertiary basalt, basaltic andesite, and upper rhyolite with which it is interbedded. It is separated from overlying Quaternary gravels, terrace deposits, alluvium, and bolson deposits by an angular unconformity.

Terrace and Pediment Gravels, Bolson Deposits, and Quaternary Alluvium

Unconsolidated and semiconsolidated deposits of sand, silt, and gravel occupy terraces along some of the streams and also form the surficial material of the alluvial fans and bajadas at the base of the mountains. Mountainward, these deposits locally merge into a thin veneer of gravel covering granite pediments.

The material consists largely of rounded to angular fragments of locally derived material ranging in size from silt and coarse sand to large boulders. The deposits are mostly less than 50 feet thick. They overlie Gila Conglomerate in many places, and on gently sloping surfaces, they cannot be readily distinguished from weathered Gila Conglomerate.

Basinward, the terrace and bajada deposits grade into finer grained bolson deposits of fine sand, silt, and mud. These are extensively developed in the southern part of the county and in adjacent areas in Luna and Hidalgo counties where they contain intercalated lacustrine and playa deposits.

The bajada, terrace, and bolson deposits range in age from post-Pliocene to Recent.

Recent stream alluvium covers the bottoms of the valleys of many of the larger intermittent streams and forms the floodplain of the Gila River. It is rarely more than 50 feet thick and consists of gravel, sand, silt, and mud carried by the streams and deposited during times of high water and flood.

STRUCTURE

Faults and fractures dominate the srtuctural pattern in western Grant County. They trend northwest to north-northwest and northeast to east-northeast. The latter are concentrated in a broad zone which stretches across the central part of the county. Major mining districts in western Grant County are at the intersection of this zone and the various northwest or north-northwest trends.

The northwest to north-northwest trends are marked by narrow but continuous fault zones which delineate geologic or topographic provinces. Most prominent are the Mogollon and Mangas faults which form eroded fault scarps and separate high-standing blocks capped by Tertiary volcanic rocks from relatively low areas filled with Gila Conglomerate and younger sediments (photo 5). The Malone and Taylor faults

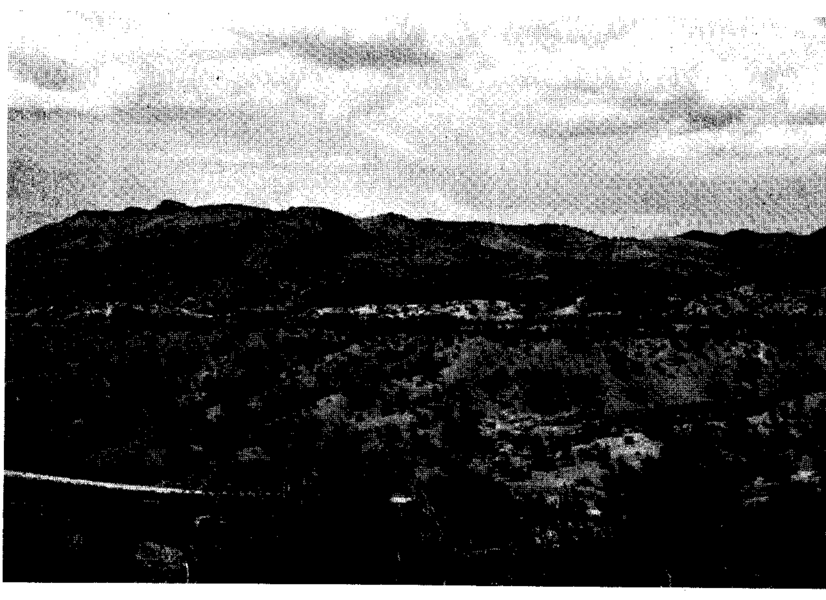


Photo 5

MANGUS FAULT SCARP AND LITTLE BURRO MOUNTAINS, LOOKING NORTHWEST FROM TYRONE

Sedimentary and volcanic rocks are dipping northeast. Beartooth Quartzite forms the caprock at left.

delimit the Knight Peak graben dropped down within Burro Mountain granite and filled with Tertiary volcanic rocks and Gila Conglomerate photo 6). The East Camp and Steeple Rock faults and a fault north of

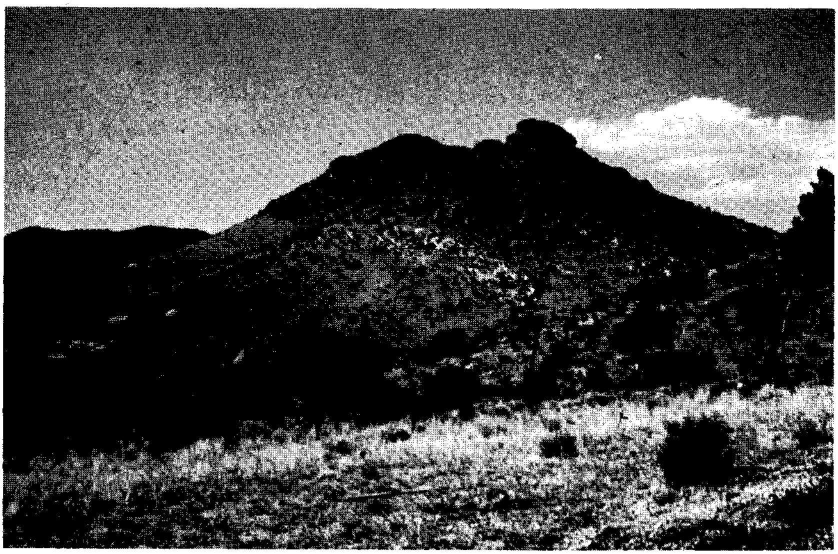


Photo 6

SCARP ALONG MALONE FAULT

Knight Peak volcanic rocks (early rhyolite) dip to northeast. Granite occupies low ground in left half of picture. Fault crosses bare area below outcrops. Dumps of Patanka mine, Malone district, at left.

Redrock are other prominent northwest-trending srtuctures. Less prominent are the Uncle Sam and Walnut Creek faults southeast and east, respectively, of White Signal, the Schoolhouse Mountain fault (which trends more nearly north) north of Bullard Peak, and numerous faults west and north of Cliff.

These faults are mostly normal faults which dip northeast and southwest at angles in excess of 60 degrees. Gila Conglomerate is exposed adjacent to the downthrown side of most of them. The faults are persistent, and many can be followed for tens of miles. Where volcanic or crystalline rocks form at least one wall of the fault, they are easily recognizable. Where Gila Conglomerate or later gravels are the surficial rocks on both sides of the fault, the easily erodable nature of these rocks obscures the fault. In some of these places the Quaternary rocks may have been involved in the faulting, but this cannot be recognized.

Northwest structural elements also include a zone of pegmatites, which stretches northwest across the eastern part of Gold Hill, and northwest-trending diabase dikes, which are particularly abundant in Gold Hill, the White Signal district, and the Big Burro Mountains.

Northeast-trending faults are most common in the Big and Little Burro mountains. In the Little Burro Mountains, all faults terminate against the Mangas fault, except for the Indian Peak fault. They appear to be tear faults related to movement along the Mangas fault and may be of different ages, corresponding to different periods of movement along the Mangas fault. Edwards (p. 43) states that displacements along the faults are mostly less than 200 feet.

In the Big Burro Mountains, the northeast-trending faults and fractures form a series of subparallel zones 10 to 100 feet wide, particularly in the area west of Tyrone. Silicification, mineralization, and dike intrusion along the faults mark their course. Some of the zones of structural weakness may have been important in localizing the intrusion of the Tyrone stock, or at least in localizing its present outcrop pattern. This is discussed further in the section on the Big Burro Mountains.

The east-northeast trending zones of structural weakness are marked by faults and by dike and plug intrusions. They are particularly prominent in the White Signal area where they dominate the structural pattern.

The Blue Jay fault, three quarters of a mile south of White Signal,

Photo 7. SADDLE MOUNTAIN AND THREE SISTERS, RHYOLITE P

can be traced for nearly five miles, almost to the Knight Peak graben. It is almost vertical at the Blue Jay mine, but no definitive measurements of the amount or direction of displacement could be made. Dikes of Late Cretaceous or Early Tertiary age or younger intruded along the fault are offset by later movement.

South of the Blue Jay fault, rhyolite plugs and dikes occupy fracture zones trending N. 65°-75° E. Most notable are the structural zone marked by the Three Sisters plugs (photo 7) and the 1000- to 2000-foot-wide zone of anastomosing rhyolite dikes south of the line of plugs. The Saddle Mountain plug lies within this zone.

Extending northward from the Blue Jay fault for at least three miles, hundreds of dikes, spaced a few feet to a few hundred feet apart and trending N. 70°-80° E., intensely fracture and traverse the country. Individual dikes are a few tens of feet to more than one mile long and are up to 150 feet wide. Rock types range from basalt to rhyolite and age from pre-Late Cretaceous to Late Tertiary. The dikes fill parallel, subparallel, and branching fractures; many occupy the same fracture zone. At least three separate periods of faulting and dike intrusion along the same zone have been recognized in numerous places in sections 11 and 14 north of White Signal and in section 13 northeast of Tullock Peak.

The Co-op–McWhorter fault in Gold Hill also trends east-northeast. No measurement of attitude or displacement could be made of this fault,

IGNED ALONG AN EAST-NORTHEAST-TRENDING ZONE OF WEAKNESS but the Co-op vein, along or adjacent to the fault, dips 40° SE. Northwest of Gold Hill the fault terminates against the Malone fault bounding the Knight Peak graben.

An east-northeast fault forms the southern edge of the area of outcrop of Burro Mountain granite northeast of Redrock.

Joints, genetically associated with the emplacement and cooling of plutonic and, to a lesser extent, shallow intrusive bodies are numerous, but no detailed studies have been made. Banding, foliation, and folding in the Precambrian metamorphic rocks have been studied in the Bullard Peak and Redrock area by Hewitt. Trends are mostly northerly, but rock outcrops are too fragmentary to formulate a regional pattern of Precambrian structure. Monoclinal folding is associated with Late Tertiary and Quaternary northwest-trending block faulting.

Mineral Deposits

Hydrothermal vein deposits, in places subjected to oxidation and supergene enrichment, constitute most of the mineral deposits in western Grant County. Two periods of hydrothermal activity are postulated, a Late Cretaceous or Early Tertiary period, which immediately followed the monzonite and quartz monzonite stock intrusions, and a Late Tertiary period, which followed the extrusion of the Tertiary volcanic rocks. The early period accounted for the base-metal deposits, dominantly copper but including also some zinc, lead, molybdenum, probably bismuth, gold, and silver. The copper deposits of the Burro Mountains and the base-metal deposits in the Steeple Rock district belong to this period. The later period accounted for fluorite, gold, manganese, uranium, and possibly silver, nickel, and cobalt. The fluorspar deposits of the area were formed during this period of mineralization, and probably much of the gold in the White Signal, Steeple Rock, and other areas was introduced then. The silver-nickel-cobalt-uranium deposits in the Bullard Peak area are also assigned to the later period.

Primary deposits mined include sulfide deposits at the Austin–Amazon mine, in the Black Hawk district, and in the Steeple Rock district and fluorspar deposits. Future mining at Tyrone will include primary sulfide ores.

Elsewhere, oxidation and supergene enrichment have been important in concentrating protore. Deposits in the oxidized zone include the gold deposits at Gold Hill, White Signal, Big Burro Mountains, Little Burro Mountains, and Steeple Rock; oxidized copper deposits of malachite, azurite, chrysocolla, and tenorite in the White Signal district and the Big Burro Mountains; turquoise; manganese oxide deposits in the Little Burro Mountains and near Redrock; and deposits of the secondary uranium phosphates in the White Signal district. Supergene-enriched deposits include the extensive chalcocite deposits at Tyrone and in adjacent areas.

Perlite, a product of late Tertiary volcanism, occurs west of Cliff within a sequence of rhyolite flows, which are part of the blanket of volcanic rocks covering the northern half of the county, and south and west of White Signal near the base of the Knight Peak volcanic series, which crop out within the Knight Peak graben. Ballmann discusses the origin of the Knight Peak perlite, but little geologic work has been done on the Wallace perlite body west of Cliff.

Diatomite occurs in the northern part of the county, about seven miles northwest of Buckhorn. It is included within a sequence of lacustrine deposits formed in a late Tertiary lake which occupied part of what is now Duck Creek valley. It has been tested by the U.S. Bureau of Mines, but no detailed study has been made of the deposit.

Ricolite and associated commodities such as asbestos and magnetite are products of metamorphism.

Economic or potentially economic concentrations of mineral commodities in western Grant County include copper, gold, silver, lead, zinc, manganese, fluorspar, turquoise, perlite, diatomite, uranium, bismuth, tungsten, ricolite, iron, nickel, cobalt, molydenum, clay, asbestos, magnesite, dimension stone, rare earths, mica, and ocher (pl 2). Copper, gold, silver, fluorspar, and turquoise are or have been of major importance. Perlite is extensive, but exploitation depends upon economic factors such as transportation and markets. Zinc, lead, and manganese have been produced in major amounts and may be of considerable importance in the future. Future exploration may prove nickel, cobalt, uranium, and diatomite to be present in important amounts. Concentrations of the remaining commodities appear to be small and of only limited commercial importance.

Descriptions

To facilitate presentation, major areas of western Grant County distinguished by geologic or topographic similarities were selected (pl. 3). The geology and mineral deposits of each area are described as a unit, followed by a description and analysis of individual deposits. These areas do not necessarily correspond to traditional mining districts, but no mineral deposit has been knowingly omitted.

BIG BURRO MOUNTAINS

The Big Burro Mountains (often referred to as simply the Burro Mountains) include the topographically high area which trends generally northwestward from the vicinity of White Signal. Low hills separate the mountains from Gold Hill to the southwest; to the northeast, the Mangas Valley lies between the Big Burro Mountains and the Little Burro Mountains. The mountains merge northwestward into the lava-covered hills north of the Redrock road and southeastward into the gravel-covered plain of the Mimbres interior basin. The mountains are dominated by three central peaks rising abruptly 1000 feet from a dissected platform which slopes gently away in all directions (photo 8).

GEOLOGY

The Big Burro Mountains consist mostly of granite and associated rocks of the Burro Mountain batholith (pl. 4). Lenses and pods of Precambrian metamorphic rocks of the Bullard Peak series are common in the northern part of the mountains and occur in a few places in the southern part. The northeastern part of the mountains is occupied by the Tyrone quartz monzonite stock. Dikes and small plugs intrude the granite complex throughout the area but are most numerous in the White Signal district in the southeastern Burro Mountains. A small outcropping of Tertiary volcanic rock overlies the granite in the north-central part of the mountains. Faults and fractures, many of them mineralized, cut the rocks.

The metamorphic rocks include schist, gneiss, amphibolite, and migmatite of the Bullard Peak series. Small lenses of schist and amphibolite occur near the Copeland shaft and the Red Hill turquoise mine in the southern part of the mountains. In the northern part, along the Redrock road, the metamorphic rocks are more abundant and are part of a large mass that extends northward into the Bullard Peak area.

Burro Mountain granite is the principal rock type in the Big Burro Mountains and is the country rock throughout the mountains except in the northeast in the area occupied by the Tyrone stock. The granite is

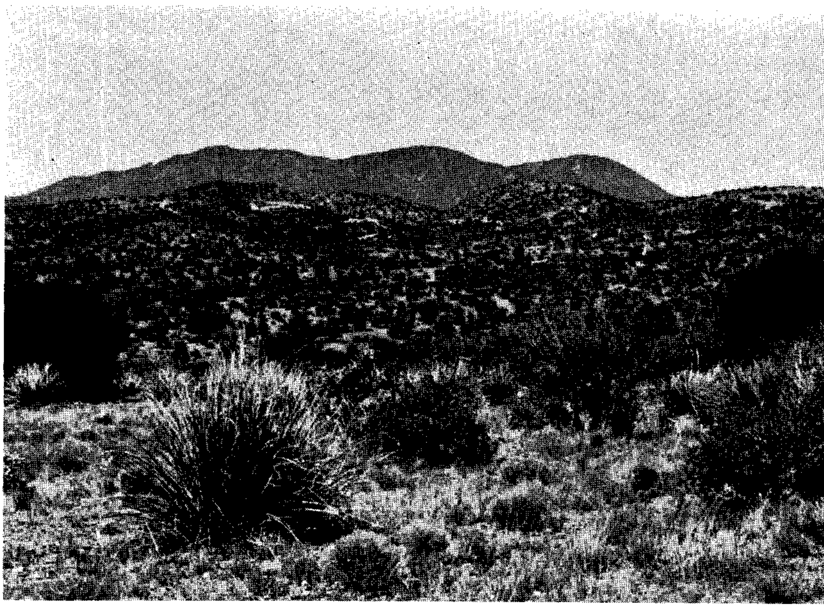


Photo 8

CENTRAL PEAKS OF THE BIG BURRO MOUNTAINS RISING ABOUT 1000 FEET ABOVE THE SURROUNDING TERRAIN

The high peaks are granite. The Tyrone copper deposit occupies the granite and quartz monzonite hills in the central part of the picture. Looking south from a point in the Little Burro Mountains just north of U.S. Highway 180.

not homogeneous but is characterized by its heterogeneity; numerous variants have been observed. Both textural and mineralogical differences are present. Fine- and coarse-grained and porphyritic and nonporphyritic varieties occur. Some granite contains orthoclase, some microcline, and some both orthoclase and microcline. The amount of alkali plagioclase feldspar varies greatly. Biotite is abundant in some varieties and essentially absent in others. The relationships between these various types is unknown, as no detailed petrographic studies have been made and there has been no attempt to unravel the complexities of the rocks of the batholith or to distinguish the various types.

A few distinct types of granite have been recognized. One of these is the Shrine granite, a coarse-grained hornblende granite which crops out along Willow Creek in the north-central Burro Mountains. It is intruded by and is distinct from the medium-grained red hornblende-free granite that is more typical of most of the Burro Mountain granite. Another type is the coarsely porphyritic variety found south of the Azure turquoise mine west of Tyrone, which contains 2-inch-long phenocrysts of both oligoclase and a potash feldspar.

Syenite and quartz diorite gneiss (tonalite) crop out in the north-central part of the mountains. The former occurs only as small localized masses, but the latter is abundant along the Redrock road. Both are intruded by Burro Mountain granite and are more abundant in the Bullard Peak district to the north.

The quartz monzonite Tyrone stock intrudes the Burro Mountain granite southwest of Tyrone. It crops out over a roughly circular area four and a half to five miles in diameter and occupies the northeastern part of the Big Burro Mountains, extending from the base of the central peaks to within a mile of Tyrone. Topographically, the stock occupies a basin surrounded by hills of a more resistant Burro Mountain granite.

Quartz monzonite porphyry and granodiorite dikes, petrographically similar to the stock rock and believed to be genetically associated with it, intrude the Burro Mountain granite and also the stock. The dikes are porphyritic, with prominent euhedral quartz and orthoclase phenocrysts. The quartz monzonite prophyry dikes are widespread in the mountains and have been used as a reference base for dating other dike rocks.

Other dikes are confined to the areas of Precambrian rocks and do not intrude the stock. White rhyolite and diabase dikes occur throughout the mountains. The unaltered diabase consists of pyroxene and plagioclase, but most dikes have been altered to iron oxide, clay, chlorite, and epidote. In the southeastern part of the mountains in the White Signal district, dikes are particularly abundant. Rhyolite, latite, quartz latite, dacite, andesite, quartz monzonite, and diabase dikes are present, and more than one period of dike intrusion has been recognized. A more detailed description of the dikes is included in the section on the White Signal district.

Small intrusive plugs of andesite and basalt intrude the Burro Mountain granite at the Shrine mine, in Pine Canyon, in the eastern Burro Mountains in sec. 10, T. 20 S., R. 15 W., and elsewhere. Rhyolite plugs intrude the granite south and east of White Signal and form prominent knolls. A plug of granite porphyry, which is fractured, silicified, and impregnated with pyrite, also intrudes the granite and forms a prominent hill in the NE¼ sec. 15, T. 20 S., R. 15 W.

The plugs all are confined to the Precambrian rocks and are believed to predate the intrusion of the Tyrone stock. Only in the White Signal area, however, is the relationship definite.

Rhyolite flows crop out on both sides of Willow Creek near the Shrine mine, over an area nearly one mile square. Two types of rhyolite were distinguished: a white, aphanitic rock and a gray and buff, ropy vesicular rock showing abundant flow structure. The rocks are similar to rhyolite of the Datil Formation which overlies the granite six miles north.

The Big Burro Mountains are a structural and topographic high bounded on the northeast and southwest by a graben and half graben, respectively. Within the horst, shearing and faulting are prominent, and the position of dikes, mineral deposits, and possibly the Tyrone stock is fracture-controlled. The bounding faults of the Big Burro Mountains horst and the marginal grabens strike north-northwest. The major faults within the mountains, however, trend northeast with few exceptions.

The four most prominent northeast faults, from northwest to southeast, are the Osmer, Bismuth–Foster–Beaumont, Austin–Amazon, and Sprouse–Copeland. Up to 100 feet wide and 2 to 4 miles or more long, they consist of innumerable parallel and en echelon fractures, intertwining dikes and segments of dikes, brecciated areas, gouge zones, silicified and argillized areas, and concentrations of minerals. The silicified zones result in topographically prominent outcrops along the trace of the faults. All are in granite, but the Austin–Amazon and Sprouse–Copeland are along or near the northwest and southeast boundaries, respectively, of the Tyrone stock. The Austin–Amazon fault dips steeply northwest, the Sprouse–Copeland steeply southeast. The Osmer fault is vertical, and the Bismuth–Foster–Beaumont is vertical or steeply dipping to the northwest but has a reverse dip near its northeastern end.

The Austin–Amazon and Sprouse–Copeland are major faults that divide the Big Burro Mountains into three distinct northeast-trending blocks. From northwest to southeast, these are designated the Willow Creek, Tyrone–Burro Peak, and White Signal blocks. The Willow Creek block is traversed by the Osmer and Bismuth–Foster–Beaumont faults and is probably a composite block.

The Tyrone–Burro Peak block appears to be a horst. The northeastern part is occupied by the Tyrone stock and is topographically low but structurally high. The southwest part consists of the topographically (and probably structurally) high central peaks of the mountains and a prominent high ridge that extends southwestward from these peaks. This block has been tilted northeastward, as excellently documented by Paige (1922, p. 33), probably after the intrusion of the Tyrone stock. The surface exposures of the stock are partly controlled by the bounding faults of the horst.

Another major fault is the Burro Chief. Although this fault also strikes northeast, it differs from those previously mentioned. It contains no dikes intruded along it; it traverses quartz monzonite; and it is not topographically prominent and, by implication, not greatly silicified. These suggest that it was formed later than the other faults. The late age is attested to by the fact that at the Burro Chief mine, Pleistocene and Late Pliocene gravels are adjacent to the fault on the northwest or hanging-wall side.

The Walnut Creek fault in the southeastern Big Burro Mountains can be traced for about four miles; it may be the northwestward continuation of the Uncle Sam fault, two miles southeast. It trends northwest and is post-Tyrone stock intrusion and displaces numerous dikes, including those of quartz monzonite porphyry related petrologically and genetically to the stock. A change in direction of the granite-stock contact and the course of Walnut Creek at about the same place is attributed to movement along this fault and displacement of the granite-stock boundary, and probably of the Sprouse–Copeland fault. The Walnut Creek fault is believed to be a Late Tertiary fault, related in time to the northwest-trending faults bounding the Big Burro Mountains horst and adjacent grabens.

The only continuous east- or east-northeast-trending faults observed in the Big Burro Mountains were the Blue Jay fault in the White Signal district, the fault at the Shrine mine, and a fault between granite and Gila Conglomerate in secs. 16, 17, and possibly 18, T. 19 S., R. 15 W. This latter fault dips north, and the conglomerate is tilted in the same direction. It forms the northern boundary of the granite and the southern or southwestern boundary of the Mangas Valley half graben at this point.

Numerous short fractures and shear zones occur within the mountains, particularly in the northeastern part of the Tyrone–Burro Peak block. They trend mostly northeast, and many are mineralized or silicified.

MINERAL DEPOSITS

Hydrothermal deposition and subsequent oxidation and supergene enrichment were the dominant processes in the formation of mineral deposits in the Big Burro Mountains. All or any of these may have been operative in a particular deposit. Many of the secondary concentrations grade downward into primary deposits. A few small and very minor deposits occur as concentrations in pegmatites or as placers; these will not be considered in this section.

Primary minerals of the deposits include chalcopyrite, bornite, pyrite, molybdenite, sphalerite, galena, native bismuth or bismuthinite, specular hematite, magnetite, gold, argentite, uraninite, fluorite, euxenite, quartz, barite, and calcite. Secondary minerals include chalcocite, covellite, chrysocolla, malachite, azurite, turquoise, cuprite, native copper, tenorite, crednerite, native silver, cerargyrite, cerrusite, bismutite, bismite, limonite and other hydrous iron oxides, autunite, torbernite, uranophane, and chalcedony. Most individual deposits include only a few of the above minerals.

Pyrite is the most widespread of the metallic minerals. It is the most abundant primary mineral in the Tyrone district, where chalcopyrite, and to a much lesser extent sphalerite and molybdenite, is found only as small grains intimately associated with the pyrite. Elsewhere, these three minerals occur as discrete masses in veins. Bornite is recorded only from the Neglected, Austin–Amazon, and Lone Pine deposits in the western and southwestern Big Burro Mountains. Other primary metallic minerals (except gold), as well as calcite, barite, and fluorite, are found at relatively few of the deposits. Secondary minerals, particularly chalcocite and the oxidized copper minerals, are abundant and widespread.

In only a few places in the Big Burro Mountains has mining progressed deeply enough to uncover primary minerals. The Neglected, Austin–Amazon, Foster zinc, probably the Apache Trail, and some of the fluorspar mines are the only places where unoxidized primary parts of the deposits were exposed, mined, or observed. Some of these were inaccessible. In the White Signal and Tyrone areas, the visible parts of all deposits are in the oxidized or supergene-enriched zones. Information on the character of the primary concentrations was deduced from study of the oxidized parts of the deposits, from study of dumps, and from incomplete data from old reports.

The primary deposits are of diverse character. Copper deposits are the most profuse, and in much of the area copper is the sole or dominant metal; elsewhere, it accompanies gold. Other deposits consist chiefly or contain important quantities of fluorspar, silver, zinc, lead, bismuth, and uranium.

Two major periods of primary epigenetic mineralization are distinguished; a Late Cretaceous or Early Tertiary period of dominantly base-metal mineralization made up of mostly copper but also iron, zinc, lead, molybdenum, probably bismuth, and some gold and silver, and a Late Tertiary period of fluoritization accompanied by the deposition of precious metals and probably uranium. No definitive date was obtained that would warrant classifying any of the epigenetic deposits earlier than Late Cretaceous, but this possibility cannot be ruled out.

The absence of exposures of primary parts of mineral deposits classified as belonging to the early period of mineralization has precluded any detailed analyses of paragenetic relationships of the ore minerals. Undoubtedly, this was not a simple period of mineralization, but instead mineralization extended over a considerable time and consisted of various phases, differing in character. This was not so true of the late period of mineralization, but here, too, there were several substages; at least three periods of fluoritization, separated by faulting and brecciation, have been identified at the Burro Chief mine.

The early period of mineralization is associated in time, and possibly genetically, with the intrusion of quartz monzonite porphyry. It is identified as being a part of the Late Cretaceous or Early Tertiary period of widespread base-metal mineralization so prevalent in Grant County and throughout southwestern New Mexico.

Filled fissures characterize the deposits, and replacement ore bodies are of minor importance. Veins are along or near prominent fault or fracture zones, but occupy only part of the zone, and are associated with silicified and brecciated areas; or they occupy fractures within a much shattered area. The metallized sections of individual veins rarely extend more than a few hundred feet in length or more than three feet in width.

In the section on structure, the mountains were described as consisting of three blocks, the Willow Creek, Tyrone–Burro Peak, and White Signal. The central Tyrone–Burro Peak block is a horst. The primary mineral deposits of the three blocks differ in character. The Tyrone–Burro Peak contains the Tyrone copper deposits, with chalcopyrite and pyrite the main minerals. The White Signal contains deposits dominantly of chalcopyrite, pyrite, and gold, and of specular hematite and gold, with some bismuth and silver minerals and galena. The Willow Creek also contains gold, chalcopyrite, pyrite, and silver and bismuth minerals with some sphalerite and galena. The Tyrone–Burro Peak block appears to represent a deeper zone of mineralization within which only pyrite and chalcopyrite were deposited in quantity, and which has been uplifted to its present position. The gold-copper and bismuth and silver and lead-zinc mineralization, with barite and calcite gangue, was emplaced at shallower depths and is preserved only in the less deeply eroded Willow Creek and White Signal blocks.

Within the Willow Creek block, the change in character of the mineralization northeastward along the Bismuth–Foster–Beaumont fault zone is of interest. Gold, bismuth, and bismite give place to sphalerite, then to molybdenite and silver, and then chalcopyrite. Zonation due to temperature is suggested except for the anomalous presence of silver with the molybdenite at the Beaumont shaft. The nature of the primary silver mineral, however, is unknown.

The late period of primary mineralization is characterized by fluoritization. Many of the deposits are within Middle to Late Tertiary volcanic rocks or are within faults that cut these rocks or Gila Conglomerate. They are presumed to be related in time to other fluorspar deposits throughout western Grant County, which are in similar rocks, and to the Late Tertiary period of precious metal mineralization described by Ferguson (1927).

The fluorspar veins are spatially close to some of the earlier deposits and are along the same or parallel faults or fractures. Nowhere, however, are any primary base-metal minerals, except pyrite, associated with the fluorspar. Gold does occur with the fluorspar at the Shrine mine, at deposits just south of the Big Burro Mountains, and elsewere. Gold and fluorspar are characteristically associated in the Mogollon district (Ferguson). At the Hines and Langford deposits south of the Big Burro Mountains, secondary uranium minerals occur with the fluorspar, and the dark purple fluorspar at the Langford deposit is radioactive, suggesting the presence of minute quantities of a primary uranium mineral intimately associated with the fluorite (Lovering, 1956, p. 354).

Gold and uranium are thus postulated as accompanying fluoritization during this late period of mineralization. Quartz, calcite, and small amounts of pyrite are the only other minerals present.

Placing the gold-uranium veins of the White Signal district into this broad framework of two major periods of mineralization is difficult. The association of gold with fluorspar, common not only in the Big Burro Mountains but elsewhere in Grant County and southwestern New Mexico, and the association of uranium with fluorite south of the Big Burro Mountains suggests that these deposits belong to the Late Tertiary period of mineralization. If so, however, the deposits were emplaced along or adjacent to fractures within which pyrite, chalcopyrite, and specular hematite had been deposited during the earlier period of mineralization.

Supergene-enriched chalcocite bodies, oxidized copper and uranium deposits, residual gold deposits in the oxidized zone, and placer deposits constitute the major mineral deposits in the Big Burro Mountains. Supergene chalcocite bodies comprise the major ore deposits in the Tyrone district and are discussed in greater detail in that section. The supergene-enriched zone is 200 to 300 feet thick but is not related to present-day topography or water table. The top of the zone is about 700 feet below the surface and below the water table near Tyrone. It slopes gradually upward to the southwest and near Leopold is within a few feet of the surface and 200 to 300 feet above the water table. The discrepancy between the present water table and the position of the enriched zone is explained by Somers as resulting solely from the greater rapidity of erosion and the subsequent lowering of the water table in higher areas than in lower ones, combined with too rapid erosion for the enriched zone to move downward in phase with the lowering water table in the higher area. Paige (1922), on the other hand, explains this partly as a tilting of the area to the northeast in relatively recent times after the formation of the supergene zone, with erosion then proceeding to wear down the higher country to the southwest faster.

Oxidized copper ore bodies are mostly chrysocolla or malachite. Azurite is less common, and tenorite, cuprite, and native copper rare. The oxidized ore bodies occur where the copper was precipitated above the water table. In most places, however, the copper content was leached from the rocks in the zone of oxidation and only limonite and silica remain. Oxidized zones are in the upper part of primary ore bodies (examples are the copper carbonate deposits at the Austin–Amazon, Apache Trail, and many places in White Signal) or in the upper part of supergene-enriched zones now above the water table (examples are the chrysocolla deposits at Copper Mountain and the chrysocolla and copper carbonate deposits at the Beaseley property, the Two-Best-in-Three, and the Ohio).

Almost all gold mined in the Big Burro Mountains has been from the oxidized parts of the veins, and only where it has been concentrated residually by the leaching of other materials is the tenor of the ore sufficient for mining. Nowhere have any of the deposits been exploited below the water table. The gold veins are mostly in the White Signal district and in the southwestern Burro Mountains.

Secondary uranium deposits consist primarily of the uranium phosphates autunite and torbernite, but an iron-uranium phosphate, uranophane, and the other oxidized uranium minerals have been identified. The deposits are in the oxidized zone and occur with gold and oxidized copper deposits. They are most numerous in the White Signal district but occur also in the southwestern Burro Mountains and in the Tyrone district. They are more fully described under the White Signal district.

Concentrations of cerussite and of native silver and cerargyrite in the zone of oxidation occur in the White Signal area and possibly in the western and southwestern Burro Mountains.

The Big Burro Mountains include a number of separate, but not always distinct, mining areas and geologic subprovinces. Five are delineated in this report: (1) Tyrone district; (2) Deadman–California Gulch–Whitewater Canyon area; (3) west Burro Mountains; (4) southwest and central Burro Mountains; and (5) White Signal district (pl. 3).

Tyrone District

The Tyrone district in the Big Burro Mountains includes the northeastern part of the mountains, bounded approximately on the south by Cherry Creek and on the west by Deadman Canyon (pl. 3). The eastern and northern limits correspond to the limits of the Big Burro Mountains. The district includes the important Tyrone copper, turquoise, and fluorspar deposits. Most of the deposits are on patented claims belonging to the Phelps Dodge Corporation. Only on the periphery of the district are there private holdings. Owners besides Phelps Dodge Corporation include Mangas Cattle Company, W. Noble, R. P. Thompson, McCauley interests, Mary Posey, Altman and Patten, Vesely, and L. L. Foster (pl. 3).

The Tyrone copper deposits are ably described by Paige (1911, 1922, 1935) and by Somers. The turquoise deposits are adequately described by Zalinski (1907), Paige (1912), and Sterrett (1908, 1909, 1911, 1912), and the fluorspar deposits by Gillerman (1952). Brief summaries and developments since these reports were published will be included here, but the reader is referred to the reports themselves for more detail.

History

Turquoise was mined by the Indians and probably by the Spaniards in the Burro Mountains prior to 1870, but modern mining history begins in 1871 when Robert and John Metcalf discovered turquoise and copper in the area. The rediscovery of turquoise in 1875 by "Turquoise John" E. Coleman marked the beginning of mining in the Burro Mountains. There is some dispute as to the original finding of turquoise, and although Coleman is generally considered the discoverer, the names of W. J. Foley and Nicholas C. Rascome are mentioned in this connection. The date (Zalinski, 1907, p. 465) is given variously as 1875 and 1879. The discovery was followed by the staking of claims and the location of numerous copper deposits within the next few years.

In 1879, the St. Louis mine was located by James Bullard, John Swisshelm, and J. W. Fleming. Copper ore was mined and shipped to Denver (Bush, 1915). The Val Verde Copper Company was organized soon afterward by Paschal R. Smith and Frank Marshall. They bought out Bullard, Swisshelm, and Fleming and built a 50-ton reverberatory furnace to smelt the ore at Paschal on Deadman Gulch. The company owned the St. Louis, Burro Chief, Boston, Copper Mountain, Marshall, and other claims. Fluorspar mined from the Burro Chief was used for flux at the smelter. The company soon folded, however, because of excess costs and the scarce supply of high-grade ore (Paige, 1922). Two years later, another company built a smelter at Oak Grove, but it also failed. Shortly thereafter, the Alessandro Copper Company was founded by Judge Deming to work claims three miles east of the St. Louis mine. A leaching operation was set up but failed. The Val Verde Copper Company and the Southwestern Copper Company merged, and although operations soon ceased because of trouble with Indians, additional discoveries were made, including the Sampson deposit found by George Sublett and Robert P. Thompson, now living in Tyrone.

In 1904, Theodore Carter interested the Leopold brothers of Chicago in the St. Louis and other mines. They organized the Burro Mountain Copper Company, took over the St. Louis, Sampson, Boston, and other properties of the Southwestern Copper Company, built a mill and a town at Leopold, and processed ore from the St. Louis, Sampson, and other mines. Shortly thereafter, the Phelps Dodge Copper Corporation obtained a third interest in the Burro Mountain Copper Company with the option of purchasing the remainder. At about the same time, the Savannah Copper Company was formed as a result of the merger of the Comanche and Copper Gulf Copper companies operating in the southeastern part of the area.

In 1906, the Briggs Oliver Development Company took over the Burro Chief group belonging to T. S. Parker and began sinking the No. 1, No. 2, and No. 3 shafts on the Burro Chief claim and in Niagara

Gulch. This became the Tyrone Development Company and later the Chemung Copper Company. The company did extensive shaft sinking, drifting, crosscutting, and blocking out of ore bodies in the northern part of the district.

By 1912, the Phelps Dodge Copper Corporation had bought out the Leopold interests in the Burro Mountain Copper Company. In 1912 and 1913, it purchased the Chemung Copper Company and had acquired the Alessandro Copper Company and the property of the Savannah Copper Company, so that by 1913 Phelps Dodge owned the entire district, except for the holdings of the Azure Mining Company in the vicinity of the turquoise deposits (which were purchased in 1959) and smaller holdings on the fringe of the main copper-bearing area. The mines were developed for large-scale operation; a 2000-ton-a-day capacity concentrator was built, a railroad was constructed to the district, and the new town of Tyrone, planned to be one of the most modern mining camps in the west, was built. The district reached its maximum importance in 1918 when it produced 17 million pounds of copper. In 1921, the mines were shut down and operations ceased, partly because of the drop in price and demand for copper and partly because of the lack of high-grade ore. The mill was dismantled, and many of the buildings of the town, which in 1920 supported a population in excess of 5000, were torn down or moved.

Shortly after 1921, leaching operations were started on some of the larger dumps and continued until 1929. In the late 1930's, leaching operations on the dumps were again inaugurated, and underground leaching in some of the old stopes was begun in 1941. This continued intermittently until about 1950. Between 1941 and 1950, 30 million pounds of copper were produced by leaching. In 1950, an intensive drilling program was started which lasted until 1959. The district is again dormant, awaiting favorable economic conditions.

Since 1880, fluorspar and turquoise mining have also progressed. After the early mining of fluorspar at the Burro Chief mine for use as flux at the smelters at Paschal and Oak Grove, operations ceased until about 1913 when the Phelps Dodge Corporation acquired the property. Subsequently, intermittent mining by lessees until 1937 and essentially continuous mining by lessees and by the Phelps Dodge Corporation itself was terminated in 1950 when the Phelps Dodge Corporation closed the mine because of interference with the drilling program and because of the large amounts of water in the lower levels.

The turquoise deposits located by Coleman were acquired in 1882 by M. W. Porterfield and T. S. Parker, who organized the Occidental and Oriental Turquoise Mining Company. In 1901, this became the Gem Turquoise and Copper Company; a few years later, the American Gem and Turquoise Company was the owner of the property, which since has been known as the Parker mine. Considerable mining and development was done on this deposit and also at the site of the old Indian workings nearby. Additional claims and discoveries were made after Coleman found the Parker mine. These were acquired by the Azure Mining Company, organized in 1891 by C. Armeny of New York. Controlling interest was held by New York jewelry firms, chiefly L. and M. Kahn and Company and M. Rothschild. In 1893, F. Vogel, superintendent of the Azure Mining Company, opened the "Elizabeth pocket," one of the most productive turquoise deposits in the country, containing turquoise which was equal to the finest Persian material.

Operations continued at the Azure, Parker, and other properties through 1905 or 1906, with small operations for a few years after that date. Since about 1911, virtually no turquoise has been mined in the Burro Mountains. In 1959, Phelps Dodge acquired the property of the Azure Mining Company, having already acquired the property of the American Gem and Turquoise Company.

Tyrone Copper

The copper deposits of the Tyrone district are the premier mineral deposits of western Grant County. They have furnished the great bulk of the mineral products in the past, and the potential for the future is equally encouraging. These deposits have been fully described by Paige (1922), Somers, Reid, Lang, Wade, Stauber (1910), Bush (1914, 1915), and others. The district was in full production when Paige and Somers made their studies but was shut down shortly thereafter. Most of the workings have been inaccessible since the early 1920's, and details of geology could not be examined during the course of this study. An examination of the surface geology and of old records, however, substantiates the earlier work. Recent developments indicate that a treatment of the area as a whole, rather than the separate study and description of each ore body, may be of value. Accordingly, the Tyrone copper area is here considered as a single large deposit and is described from this viewpoint.

As herein used, the term *Tyrone copper deposit* includes those deposits occupying a roughly circular area two to three miles in diameter. Tyrone is on the northern edge of the district. Most of the area is controlled by the Phelps Dodge Corporation, but various other owners hold claims on the margins of the area contiguous to the Phelps Dodge holdings (pl. 5). The central area includes all the major deposits previously mined and has the greatest potential.

Mining has been confined in the past to the high-grade areas of chalcocite mineralization, averaging 2 to 3 per cent copper or better. After 1921, when the district was virtually closed down, leaching of some of the areas of lesser grade was profitable. Prior to 1920, much of the area had been explored by drilling, but in 1949, Phelps Dodge Corporation inaugurated an extensive systematic drilling program covering an area approximately 8400 feet east to west by 9400 feet north to south, with churn drill holes every 200 feet along the grid lines. The holes range to about 1000 feet in depth.

The Tyrone deposits occur within both the Burro Mountain granite and the Tyrone quartz monzonite stock. Both rocks are equally susceptible to mineralization. Variants of the stock, such as granodiorite, monzonite, high plagioclase quartz monzonite, and others, are also equally mineralized. Surficial indications of copper mineralization are most intense in a wedge-shaped area bounded on the northwest by the Burro Chief fault, on the south by an indefinite boundary approximately along the south line of secs. 26, 27, and 28, and on the northeast by gravels. Fluorspar occurs on the edge of the area, within the Burro Chief fault; turquoise is plentiful to the northwest, across the Burro Chief fault, but small deposits have been found within the limits of the copper ore body.

Primary minerals are pyrite, chalcopyrite, sphalerite, molybdenite, quartz, and fluorite. Pyrite is the dominant primary mineral and, with quartz, makes up most of the original vein and replacement material. Chalcopyrite occurs as blebs and specks within pyrite and quartz. Sphalerite and molybdenite, both rare, also occur as minute specks.

Chalcocite occurs in the supergene zone and is the most important ore mineral. Both massive and sooty chalcocite are present.

In the oxidized zone, chrysocolla is the most abundant copper mineral. It is widespread and in places forms discrete veins. Locally, it is stained dark brown to black by manganese or is mixed with chalcedony. Malachite, azurite, cuprite, native copper, turquoise, and probably tenorite are also present. Limonite, hematite, and jarosite are common, and the presence of torbernite is suspected because of radioactivity recorded from some drill holes. Sericite, quartz, chlorite, epidote, and kaolinite are common alteration products in the country rock.

The ore minerals occur in fractures and also as disseminations in the country rock adjacent to the fractures. The primary suphides fill fractures and impregnate the adjacent country rock, filling minute open spaces and replacing the original minerals of the rock, mostly feldspar. The fracture fillings range up to one foot in width, although most are merely a fraction of an inch wide. Where fracturing is abundant and close-spaced, the rock is more or less impregnated from one fracture to another. Inasmuch as secondary sulphides occupy essentially the same fractures and areas of disseminated country rock as primary sulphides, the tenor of the chalcocite enrichment is largely dependent upon the spacing and abundance of fractures.

According to Somers (p. 622), the larger and more persistent fractures are usually straight, parallel to one another over small areas, a few inches to a few feet apart, and dip steeply. Single fractures or a zone of close-spaced fractures can be traced about 100 feet and are most common along the sides of the wedge-shaped area. In the central part of the wedge, the fractures are less persistent and more irregular in trend. Numerous cross fractures are present, and most of the fracture fillings are thinner. Somers also states that the larger fractures converge toward an imaginary point about two miles south of Leopold and that, in general, fractures in the western half dip east and southeast; those in the southern part dip north. From these and other data, Somers deduced that the fractures represent small displacements of contemporaneous age and might be explained by the subsidence and collapse of the pie-shaped block because of the withdrawal of magma from beneath it.

Paige (1922, p. 16), on the other hand, states that the fracturing is directly connected with faulting. Fracturing is most intense along the northwest side of the area, and the change from intensely fractured rock to that which is much less shattered is abrupt on the northwest side. This boundary is marked by the Burro Chief fault, along which there has been notable movement, at least in the vicinity of the fracture area. On the southeast side of the fracture area, the change from much to less intense fracturing is more gradual and is not marked by any pronounced structural feature. Paige believed that the fracturing could be regarded as distributive faulting, with movement taken up by numerous small slips rather than by a few major breaks. Although the fracture zones follow particular trends, individual fractures within the zones are discontinuous and curved, have no consistent strike, and split and join again; in general, the pattern is that of an anastomosing system.

Data on the distribution of fractures, obtained from the recent extensive drilling program, show that abundant fractures are present in the crystalline rocks beneath the gravel cover, northeast of their surface exposures. Thus, the description of the area of intense fracturing as a triangle is no longer desirable. A better description is that it includes that section of the northern part of the Tyrone–Burro Peak block that lies southeast of the Burro Chief fault. As such, it is a polygon bounded on the northwest by the Burro Chief fault and on the southeast by the projection of the Sprouse–Copeland fault, which is along or near the boundary of the stock. The southern boundary is gradational, and the northeastern obscured by gravel.

Studies of ore distribution from the recent drilling data show four or five definite northeast trends within the fracture area. These parallel the Burro Chief fault and are zones of relatively higher-grade ore that are separated by barren areas. They are also zones of closely spaced fractures, mostly in a direction parallel to the elongation of the zone. They have been designated the Sampson, Bison–Thistle, Niagara–Mohawk, Copper Gulf–Rocket–Virginia–Klondike, and Gettysburg–Oquaque–Boone trends (pl. 3).

These trends are interpreted as representing the principal zones of weakness within the fracture area, along which most of the shattering, fracturing, and adjustments took place, and which later were the loci of mineralization. The close spacing of the zones resulted in the shattering and fracturing of the entire block between the Burro Chief fault and the southeast boundary of the block. Fracturing, and mineralization, is most intense along the axes, with areas of few fractures, and consequently little mineralization, existing between.

In his discussion of the Burro Chief fault, Paige shows that topographical evidence indicates that the southwest end of the fault is downthrown on the northwest side. Geologic evidence along the northeast end of the fault indicates that in this area the northwest side is upthrown. Paige therefore proposes that this is a hinge fault with the hinge point at about the southern limit or apex of the fracture area. This hinge type of movement may be postulated for the entire block southeast of the fault, the hinge line of the block being at about the southern limit of the fracture area. The intense fracturing northeast of the hinge line could be caused by differential settling and movement of the block with major breaks and most intense fracturing along the Sampson, Bison–Thistle, Niagara–Mohawk, Copper Gulf–Rocket–Virginia–Klondike, and Gettysburg–Oquaque–Boone axes, with only minor shattering between.

The chalcocite enrichment that constitutes the bulk of the economic deposits at Tyrone is a result of supergene enrichment of the primary sulphides, with a history of oxidation, weathering, and leaching complicated by probable tilting of the land surface. Chalcocite is disseminated in the country rock and is concentrated in veins or shear zones. In the past, the richer concentrations, mostly along shear zones, were mined, but a chalcocite blanket of varying grade and thickness extends over most of the fracture area. Its irregular thickness is 200 to 300 feet. Its depth below the surface ranges greatly, but in general the blanket slopes northeast at about 5 degrees, greater than the slope of the land surface. Chalcocite occurs within a few feet of the surface at the Sampson shaft, but two miles to the northeast, at the Mohawk shaft, it is about 500 feet below the shaft collar, a drop in elevation in this distance of nearly 700 feet.

The chalcocite grades downward into primary sulphides, the lower boundary of enrichment being very irregular. Above, it is overlain by an oxidized zone which either is barren or contains copper carbonates, chrysocolla, or other oxidized minerals. Where it is above the water table, the chalcocite is being oxidized. This is most apparent in the southern part of the district. The top of the chalcocite zone does not correspond to the present water table. Instead, there is a wide discrepancy, the top of the enriched zone being tilted northeastward relative to the present water table, which closely follows the present land surface. To the southwest, the top of the chalcocite zone is more than 500 feet above the water table; to the northeast, in the vicinity of the Mohawk shaft, the two correspond or the water table is slightly lower.

This divergence of the water table and the top of the sulphide zone has been variously explained as due to tilting of the land northeastward coincident with Pleistocene faulting along the Mangas fault (Paige, 1922, p. 33) or to the differential rate of erosion due to differences in elevation (Somers, p. 635). The evidence of faulting along both the Mangas and Burro Chief faults in Late Pliocene or Pleistocene times is incontrovertible (Gillerman, 1953; Edwards). Pliocene and possibly Pleistocene gravels are involved in the faulting. This effectively tilted the Tyrone area northeastward and, with subsequent erosion, could well be the cause for the present position of the chalcocite zone relative to the present water table. Somers' theory, however, is quite logical and may also have been operative, so that the present relative positions of water table and sulphide zone may be a combination of both factors. The faulting in Pliocene or Pleistocene time along the Burro Chief and Mangas faults was merely the latest of movements along these zones. Repeated movement along the Burro Chief fault is indicated by two stages of brecciation and later recementation of the fluorspar filling and by numerous subparallel faults comprising the zone.

The presence of uranium within the Tyrone district was first suspected in 1951 when churn drill holes sunk by Phelps Dodge were logged with a gamma ray radiometric logging device by the U.S. Geological Survey in connection with studies of uranium in the White Signal district to the south (Raup, 1953). Numerous holes showed traces of radioactivity, and although no uranium minerals were identified, the presence of torbernite in the oxidized zone is suspected.

Turquoise Deposits

Turquoise was mined near Tyrone between 1890 and 1910. Since then little, if any, has been produced. At the time of operation, the deposits were among the largest in the United States, and the turquoise produced, especially from the "Elizabeth pocket," was of excellent quality, comparing favorably with the finest Persian turquoise. The Azure mine, in the NE¼ sec. 15, T. 19 S., R. 15 W., 3300 feet N. 30° E. of the Burro Chief shaft, was the major producer. (This is not shown as a turquoise mine on the U.S. Geological Survey topographic map of the Wind Mountain quadrangle, which mistakenly indicates as a turquoise mine some old copper shafts half a mile slightly south of west of the Azure mine.) The Parker mine, 2000 feet southeast of the Azure, is on the site of Coleman's original discovery of turquoise in old pits. Prehistoric Indian diggings are near the Parker mine and also on the Azure property at the New Azure mine, 500 feet east of the major Azure workings. The Porterfield mine (presumably the Maroney deposit of Zalinski) is about half a mile south of the Azure on the west side of St. Louis Canyon and the Tyrone–Leopold road, southwest or west of the Burro Chief mine. Other noncommercial occurrences of turquoise are at the Burro Chief mine and elsewhere in the vicinity.

The turquoise occurs in granite and in quartz monzonite porphyry. The rock in the vicinity of the deposits is much altered. The feldspars are kaolinized and sericitized, and quartz is deposited in seams and fractures in the rock and in the interstices between the grains. Limonite stains the feldspars.

The turquoise occurs in veins and veinlets and as nodular masses, in wide, fractured zones in the altered rock. It is in the upper oxidized zone of weathering and is associated with malachite, chrysocolla, tenorite and other oxidized copper minerals, and with halloysite(?).

A number of excellent papers were published during or shortly after the period of maximum operation of the deposits (Zalinski, 1907, 1908; Sterrett, 1908, 1911; Paige, 1912). Zalinski (1907, p. 487) suggested that the turquoise was formed when copper-bearing solutions, rising along northwest-dipping fractures, came into contact with phosphatic solutions moving along southeast-dipping fractures. The phosphate and alumina were derived from the decomposition of apatite and feldspar in the granite. The copper was derived from the same source as copper elsewhere in the Burro Mountains and was part of the widespread phase of copper mineralization.

Paige (1912, p. 382) differed with the theory as to origin of the turquoise. He believed in a secondary, supergene origin of the deposits as opposed to Zalinski's primary hypogene origin. Paige derived the copper from the oxidation of copper minerals already emplaced and the phosphate from the decomposition of apatite by sulphate solutions derived from the oxidation of pyrite. The turquoise formed in the zone of weathering by the interaction of the copper-bearing and phosphate-bearing solutions.

Azure mine. The Azure mine was the largest producer of turquoise and is quoted by Zalinski (1907) as having produced several million dollars worth of fine stone. The mine was originally worked by four adit levels, but the area above the second level was excavated to the surface, so that the mine consists of a large open pit, 500 to 600 feet long, 100 to 200 feet wide, and 50 to 60 feet deep, with caved and inaccessible underground workings below the bottom of the pit. The pit trends northeast and occupies a small side draw on the east side of Azure Canyon. The New Azure mine, 500 feet east and across the road from the main pit, originally consisted of an adit, at least 260 feet long, connected by raises to an upper level and to surface workings. Much of this is now caved and a large open pit occupies part of the workings. Old Indian workings, consisting of tunnels and openings filled with rubbish, were exposed in the upper parts of the mine.

The turquoise is within a wide, fractured zone in granite, which at the mine is a medium-grained, slightly porphyritic rock, typical of much of the granite in the Burro Mountains. Less than half a mile southwest, at the Copper King mine, which is along the same fracture system as the New Azure workings, the granite is coarsely porphyritic, with large orthoclase and oligoclase phenocrysts up to two inches long. The fracture zone or "vein" at the Azure mine strikes N. 55°-60° E. and dips 45° SE. The vein is 40 to 60 feet wide with distinct hanging and footwalls. Between the walls, the material is mostly sheared and altered granite with streaks and blebs of kaolinite and secondary silica. The turquoise occurs within, and is confined to, the "vein."

The following description of the Azure deposit is from Sterrett (1908, p. 829):

> Turquoise occurs as veins and veinlets filling the joints and fissures in the rock and as nuggets. In places these veinlets are mere films, and in others they are as much as three fourths of an inch thick. Part of the turquoise is found in groups of small rounded masses resembling nuggets, fitted roughly together though separated from one another by kaolin or clay and enveloped in it. These groups of nuggets generally fill a flattened lenticular-shaped pocket in one of the veinlets. The best turquoise came from a portion of the vein known as the "Elizabeth pocket," which extends from the second level to the surface, a height of 40 to 60 feet, and may include a width of 40 feet and a length along the vein of 150 feet. The vein rock near this pocket is cut by an unusually large number of quartz seams and veinlets up to half an inch wide. These contain crystal-lined cavities in places, and veins of turquoise sometimes contain quartz crystals penetrating them. The quartz veinlets sometimes give place to turquoise veinlets or include patches of turquoise. Where portions of the rock are less altered and pink feldspars occur, turquoise of a bright blue color is found. Turquoise veinlets of different shades of color are found crossing each other, indicating different periods of deposition and different sources of material.
>
> Good turquoise was found at places in the vein other than in the Elizabeth pocket. To the northeast of this pocket, much of the turquoise had a greenish cast, while still farther along a good blue variety was more plentiful. To the northeast of the open cut in a drift several hundred feet long, the Azure mine did not yield much turquoise of good color. To the southwest of the open cut, the vein is readily traced for several hundred yards up Morrill's Canyon. It contains very little turquoise, however, but has proved to carry rich copper ores. Mr. William R. Wade, who has directed the openings on this vein for copper, reports that a little turquoise was found in the Copper King mine at a depth of 410 feet. In the workings at the Azure mine, the best turquoise was found at depths of less than 100 feet. Pyrite or sulphides were not observed associated with the turquoise, though the walls are covered red with hematite in places. Where the feldspars of the rock have been most extensively kaolinized, turquoise is found mostly in nugget form. In less altered rock, hard vein turquoise is found, and both varieties are found in moderately altered rock.

Referring to the New Azure mine, Sterrett states (1908, p. 846),

> Mr. Wade states that the deposit was worked by the Aztecs down to the present first level. The workings are so old that they are seen only when encountered in drifts and crosscuts. The ancients evidently filled in the openings and the filling has become so hardened that it is often easier to remove it by blasting. Numerous stone implements and fragments of charcoal are found in these old workings.

Parker mine. The Parker mine is 2000 feet southeast of the Azure mine. In 1907, it was owned by the American Gem and Turquoise Company. It was the first turquoise mine developed in the district and was the site of Coleman's original discovery. Formerly, it had been operated by Parker and Porterfield under the name of the Occidental and Oriental Turquoise Mining Company and later the Gem Turquoise and Copper Company. Two large open cuts constituted the main workings. The northernmost cut was 300 feet long and 10 to 25 feet deep. The cut farthest south had a maximum depth of 50 feet and was about 100 feet across. About 500 feet northwest of the Parker mine were some old Indian workings. Near these the American Gem and Turquoise Company had driven two adits each 50 to 60 feet long. Production from this property is unrecorded, but the turquoise was said to be of the same high grade as much of that elsewhere in the Burro Mountains (Sterrett, 1908).

The contact between the granite and the quartz monzonite porphyry runs through the southernmost cut at the Parker mine. The other workings are mostly in quartz monzonite porphyry, but the prehistoric Indian workings are in granite. Turquoise occurs in films, seams, nuggets, and irregular masses in sheared and altered country rock. The most prominent seam in the northernmost open cut was two to six inches thick but contained turquoise too soft and of too poor a color to yield good stones. The fractures and veins trend generally northeast and dip southeast.

Porterfield mine. The Porterfield mine is described by Sterrett (1908) as being on the west side of St. Louis Canyon near the mouth of a small gully. It is probably the same deposit described by Zalinski (1907) as Maroney's prospect, which he stated lay near the Silver City road northeast of Leopold. This would put it in St. Louis Canyon. Sterrett describes workings at the mine as consisting of two shafts 40 to 50 feet deep, a tunnel nearly 170 feet long, and some small open cuts and pits. These are now all inaccessible.

Choice turquoise of deep robin's-egg blue to pale shades of blue that would yield one-color gems up to 20 to 30 carats are reported to have been obtained from the mine. Much mottled turquoise and matrix also was present.

Granite, some of it coarsely porphyritic and similar to the granite occurring at the Copper King mine, is the country rock. The granite is sheared, kaolinized, and silicified. Turquoise occurred in seams trending in "various directions" in a belt about 300 feet wide and more than 600 feet long trending "east of north" (Sterrett, 1908). The most prominent fractures and joints in the zone trend northeast. The turquoise was in seams, veinlets, lenses, and groups of nodules or nuggets in lens-shaped masses. White clay coats the nuggets and in places forms a major part of the filling in the seams. Hematite, quartz, limonite, opal, chalcedony, and nuggets of waxy green halloysite were associated with the turquoise.

Burro Chief Fluorspar

The Burro Chief fluorspar deposit is one and a half miles southwest of Tyrone in the SE¼ sec. 15, T. 19 S., R. 15 W. It is owned by Phelps Dodge Corporation. The deposit was first worked in the 1880's, the fluorspar being used for flux in copper smelting, and was worked intermittently from about 1913 to 1937. From 1937 to about 1950, the mine was worked almost continuously by various lessees and by the Phelps Dodge Corporation. It was closed because operations interfered with the extensive drilling program then being undertaken by Phelps Dodge Corporation.

Workings consist of a 700-foot-deep vertical shaft with levels at 260, 400, 500, and 600 feet, an adit, and some open cuts. Stoping is extensive, particularly above the 260-foot level, and some stopes are open to the surface. A total of more than 100,000 tons of fluorspar averaging more than 60 per cent fluorite has been shipped from the property.

The deposit is described in detail in an earlier report (Gillerman, 1952) with maps of surface and underground workings; hence, only a brief summary is given here.

Fluorspar occurs in a wide breccia zone on the footwall side of the north-northeast-trending Burro Chief fault. The ore zone is 10 to 100 feet wide, with individual ore shoots as much as 35 feet wide and more than 400 feet long. The zone dips 75° SE and plunges 50° SW. Individual ore shoots also plunge southwest. The footwall side of the zone is marked by numerous echelon faults. The deposit is in granite and in quartz monzonite porphyry, both of which are intensely sericitized and silicified.

Individual ore shoots occur as veins of almost pure fluorite and as breccia ore bodies of mostly lower-grade material. Small amounts of quartz, calcite, clay minerals, iron oxide, and manganese oxides are associated with the fluorite. In a few places in the mine, turquoise, chrysocolla, and copper carbonates are present.

The Burro Chief is the major fluorspar deposit in Grant County and probably in southwestern New Mexico. It has been opened to 800 feet below the surface outcrop, and there is no change in character of the mineralization or tenor of the ore except that the soft, clayey, brecciated ore of the upper levels is more compact at depth. The width of the vein on the 600-foot level is more than 50 feet, and the structure looks as strong if not stronger than on the upper levels. Water is a problem on these lower levels, as it stands at just under 400 feet in the shaft if pumps are not used.

Copper Mountain–Liberty Bell

The Liberty Bell mine is on a patented claim owned by R. P. Thompson, Tyrone. Copper Mountain is part of the Phelps Dodge holdings. The claims are in the N½ sec. 28 and SE¼ sec. 21, T. 19 S., R. 15 W., east of Deadman Canyon and about three fourths of a mile west of the old town of Leopold (pl. 3). This deposit is described separately from the Tyrone copper because in many respects it is a discrete deposit and is not a part of the main copper body.

Copper Mountain was first worked in the 1880's by the Southwest Copper Company, which had a smelter where the present main road crosses Deadman Canyon. The slag pile remaining from the smelter can still be seen. Little work was done after the early mining had ceased. A large open cut, stopes partly open to the surface, adits, and probably additional underground workings are present.

The Liberty Bell, too, was worked in the early days. After Thompson acquired the property, it was worked intermittently by Thompson and various lessees. In recent years, leaching operations were tried but proved unsuccessful. A 100-foot-long adit with a winze inclined 47 degrees downward for 100 feet constitutes the main workings. Drifts and crosscuts extend from the bottom of the winze and a short drift and stope are present at 44 feet on the incline. An old winze, now caved and filled, extends downward on the vein a reported 60 feet (R. P. Thompson, oral communication). This is connected to the surface by a partly filled caved stope and open cut lying above the adit. Smaller workings are present on both claims (fig. 2).

Both Copper Mountain and the Liberty Bell are along the Burro Chief fault which strikes N. 50°-55° E. and dips 40° to 60° SE. Quartz monzonite porphyry is the country rock. The quartz monzonite porphyry is intensely sericitized, kaolinized, and silicified, and quartz is the only original mineral that can be recognized. The rock is fractured along the fault. Fracturing is most intense on the northwest side where the shattered zone is about 50 feet wide and the fractures are closely spaced. On the southeast side, the fractures are wider spaced and the rock is not so intensely altered. Nearly parallel faults are present on both sides of the main slip. Those to the southeast are more persistent and definitive, whereas on the northwest side where the rock is more brecciated and shattered, there are fewer continuous faults.

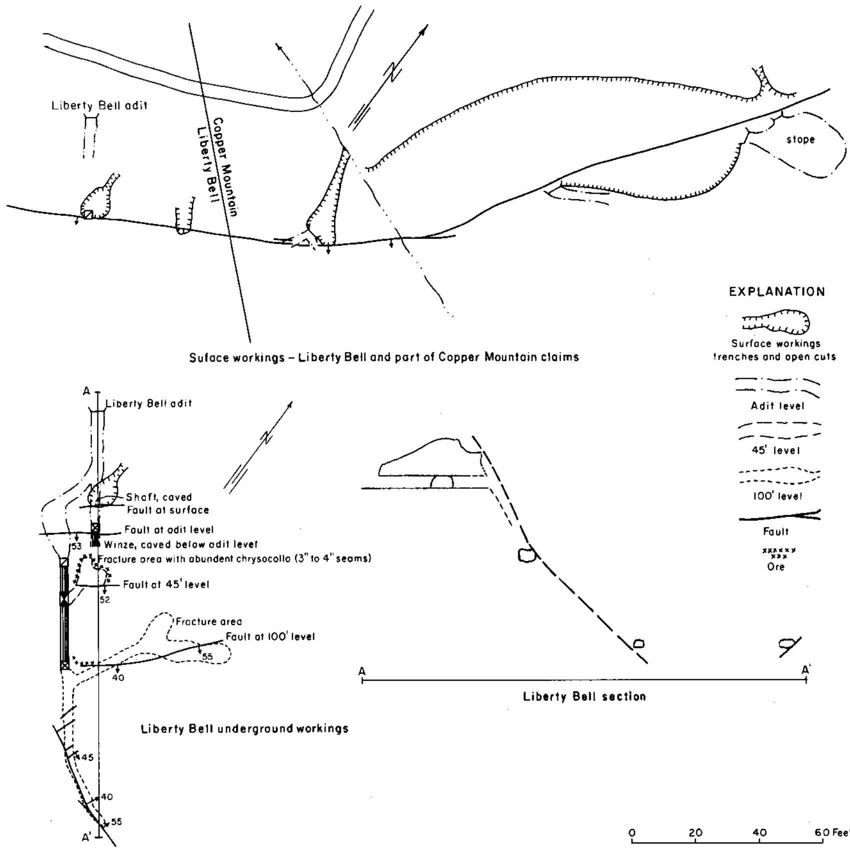


Figure 2

Liberty Bell and Copper Mountain deposits, surface and underground workings, Tyrone area, Big Burro Mountains

Chrysocolla is abundant as veins, stringers, and coatings along fractures. Manganese oxide stains some of the chrysocolla black in some places. Azurite is present in small amounts. No sulphides were observed, but Thompson reports that chalcocite was mined at the Liberty Bell.

At the Liberty Bell, chrysocolla and carbonates fill seams and fractures on the footwall side of the fault in a zone exceeding six feet in width. Little ore is present southeast of the fault. Pods and veins of chrysocolla up to six inches wide are present on the 44-foot level in the winze.

At Copper Mountain, chrysocolla permeates the rock for nearly 100 feet northwest of the fault, and the mineralized area extends for more than 500 feet along the strike of the fault, up the side of the mountain. Surficial showings and staining give the impression of a great copper ore body. Seven drill holes, 210 to 176 feet deep, were put down in 1961 (L. L. Osmer, Jr., oral communication). Three were near the top of the mountain, the others near the base. Their exact positions relative to the fault are not known. Assay results from the first hole drilled showed an average of about 1.0 per cent copper. The sludge averaged 1.2 per cent copper. The results for the other holes are not available. There appeared to be no change of mineralogy or character of the host rock with depth in any of the holes. The ore body was believed to be of too low a grade for the proposed leaching operations, and the program was discontinued.

Emma and Surprise Claims

The Emma and Surprise claims, owned by Phelps Dodge Corporation, are in the NW¼ sec. 36 and SW¼ sec. 25, T. 19 S., R. 15 W. on the southeastern fringe of the Tyrone copper district (pl. 3). Because of recent activity on the claims, and more especially because of the character of the mineralization on the Surprise claim, these deposits are described separately from the Tyrone ore body.

In 1960, the Phelps Dodge Corporation leased the Emma claim to Ira L. Wright, Ray E. Holmquist, and Jack Evans. Evans sank a 15-foot-deep shaft on the site of an old prospect and drove an adit which terminated at the bottom of the shaft. The vein in the shaft and adit strikes N. 50° E. and dips 60° NW. The country rock is granite. A 200-foot-deep shaft, caved and inaccessible but with abundant pyrite on the dump, is about 200 feet northeast on the Surprise claim.

In the Emma workings, chrysocolla is the most abundant copper mineral. Small amounts of malachite, azurite, cuprite, possibly tenorite, and chalcocite were observed. The chrysocolla occurs as a vein up to three inches wide along a prominent fracture and as seams and veinlets that permeate the granite in a fracture zone up to four feet wide on the footwall side of the main vein. The chalcocite observed was associated with the chrysocolla.

Ten tons of ore containing 7.31 per cent copper were shipped in August 1960. The ore was all hand-picked and sorted and consisted almost entirely of chrysocolla. Much of it could have been sold for specimen material. Operations ceased shortly thereafter, partly because of the death of Mr. Wright.

North of the old Surprise shaft, copper-bearing conglomerate crops out for more than 200 feet along the strike, across a minimum width of 50 feet and through a vertical distance of at least 20 feet. A trench bulldozed along the outcrop exposed it for more than 300 feet. It seems to dip east, but the amount of dip, if any, could not be ascertained. Copper minerals present include chrysocolla, malachite, possibly tenorite, and crednerite. The material greatly resembles the copper-bearing conglomerate on the Southern Star group of claims in Deadman Canyon and California Gulch west of Tyrone. An assay showed 4.4 per cent copper.

The conglomerate consists of well-rounded fragments, some six inches or more in diameter, of country rock and specular hematite set in a matrix of coarse sand and small pebbles cemented by malachite, crednerite, and chrysocolla.

Large tonnages of conglomerate seem to be present. Mining and access to these deposits is easy. If the copper content is comparable over considerable thickness and area to the sample assayed, a commercial ore body may exist. Both the Surprise and the Southern Star deposits should be systematically sampled and tested.

Deadman–California Gulch–Whitewater Canyon Area

The Deadman–California Gulch–Whitewater Canyon area comprises most of the deposits in secs. 16, 17, 18, 19, 20, and 21, T. 19 S., R. 15 W. west of Tyrone (pl. 3). It excludes the Phelps Dodge holdings and includes all the properties west of them. Many of the area deposits were mined for copper prior to 1900 and shortly thereafter but have been idle for years.

The deposits lie within the Tyrone–Burro Peak upthrown block already described and are in granite. In addition to the major deposits noted below, other small deposits are present throughout the area. All are similar in that they consist of fracture fillings in granite, generally trending northeastward, in zones of intense shearing. Ore minerals are copper carbonates or silicates, with sulphides in places where erosion has not lowered the water table sufficiently to oxidize the sulphide ore bodies. The possibility of more extensively oxidized, supergene, or primary ore bodies than exist at the surface cannot be discounted, and the area should be adequately tested. The localization of the major ore bodies along distinct faults and shear zones should facilitate exploration. The vicinity of the Two-Best-in-Three and the Thompson claims is particularly recommended as worthy of further consideration.

Beaseley property. The Beaseley property is a group of fourteen unpatented claims, in the N½ sec. 18 and S½ sec. 7, T. 19 S., R. 15 W. (pl. 4). They were owned in 1960 by the Western Exploration Development Company (Harry J. Harris, president, Melrose Park, Illinois). Mr. Joseph E. Hodges, Silver City, was interested in the claims. Two old shafts and a number of pits existed on the property prior to its acquisition by the present owners, who sank a new shaft and did some trenching in 1956.

This mine is referred to by Paige (1911) as the Knucky and Cosgrove property. The two old shafts are the National (not to be confused with the National Copper Company referred to later) in the center of the Shamrock No. 6 claim in the eastern part of the property and the Mayflower on the Buster No. 10 claim 2000 feet farther west. According to Paige, the National shaft is 180 feet deep. It is vertical for the first 55 feet and then inclined 60° SE. The Mayflower shaft is 112 feet deep.

The shaft sunk in 1956, called the Beaseley, is on the end line between the Shamrock No. 3 and No. 6 claims, about 500 feet southwest of the National shaft. In 1960, it was 50 feet deep. A 100-foot-long open cut, 15 feet wide and 12 to 15 feet deep, is 500 feet south of the shaft.

Paige reported that the upper part of the National shaft followed no distinct fracture, but below 55 feet, it followed a fracture striking N. 70° E. and dipping 60° S. The upper 90 feet of the shaft was in oxidized material, and scattered copper carbonate was in vertical fractures. The lower 90 feet was below the zone of oxidation and showed pyrite and a narrow seam of chalcocite, an inch or less in thickness, along the slip. The granite country rock was fractured.

The Mayflower shaft encountered unoxidized sulphides at 100 feet. Pyrite and copper carbonates occur on the dump. The granite country rock is impregnated with sulphides, the feldspars are sericitized, and secondary quartz has been introduced.

At the new shaft, the vein trends N. 70° E. and is vertical to 80° SE. The granite host rock is fractured. Azurite is abundant on the dump. Chalcocite is rare. The open cut trends S. 85° W. and is probably along an indistinct vein or zone of fracturing.

No records of shipment are extant from the old workings. The present owners shipped one carload of ore in 1956 which averaged 9 per cent copper. The ore on the pile remaining at the shaft does not appear to be that high a grade.

In 1911, Paige stated that the examination of the Mayflower shaft gave no encouragement that an ore body would be found at depth. Nor did he appear to be enthusiastic about the showings at the National shaft. The granite is fractured and altered, and copper carbonate, particularly azurite, is plentiful in some of the seams, but no strong and persistent vein is apparent.

The Mayflower shaft is most probably along a continuation of the Beaumont vein or mineralized zone, and as such is along the extension of the same structure as the Bismuth Lode and the Foster zinc mine, two and a half to three miles to the southwest. The National and Beaseley shafts and nearby pits may be on this same zone or on parallel fissures.

National Copper Company. The property of the National Copper Company consists of nine patented claims in the SW¼ sec. 17, SE¼ sec. 18, and NE¼ sec. 19, T. 19 S., R. 15 W. (pl. 4). It is owned by the Laughlin Brothers, Hobbs, New Mexico, heirs of C. P. Laughlin, the original locator. Major workings include a shaft in Whitewater Canyon on the

Hazel claim and an adit on the National claim 1700 feet south of the shaft, on the east side of Whitewater Canyon and east of Sugarloaf Mountain. They are on separate structures. The adit was driven prior to 1910 and the greater amount of the mining was at this locality. The shaft was probably sunk between 1910 and 1926 but may have been put down prior to 1910. In the 1950's, bulldozing and stripping was done on the ridge above the adit.

The shaft is reported to be 200 feet deep (anonymous, unpublished report) and is along a quartz vein in granite that strikes N. 40° E. and dips 80° NW. In 1961, it was caved and inaccessible.

The adit is excavated southeastward into the hill for 365 feet (anonymous, unpublished report). At 300 feet, it intersects a shear zone. Drifts are cut southwestward for 50 feet and northeastward for 125 feet. Fifty feet north of the adit, a winze was sunk 214 feet. A crosscut on the 100-foot level extends 90 feet and one on the 214-foot level 42 feet into the hanging wall (northwestward). In 1910 and 1926, the winze and most of the north drift were inaccessible. In 1961, only the first 150 feet of the adit were accessible.

According to old reports, the shear zone is mineralized over a width of 50 feet in the adit and over a width of 60 feet in the crosscuts from the winze. Chalcopyrite occurs in bunches and masses with quartz and calcite in a sheared, altered, and partly leached zone. Paige reports that material from the dump indicated that the chalcopyrite, calcite, and quartz were in a "rather tight fracture zone." I was able to observe only azurite and chrysocolla on the dump. A 300-pound sample from the adit showed 2.0 per cent copper, 0.10 ounce of gold, and a trace of silver a ton (anonymous, unpublished report).

The stripping and bulldozing above the adit on the ridge are along what is presumed to be the outcrop of the shear zone exposed in the adit 300 feet below. No ore was found, but oxidized copper minerals were uncovered.

California Gulch. The California Gulch fluorspar deposits are in the NE¼ sec. 17, T. 19 S., R. 15 W. on the ridge west of California Gulch. Some of the deposits are on the Fluorspar Lode patented claim owned by A. A. Leach, Lordsburg. Others are on unpatented claims controlled by R. P. Thompson, Tyrone (pl. 4). The deposits are described in detail in an earlier report (Gillerman, 1952), and only a brief summary is given here.

The deposits are exposed by shallow shafts, cuts, and adits. They were worked in the 1940's and a few carloads of fluorspar shipped. The fluorite occurs with quartz in veins 6 inches to 3 feet wide and in small stringers in breccia zones up to 30 feet wide. The veins generally strike east-northeast, but one strong zone strikes northwest. Exposures are poor and the relationships of the various deposits are obscure. The country rock is granite.

A small vein is exposed in an adit on the west bank of California Gulch northeast of the main deposits. This vein is cut off to the north by a fault between granite and Gila ? Conglomerate. The fault strikes N. 60° E. and dips 75° NW. Traced across the hillside to the west, it trends generally westward. The conglomerate dips 55° NW and strikes N. 60° E.

Southern Star. Copper-bearing conglomerate crops out along the front of the Big Burro Mountains between Deadman and Whitewater canyons in the N½ sec. 17 and the NW¼ sec. 16, T. 19 S., R. 15 W. Three old adits driven in the early 1900's expose the conglomerate on the point of a ridge and in a wide draw west of Deadman Canyon. Old workings in California Gulch also expose this conglomerate (fig. 3).

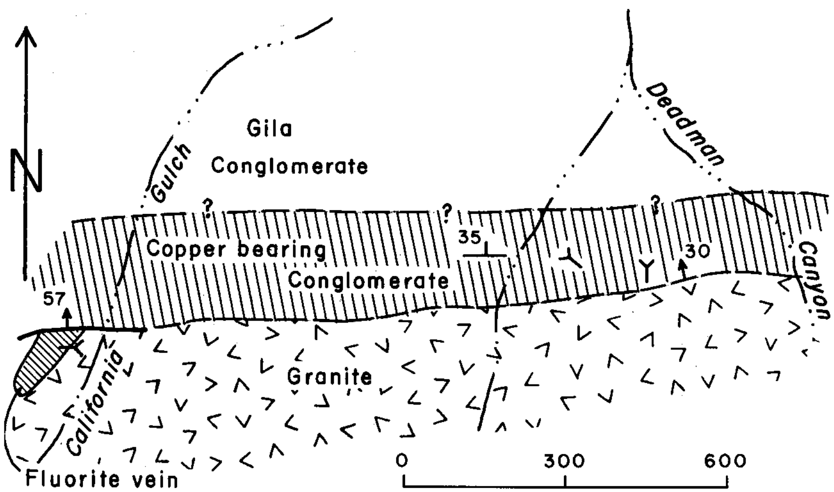


Figure 3
GEOLOGIC SKETCH MAP OF THE SOUTHERN STAR DEPOSIT, BIG BURRO MOUNTAINS

In 1959 and 1960, Dave and L. L. Osmer, Jr., who own three claims lying lengthwise along the outcrop west of Deadman Canyon, cleaned out the adits, excavated some cuts across the conglomerate in the small side draw and in California Gulch, and constructed some leaching vats on the ridge between California Gulch and Whitewater Canyon.

The conglomerate, where exposed west of Deadman Canyon, strikes almost due east and dips 35° N. It is well bedded and well consolidated but poorly sorted, with pebbles up to four inches and more in diameter. The larger pebbles are rounded to subangular, but the smaller pebbles and sand size fragments are mostly subangular to angular. Fragments consist of granite, quartz monzonite, and the individual minerals that constitute these rocks. In the section on the California Gulch fluorspar deposit, this same conglomerate is identified as the Gila ? Conglomerate. There, it strikes N. 60° E. and dips 55° NW but is in fault contact with the granite. The westernmost of the adits in the side draw west of Deadman Canyon is cut 35 feet S. 10° E. into the hillside and exposes the contact of granite and conglomerate at the end of the adit. It appears to be a normal contact, dipping 25 to 30 degrees northward. One of the other adits goes due south 70 feet and is in conglomerate all the way. A minimum thickness of 50 feet of conglomerate is exposed in this adit.

Copper occurs as chrysocolla, probably some carbonate, and the uncommon mineral crednerite ($CuO{\cdot}Mn_2O_3$). The crednerite is most abundant and imparts a black color to the conglomerate. The crednerite coats pebbles, fills cavities, and appears to be part of the cementing agent of the conglomerate or has thoroughly impregnated the cement. No analyses of the conglomerate are available, but an analysis of almost identical material on the Surprise claim southeast of Tyrone showed 4.4 per cent copper.

Ohio, Little Rock, and nearby properties. Mr. R. P. Thompson, Tyrone, owns a number of patented and unpatented claims in secs. 16 and 17, T. 19 S., R. 15 W. on both sides of California Gulch (pl. 3). The properties lie between those of the National Copper Company and the Two-Best-in-Three claim. Several pits, adits, and shafts are present, but the principal workings are the Ohio and Little Rock mines. They were operated about 1900.

At the Ohio mine, the main shaft is vertical and was inaccessible in 1960. Thompson (oral communication) states that it is 340 feet deep with a crosscut excavated 100 feet southeast on the 135-foot level. Paige (1911) states that the shaft is 240 feet deep with a crosscut running 96 feet southeast on the 155-foot level. According to Thompson, the ore zone was 15 feet wide fifty feet below the collar in the shaft. The ore on the dump averaged 5 per cent copper, but ore that was picked and sorted for shipping averaged 17 per cent copper. Paige states that the crosscut averaged 2 per cent copper, largely as carbonates (presumably over the entire 96 feet). Fluorspar is found with chalcedony and chrysocolla on the dump.

About 150 or 200 feet east of the main shaft, two shallow inclined shafts are sunk on a vein which strikes N. 20°-30° E. and dips 45° E. The vein lies between two faults and is silicified breccia containing malachite, chrysocolla, hematite, and limonite. A 2- to 8-inch-wide vein of fluorspar lies on the footwall side of the breccia and encrusts some of the breccia fragments. About 100 feet west of the main shaft in the bottom of California Gulch, an adit is driven 30 feet eastward toward the main shaft. A 40-foot-deep vertical shaft is at the portal of the adit. Two carloads of ore averaging 5 per cent copper and one carload averaging 8 per cent copper were shipped from this locality.

The collar of the main shaft is on the footwall of a resistant, silicified zone that strikes N. 65° E. and dips 65° SE. The shaft and adit in California Gulch are on the southeast side of this same zone. It appears to have been displaced a few feet west of the main shaft. The zone continues westward across California Gulch.

At the Little Rock, a shaft inclined due south 50 degrees slopes downward 180 feet. A short crosscut goes north from the bottom. A 30-foot vertical shaft is 50 feet southwest of the inclined shaft, which was driven or rehabilitated in 1947 and 1948 and in 1960 was in excellent condition.

The inclined shaft is driven along a vein which strikes almost due east and dips 50° S. A quartz monzonite porphyry dike parallel to the vein crops out about 100 feet to the north. Most of the veins in the vicinity, however, strike N. 70° E. and dip about 55° SE. A number of pits, bulldozed cuts, adits, and shallow shafts are sunk on these veins, which occupy an area 1000 feet southward from the inclined shaft. The ore in these veins consists of chrysocolla with some chalcocite. Chalcopyrite is reported by Thompson (oral communication, 1960) to be sparingly present. According to him, ore shipped from the property contained 4 to 5 per cent copper.

In the 1940's, some diamond drill holes were put down in the vicinity of the inclined shaft, but no information is available as to the results obtained. It is believed that these were drilled by the U.S. Bureau of Mines at the same time that the work was done on the inclined shaft.

The Nellie Bly mine, in the southeast corner sec. 16, is on the Nellie Bly claim. An adit inclined downward 35 degrees goes due south for 100 feet along the footwall of a vein that strikes east. The vein is one foot wide in the roof of the adit. Good ore is reported to have been mined from stopes and workings near the bottom of the incline.

Two-Best-in-Three. The Two-Best-in-Three patented claim is in Deadman Canyon in the W½ sec. 16, T. 19 S., R. 15 W. (pl. 3). It is owned by Mrs. Ira L. Wright, Silver City. The ore body is developed by an adit driven eastward into the hill for at least 375 feet, at which point a winze inclined 50 degrees extends downward 90 feet (fig. 4). In 1960, the winze was partly filled and caved. An old shaft and some pits are on the property.

About 2000 tons of ore containing as much as 15 per cent copper and a trace of gold are reported to have been shipped from the property in the 1890's (Ira L. Wright, oral communication). In the 1940's, two inclined drill holes were sunk from the adit level at a point 375 feet from the portal. The mine has been idle for many years.

A quartz monzonite porphyry dike, striking N. 70° E. and nearly vertical, crops out along the center line of the claim. A 100-foot-wide shear zone, consisting of faults and fractures parallel to the dike in addition to cross faults and fractures, parallels and is adjacent to the dike on the northwest. The granite is kaolinized, sericitized, and silicified

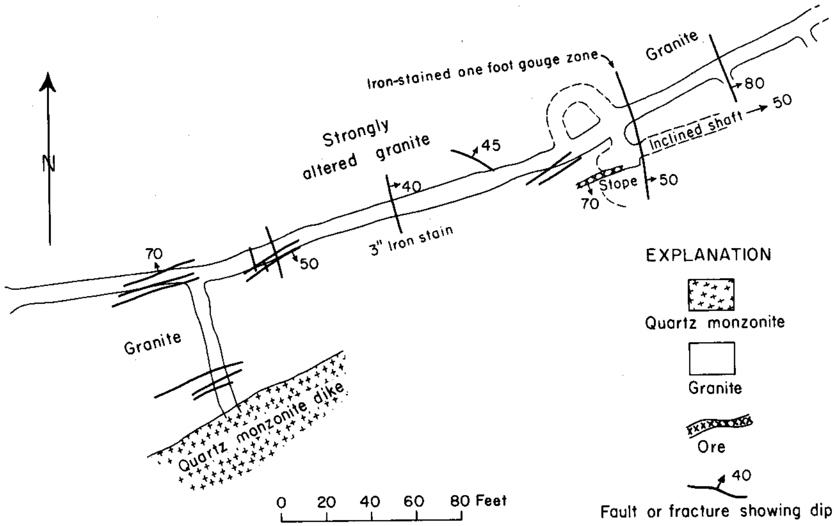


Figure 4
MAIN ADIT, TWO-BEST-IN-THREE MINE, BURRO MOUNTAINS

along the shear zone. Copper minerals are present in places along the zone.

The only developed ore shoot is at the intersection of the shear zone and a fault which strikes S. 25° E. and dips 50° NE. The ore shoot has the form of a steeply inclined chimney about 25 feet in diameter. It has been mined for 50 feet below the adit level. The ore is composed of copper carbonates, silicates, and probably some oxides. E. M. Sawyer, former manager of the Phelps Dodge operations at Tyrone, is said to have reported good ore in the bottom of the winze (I. L. Wright, written communication). One of the drill holes, inclined 73 degrees, intersected 12 feet of ore containing 6 per cent copper 80 feet below the adit and 45 feet horizontally beyond the bottom of the winze.

WEST BURRO MOUNTAINS

Deposits in the west Burro Mountains include all those in T. 19 S., R. 16 W. that are south of the Redrock road, except for a few small tungsten-bearing deposits adjacent to the road, and a deposit in sec. 3, T. 20 S., R. 16 W. (pl. 3). Most of the deposits lie along the wide, northeast-trending shear zones. They include gold, bismuth, zinc, silver, fluorspar, and copper deposits, some of which have been important producers in the past, but which are all now inactive. To the north, this district adjoins the Bullard Peak area. The boundary between the two, chosen as the Redrock road, is an arbitrary one.

Austin–Amazon. The Austin–Amazon mine (fig. 5) is on a group of fifteen patented mining claims mostly in secs. 35, 36, 25, and 26, T. 19 S., R. 16 W. (pl. 4). It is owned by L. L. Osmer, Tyrone, R. J. McCoun, Silver City, and John A. Dogendorf, Albuquerque.

The mine was first opened in the 1880's, probably for gold, by William McKinney and Joe Sheridan. One of the early workers of the property was Robert P. Thompson, Tyrone. In 1914, Brown and Beal leased the mine for six months, during which they and sublessors shipped 25 carloads of ore, averaging 17 per cent copper, worth $65,000. Sulphides were the major ore minerals. Between 1915 and 1920, the Austin–Amazon Copper Company shipped 59 carloads of ore averaging more than 5 per cent copper. (According to a private report by J. H. Shockley, 125 carloads were shipped between 1915 and 1917, but this may have included the 25 carloads shipped by Brown and Beal; according to other reports, the figure should be 200 carloads. Records, however, are extant for only 59 carloads.) The mine was closed in 1921.

Between 1921 and 1956, only desultory work was done on the property, and the workings caved and became inaccessible. In 1956, the Tejano Mining Company, controlled by James MacGregor and J. Stinson Young, leased the property. They and succeeding companies did considerable trenching and sampling of the deposits, and a series of steplike benches was excavated along the northern part of the vein. In the course of this work, many of the older workings were covered, filled, or excavated. From May to September 1956, 1455 tons of ore averaging 0.875 per cent copper were shipped to the Peru Mining Company mill at Deming, New Mexico. In addition, 11 tons of 10.0 per cent ore and 33 tons of 3.0 per cent ore were shipped to the smelter. In 1957, operations ceased and the lessors gave up their option. The property has been idle since.

According to a private report written in 1917 by J. H. Shockley, there were then about 2500 feet of underground workings consisting of shafts, drifts, tunnels, and crosscuts. The major workings were off shafts No. 1 (the main shaft) and No. 3. These are both north of the main Burro Mountain road which crosses the property. Shaft No. 1 was 200 feet deep, and drifting and crosscutting was being done on the 200-foot level when the report was written. All other workings were less than 100 feet deep; all ore shipped had been from levels above 80 or 100 feet. Workings extended for almost a mile along the vein and through a vertical distance of about 400 feet. The Beal tunnel, with a 60-foot winze sunk from the adit level, was the most southwesterly. The portal of the tunnel was slightly more than 300 vertical feet below the collar of shaft No. 1.

In 1961, the underground areas were all inaccessible. In 1956, the Tejano Mining Company had trenched and bulldozed the section north of shaft No. 1. Large open cuts, stepping downward toward the north, uncovered the vein through a vertical distance of more than 90 feet (fig. 5). The southernmost edge of the cuts was within 80 feet of shaft No. 1. Shaft No. 3 was within the excavated area. Diamond drilling by this company consisted of seven vertical drill holes ranging from 100 to 600 feet deep and spaced about 750 feet apart in two rows approximately 300 and 500 feet northwest of the outcrop. Churn drilling and wagon drilling were done and numerous samples taken.

The ore deposits on the Austin–Amazon property are along a complex shear zone that strikes about N. 50° E. and apparently dips 70° to 75° NW at the surface. The failure of a water well and of the diamond drill holes to penetrate the zone indicates that it may steepen with depth. Shockley, who had access to underground workings to a depth of 200 feet, states that the vein dips 65° NW. The shear zone is at least 100 feet wide throughout most of the one and a half miles that it is exposed on the property. It continues both northeast and southwest for many thousands of feet and can be traced by a zone of red gossan with abundant silica.

The shear zone traverses granite a few hundred feet northwest of the contact of the granite and the Tyrone quartz monzonite stock. Unaltered granite forms both hanging and footwalls, at least in the vicinity of the major workings. Within the zone, the rock is mostly sheared and altered granite, but rhyolite, andesite, and quartz monzonite dikes are also present. The andesite and the quartz monzonite have been involved in the shearing and alteration and are now merely disconnected slivers and segments lying between shears. The rhyolite is more continuous, though it, too, is sheared but not so extensively. The dike rocks are locally so intensely altered and sheared that their original character is difficult to ascertain. In some places, however, the quartz monzonite is relatively unaltered.

The footwall of the zone is well defined. In many places in the workings, the contact between unaltered granite and sericitized, argillized, and sheared granite either is exposed or its position can be ascertained within a very few feet. No good exposures of the hanging-wall contact of the zone were observed.

Within the zone, subparallel fractures bound lenses of mineralized or barren sheared areas. Reinhardt (unpublished report, 1956) stated that the individual faults within the shear zone trend diagonally across the zone and feather out against the hanging wall. I could not verify this.

Sulphides and quartz form veinlets and fracture fillings of varying widths within the zone and locally are concentrated enough to constitute commercial ore bodies, especially on the footwall side of the zone. The ore shoots stoped in the old workings and exposed in the open cuts are also on or near the footwall. The stopes average 8 feet wide, but in some places the ore bodies were 25 feet wide. In the southernmost open cut, a horse of granite 30 to 40 feet wide lies northwest of the footwall ore. Between this and the hanging wall is a lenslike ore shoot with a maximum width of 50 feet, which consists of sheared and altered granite impregnated with iron and copper minerals. Nowhere else has the hanging wall side of the zone been explored. This should be considered in any future exploration work undertaken.

Primary sulphides comprise the major portion of the ore minerals. Chalcopyrite occurs at the surface with massive calcite near the northeastern end of the property where Iron Creek has cut deeply along the vein. Shockley records it as being the principal ore mineral on the 80-foot level of shaft No. 3. Sulphides, primarily chalcopyrite with some chalcocite, made up the bulk of the ore shipped when the mine was operating. Oxidized minerals show at the surface and in the open cuts.

Besides chalcopyrite and chalcocite, bornite is recorded, and pyrite, molybdenite, and traces of gold and silver are noted. No lead or zinc minerals have been recorded or observed. Oxidized minerals are azurite, malachite, cuprite, native copper, and tenorite. Gangue minerals are quartz and calcite. Torbernite was found with native copper in two drill holes along the vein a few hundred feet southwest of the Austin–Amazon property, on the High Point claim.

Lone Pine. The Lone Pine shaft was sunk by Bill Dyer in 1950 and 1951 on a vein striking N. 20°E. The shaft is vertical for 25 feet and then inclines 70° E. It is 80 feet deep. The property is in the NW¼ sec. 3, T. 20 S., R. 16 W. about 6500 feet southeast of the Silver Dollar mine and two miles southwest of the Austin–Amazon. It was inactive in 1961.

The vein appears to be along the contact between a fine-grained granite on the hanging wall and a coarse, porphyritic granite on the footwall. Material on the dump shows segregations and stringers of sulphide in the coarse granite. A nearby pit reveals veinlets in the fine-grained granite. The vein can be traced for only a few feet in either direction from the shaft.

The major ore mineral is galena, some of which is altered to cerussite, both near the surface and, to judge from specimens on the dump, also at depth. Pyrite and bornite are also found on the dump. The galena carries a few ounces of silver a ton.

Silver Dollar mine. The Silver Dollar mine consists of a number of shafts and pits principally in the NE¼ sec. 33, T. 19 S., R. 16 W., but reaching into sec. 34. It is owned by Marshall N. Kuykendahl, Lordsburg, and was last operated for a few months in 1946 and 1947; only assessment work has been done since. The mine was opened as early as 1908.

The shaft is 160 feet deep and inclined 75° NW. Drifts on the 100-foot level extend 150 feet in each direction from the shaft, those on the 160-foot level only 30 feet in each direction. Gold and silver were the metals mined. In the 1940's, the value of the ore averaged $9.50 a ton, most of this in silver. The gold-silver ratio was 1:100. Lead ran 0.5 per cent.

The deposit is along a fracture system which strikes N. 60° E. and dips 75° SW. Fluorspar deposits at Spar Hill and Pine Canyon to the northeast are along this same structural zone of weakness.

Spar Hill and Pine Canyon. The Spar Hill and Pine Canyon fluorspar deposits are in the S½ sec. 27, T. 19 S., R. 16 W. and are owned by Marshall N. Kuykendahl, Lordsburg.

The Spar Hill deposit was first opened by Kuykendahl in 1941. About 800 tons of fluorspar were shipped between February 1942 and March 1944. Except for assessment work, the property has been idle since 1944. The Pine Canyon deposit was explored simultaneously; no shipments have been made from it.

Workings at Spar Hill consist of an inclined shaft 40 feet deep, a drift driven 90 feet southwest from near the bottom of the shaft, a large glory hole, and several pits and trenches. At Pine Canyon, pits and bulldozed trenches are present.

The Spar Hill fluorspar is along a fault which cuts granite and some rhyolite dikes. The fault strikes N. 60°-70° E. and dips 70° NW. Fluorspar is more abundant where both walls are granite. It cements fragments of granite, rhyolite, and andesite in a breccia zone as much as 20 feet wide that forms the hanging wall of the fault surface. It occurs also as veinlets filling fractures and cavities in the country rock beyond the breccia zone. Quartz is the only associated mineral. At the shaft, fluorspar has been mined through a width of 30 feet, but the vein narrows to the southwest and is cut off by a fault to the northeast. Subparallel veins are northwest of the main zone.

At Pine Canyon, half a mile southwest of Spar Hill and along the same mineralized zone, fluorspar is found with quartz as small stringers and veinlets in granite, rhyolite dikes, a small andesite plug, and small dioritic intrusive masses. None of the veins is wide enough to be mined commercially.

The deposits are described in more detail in an earlier report (Gillerman, 1952).

Bismuth Lode mine. The Bismuth Lode mine, owned by G. O. Gwyn, Silver City, is in the NE¼ sec. 27, T. 19 S., R. 16 W. A vertical shaft about 70 feet deep (L. L. Osmer, Jr., oral communication) and pits, trenches, and shallow shafts explore the property. At the 22-foot level in the shaft, drifts run 20 to 30 feet southwest and northeast along the vein, and a 15-foot crosscut is driven southeast from the end of the northeast drift.

The shaft was probably sunk for copper or gold prior to 1900. Bismuth minerals were later found on the dump by Joe E. Sheridan, Silver City, who acquired the property. Subsequently, it was operated by a Mr. Fredrickson. Osmer reports that Fredrickson shipped five tons of ore containing 20 per cent bismuth which was processed into chemicals at Tyrone. A. A. Leach (unpublished report) states that selective mining resulted in shipments containing 6 to 13 per cent bismuth. There have been no shipments since the 1920's or early 1930's. Besides bismuth, the ore contains small amounts of copper, silver, and gold.

The deposit is along a nearly vertical vein which strikes N. 45° E. and dips 80° SE at the shaft. It lies on the south side of a well-defined, persistent, silicified fault zone which has considerable relief and can easily be traced for half a mile southwest and more than a mile northeast. The Foster zinc mine, half a mile northeast, is along this same structure. In the vicinity of the shaft, the fault zone consists of two 8- to 10-foot-wide silicified zones or quartz veins separated by partly silicified and altered granite. A rhyolite dike is adjacent to the northwest side. Dikes of rhyolite, quartz monzonite, pegmatite, and diabase are intruded along the shear zone at various places, and quartz veins up to 25 feet wide are locally present.

The Bismuth Lode vein averages 2 feet wide. Cream-colored and light yellow crystals and branching spikes of bismutite coat fractures and fill crevasses in leached vein material on the dump. A. A. Leach (unpublished report, 1936) states that bismutite is distributed through the vein in pods and veinlets from ten feet below the collar of the shaft to the bottom (43 feet when the report was written). In the floor of a small stope on the southwest side of the shaft six feet from the bottom, Leach reports native bismuth. No bismutite was associated with the native bismuth. Oxidized copper minerals are on the dump and in the upper parts of the shaft.

A 40-foot-deep shaft 1000 feet northeast of the Bismuth Lode shaft and along the same fault zone contains much pyrite, and traces of bismuth appear on the dump. The vein at this place dips 85° NW. It is 5 feet wide, and 3 feet of gouge or intensely argillized granite lie between it and a rhyolite dike on the northwest. This shaft is about halfway between the Bismuth Lode shaft and the Foster zinc mine. The U.S. Bureau of Mines analyzed the dump material for zinc but found only a trace (R. J. Holmquist, written communication).

Foster Zinc mine. The Foster zinc mine in the NW¼ sec. 26, T. 19 S., R. 16 W. is half a mile northeast of the Bismuth Lode shaft and along the same prominent silicified fault zone. Sphalerite was found on the dump of an old shaft by Lewis Foster, Silver City, in 1940 or 1941. The shaft had been put down for gold, copper, or silver prior to 1900. Foster cleaned out the shaft and shipped at least 16 tons of ore containing 15 per cent zinc in 1950 (L. L. Osmer, Jr., oral communication). The mine has been idle since 1951, and water filling the shaft made it inaccessible in 1961. The shaft is about 80 feet deep, with a 40-foot-long drift to the northeast and stopes above the drift.

The vein at the shaft strikes N. 55° E. and dips 75° NW. A rhyolite dike forms the footwall here but cuts across the vein a short distance northeast of the shaft. The hanging wall is much fractured and kaolinized. The vein consists mostly of quartz and pyrite, and considerable iron oxide and hydrous iron oxide occur on the outcrop. Sphalerite was found in the mine only below a narrow kaolin-filled fracture which cuts diagonally across the vein on the 45-foot level, dipping 70° SE. It was plentiful northeast of the shaft where it was concentrated adjacent to rhyolite. Much pyrite was associated with the sphalerite, and above the diagonal fault, small pods of pyrite were observed in the vein up to the 25-foot level.

The U.S. Bureau of Mines sampled the deposit and recommended a program of exploration (R. J. Holmquist, written communication). It was believed that indications favored the location of an ore body along the fault zone northeast of the shaft. The program was never put into operation.

Beaumont. The Beaumont mine in the E½ sec. 13, T. 19 S., R. 16 W. was mined for silver by C. Amory Stevens in the 1880's, who also operated a small stamp mill on the property. The mine is on a patented claim, owned by A. A. Leach, Lordsburg, which extends into sec. 18, T. 19 S., R. 15 W. (pl. 3). In addition to the main shaft, two shallower shafts and some pits explore the Beaumont and subparallel veins. Pits and adits east and west of the end lines of the claim are along the Beaumont fault zone.

The Beaumont shaft is reported to be 350 feet deep (L. L. Osmer, Jr., oral communication). It is open for 160 feet. At the surface, the shaft is inclined 60° SE, but 100 feet below the collar it steepens to 70 or 75 degrees. Above 160 feet, the only working off the shaft is a small stub drift which runs eastward about 5 feet at the 100-foot level. No information is available about workings below 160 feet.

At the shaft, the vein is 18 inches wide at the surface but 100 feet below the collar widens to 3 feet. It strikes N. 70° E. and dips 60° SE at the surface, steepening with depth. Argentite, native silver, and probably argentiferous galena were the principal ore minerals. Native silver and galena can be found on the dump. Molybdenite is extensive on the dump and Leach (oral communication) reports that it is in a quartz vein on the hanging wall in the deeper parts of the mine. Pyrite is common, and manganese oxides and hydrous iron oxides are abundant on the dump. The dominance of silver and the presence of molybdenite make the Beaumont unique among mineral deposits in the Burro Mountains.

In the shaft near the east end of the claim, the vein dips 75° SE and strikes more northeasterly. This may be a subparallel vein rather than the same as the one in the Beaumont shaft. At the shaft southwest of the main shaft, oxidized copper minerals are present, also perhaps along a subparallel vein. The zone of subparallel veins can be traced southwest to workings in Iron Gulch. Northeastward, it can be traced to the old

Mayflower shaft on the Buster No. 10 claim of the Beaseley holdings, 2000 feet from the Beaumont shaft.

The Beaumont is along the northeastward extension of the fracture zone that cuts through the Bismuth Lode and the Foster zinc mines. With few interruptions, this sheared and mineralized zone can be traced for almost four miles. The nature of the mineralization changes as one goes northeastward along the zone from bismuth and gold to zinc to silver and molybendum to copper.

Bolton mine and nearby deposits. The old Bolton mine in Iron Gulch in the NE¼ sec. 24, T. 19 S., R. 16 W. was last worked in the 1920's. According to Paige (1911), the Bolton and Wilson properties on the east side of Iron Gulch in secs. 13 and 24 contained a number of shallow shafts and pits in which small fractures, trending generally northward and northeastward, carried copper carbonates to depths of 50 feet. Sulphides, however, occurred near the surface in many of the localities and included pyrite, chalcopyrite, and some chalcocite. Molybdenite was present at one locality. Carbonate ore was shipped from a number of the prospects, but according to L. L. Osmer, Jr. (oral communication), ore shipped from the Bolton shaft in the 1920's was mostly chalcopyrite.

South of the Bolton group in the SE¼ sec. 24 and NE¼ sec. 25, some pits and prospects on the Tall Pine group of claims, owned by Altman and Patten, show carbonate and suphides in veins two feet wide.

Shrine mine. The Shrine fluorspar mine is on Willow Creek, near the center of sec. 13, T. 19 S., R. 16 W. The property consists of four patented claims owned by the General Chemical Division of the Allied Chemical and Dye Company. It was first located by L. L. Osmer in 1942 and was operated by General Chemical from 1942 to 1950; it has been idle since. The deposit is described in detail in an earlier publication (Gillerman, 1952) and is discussed only briefly here.

A shaft inclined 55° S slopes downward for nearly 500 feet. Mining was from numerous levels and stopes both east and west of the shaft. The vein can be followed for more than 400 feet east and 700 feet west of the shaft.

Fluorspar is along a fault that strikes N. 75° W. and dips 46° to 68° S. The fault cuts granite, an andesite porphyry plug, rhyolite flows, and latite, quartz latite, and rhyolite dikes. The vein narrows perceptibly as it passes through the plug; it widens where both walls are granite. The fluorspar occurs within a breccia and gouge zone along the hanging wall of the fault as clear green fluorite with only small amounts of quartz. A little pyrite and traces of gold and silver are present. The ore shoots, up to 10 feet wide and 500 feet long, are localized by irregularities in the fault and by the character of the wall rock. Subparallel veins 400 to 600 feet to the north contain pyrite, quartz, some gold, and traces of fluorite.

Osmer gold. Five unpatented claims in secs. 22 and 23, T. 19 S., R. 16

W., known as the Shamrock Group, extend 7500 feet along a vein which has been mined intermittently since the early 1880's. Rich ore was shipped from numerous localities along the vein, but the ore shoots were small and mining operations were short-lived. The property is now owned by L. L. Osmer, Tyrone.

No records are extant as to early operations, but it is presumed that the ore shipped was very high grade. In 1912, Lewis Foster shipped 17 tons of ore which averaged 9 ounces of gold a ton. In 1918, one carload of ore was shipped from the Sheridan shaft and nearby open stopes. In 1919, the property was acquired by a small mining syndicate which operated it for a number of years. A new strike was made in 1924 at the Aplite shaft and a small mill was installed about that time near the eastern end of the property. Again in the 1930's, ore was mined and shipped from the vein. The property was dormant in 1960.

Gold occurs in a quartz vein which strikes N. 60° E., is almost vertical, and lies along one of the major shear zones in the Burro Mountain granite. The shear zone is parallel to a similar zone lying slightly less than a mile southeast along which the Bismuth mine, Foster zinc mine, and other deposits are situated. Dikes of different ages and rock types are intruded along the shear zone. Rhyolite and quartz monzonite are the most prominent. The quartz vein lies adjacent to the dikes, most commonly next to the quartz monzonite. Repeated movement and intrusive activity has resulted in discontinuity of the dikes and of the quartz vein. Cross fractures displace both dikes and veins, particularly near the northeastern end of the structure.

Small amounts of pyrite and hematite are associated with the gold in a gangue of quartz. Comb structure within the vein is common. At the Sheridan shaft, bismutite and copper and silver minerals were associated with the gold and occurred as irregular segregations within the quartz. At the Aplite shaft, pyrite and copper minerals were particularly common. In general, copper minerals are more prevalent in the southwestern part of the vein. Wulfenite has been reported from the Aplite shaft (anonymous, unpublished report) where it was intimately associated with high-grade gold ore. Galena occurs in the floor of the drift of the shaft near the northeastern end of the vein.

Gold is concentrated along the vein in many small pods and lenses. These have been mined at different times and from separate workings, resulting in numerous shafts, open stopes, trenches, and pits, most of which were inaccessible in 1961. Major workings are near the southwestern end, near where the main road crosses the vein, and near the northeastern end. The successive discovery of the different ore bodies was the cause of the intermittent activity on the property.

An open stope, 50 feet deep, is the most southwesterly of the major workings. Adjacent to it on the northeast is the old Fisher Brothers shaft which is 70 feet deep. About 100 feet farther northeast is another shaft, also 70 feet deep, with drifts extending 30 feet in either direction along the vein on the 35-foot level. A few feet northeast is the shaft sunk by Lewis Foster in 1912. This shaft is 60 feet deep with drifts along the vein in both directions from the bottom.

The Aplite shaft, about 300 feet southwest of where the main road crosses the vein, is 35 feet deep. At this point, the vein cuts through a rhyolite dike.

The Frank or Sheridan shaft is 50 feet northeast of the main road. It is 44 feet deep, with drifts extending 40 feet in each direction from the bottom of the shaft. It was from the west drift, at a point 20 feet from the shaft, that 400 pounds of ore valued at $80,000 a ton were mined (L. L. Osmer, Jr., oral communication). Open stopes and caved shafts extend for more than 300 feet along the vein at this locality.

Ore was shipped from another caved shaft about 2200 feet northeast of the Frank shaft.

About 1000 feet farther northeast, and near the northeastern end of the property, a 100-foot-deep shaft explores an ore body that plunges northeast. A 50- to 60-foot-long shaft extends northeast on the 50-foot level. Ore is exposed in the shaft and in the drift. A short drift on the 100-foot level, however, does not extend far enough northeastward to cut the ore body. More than $60,000 worth of ore was mined from this shaft.

About 800 feet farther northeast some small pits expose a fluorspar vein which strikes N. 70° W. and crosses the major structure. Gold occurs at the intersection of the two veins.

Astrologer mine and Live Oak prospect. The Astrologer mine, in the SW¼ sec. 20, T. 19 S., R. 16 W., on the west side of the Big Burro Mountains, is owned by Charles Ray, Lordsburg. The mine has been inactive for many years but at one time was worked for silver, gold, and lead. Two vertical shafts on separate veins explore the deposit. Six drifts, none exceeding 75 feet, extend from the shafts. All were inaccessible in 1961.

The ore concentrations occur in several subparalled quartz veins which cut Burro Mountain granite. The veins are almost vertical and strike northeasterly. Short andesite and more continuous rhyolite dikes also trend northeast. Numerous aplite and pegmatite dikes intrude the granite in the vicinity. A prominent rhyolite dike, which can be followed for more than four miles, trends northwestward 1000 feet west of the mine. Minerals identified on the dump include chalcopyrite, pyrite, galena, chalcocite, and quartz.

Two small lead-silver prospects lie northwest of the Astrologer mine. Neither has been active in recent years. Both have been explored only by shallow pits. The Live Oak prospect, owned by N. P. Grenfell and H. R.

Eaton, Silver City, is in the NE¼ sec. 19, about 3000 feet northwest of the Astrologer mine. Two 15- to 20-foot-deep shafts expose a northwest-trending vertical quartz vein about one foot thick cutting the Burro Mountain granite. Pods and granular masses of galena, sphalerite, pyrite, and quartz less than four inches long occur within the vein. Polished-section studies of the ore by Hewitt showed that the sphalerite was deposited in small cavities lined by quartz druses and contains tiny blebs of random- or parallel-oriented chalcopyrite.

A similar vein lies about midway between the Live Oak and the Astrologer. It is exposed in a shallow trench.

Long Lost Brother. The Long Lost Brother fluorspar deposit in the SE¼ sec. 14, T. 19 S., R. 17 W. was owned in 1949 by Charles Ray and Sid Watson, Lordsburg, who operated it for a short period in 1943 and 1944. Ownership in 1960 was unknown, but the deposit has not been operated since 1944 and is probably abandoned. Workings consist of a shaft 18 feet deep, from which stopes have been excavated to the surface, and shallow pits and trenches. A few truckloads of ore were shipped to the mill at Lordsburg, but no accurate production records are available.

The following description is taken from a report (Gillerman, 1952, p. 278).

> The fluorspar occurs in veins, along two subparallel nearly vertical faults striking N. 45° to 65° E. that cut mica schist and granite of pre-Cambrian age and andesite dikes of pre-Tertiary age. The mica schist is confined mainly to the area between the two faults. Perthitic pegmatite dikes cut the granite, and a late Tertiary basalt dike cuts the westernmost fault. Fluorspar mineralization can be traced at intervals along the westernmost fault for more than 1,200 feet, and the vein continues to the northeast beyond the mapped area. To the southwest this vein is concealed by recent fill. The easternmost vein can be traced for slightly more than 400 feet.
>
> The fluorspar veins are as much as 4 feet wide. Four distinct types of fluorspar are present: massive crystalline clear green fluorite; a breccia containing fragments of the clear fluorite cemented by quartz, jasper, chalcedony, and later fluorite; a fibrous columnar variety, yellow-green to ivory in color, associated with manganese oxide; and a wormlike aggregate of fluorite, chalcedony, and manganese oxide. The wormlike fluorspar occupies the center of the zone along the westernmost vein but is not found in the easternmost vein. The columnar fluorspar occurs as crustiform masses and as vein fillings in the breccia and along the edges of the zone.
>
> Two and probably three stages of fluoritization separated by periods of brecciation and silicification occurred. The stages of fluoritization were probably closely spaced in time, and the manganese mineralization appears to be associated only with the last stage or stages. The appearance, texture, and mineralogical associations of the deposits were probably associated with hot springs.

Southwestern and Central Burro Mountains

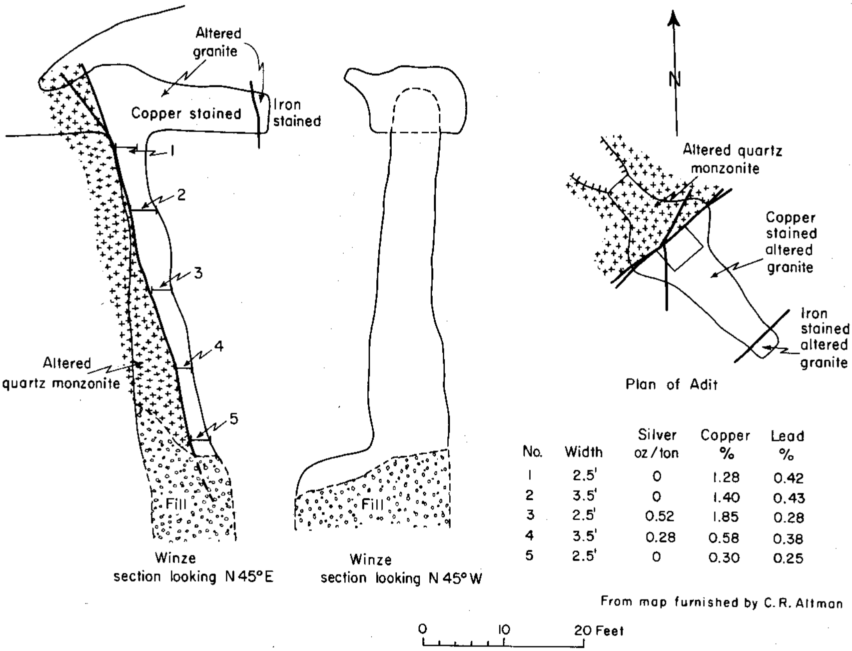
The southwestern and central Burro Mountains area includes a number of small, scattered copper, gold, silver, and fluorspar deposits southwest of the central peaks of the Big Burro Mountains, and also the important Sprouse–Copeland deposit in the central part of the mountains, east of the central peaks (pl. 3). This is an arbitrary grouping. The Sprouse–Copeland deposit is isolated from, and cannot reasonably be included in, any of the other four subprovinces, except possibly the White Signal district. Geologically, it has little in common with the White Signal district, which is a very compact and homogeneous unit. Its inclusion with the deposits southwest of the central peaks is warranted only because it may be along an extension of the same zone as the Neglected mine and the Moneymaker fluorspar deposit, which logically are part of the southwestern group, although on the fringe of the White Signal district.

Joy Group (Sprouse and Copeland shafts). A group of 12 claims in secs. 4, 8, 9, and 17, T. 20 S., R. 15 W., known as the Joy Group, are owned by Charles Russell, Tyrone, and C. R. Altman, Silver City. They are along a wide and persistent mineralized zone on which the Sprouse, Copeland, and Indian Hill shafts were sunk about 1900. Six claims, the Ann, Mary, Dot, Joy, Oxide No. 1, and Oxide No. 2, were up for patenting in 1961. The property extends for two miles in a northeasterly direction along the zone.

The Sprouse, Copeland, and Indian Hill shafts were put down apparently for copper. Little information is available about them and they were abandoned for many years. Since the 1930's, the properties were acquired by Russell and Altman, and considerable work, including partial rehabilitation of the Sprouse and Copeland shafts, trenching, diamond drilling, and detailed sampling and assaying, has been done.

The Sprouse shaft, on the Mary claim, is filled below 40 feet, but in 1959, a drift on the 40-foot level was cut 50 feet N. 70° E. and then turned east for 11 feet. Cuts, pits, and trenches and one diamond drill hole are near the shaft. Other cuts and another drill hole are on the Mary claim near where the Mary, Oxide No. 1, and Oxide No. 2 claims meet.

The major workings on the property are on the Dot claim in the vicinity of the Copeland shaft, which is 110 or 120 feet deep but, in 1959, was open only to 80 feet. A 60-foot-long drift runs east on the 45-foot level, but the total amount of drifting is unknown. An adit, the portal of which is a few feet above and 35 feet south of the collar of the shaft, is driven 65 feet S. 45° E. A steeply inclined winze 50 feet from the portal slopes downward a minimum of 50 feet; it is filled below this point (fig. 6). In 1959, the adit was partly excavated, and in 1961, the winze was only ten feet from the portal of the adit. Numerous cuts expose the mineralized zone near the shaft. Two diamond drill holes were put down



No.	Width	Silver oz/ton	Copper %	Lead %
1	2.5'	0	1.28	0.42
2	3.5'	0	1.40	0.43
3	2.5'	0.52	1.85	0.28
4	3.5'	0.28	0.58	0.38
5	2.5'	0	0.30	0.25

Figure 6

GEOLOGIC SKETCH MAP OF THE ADIT AND WINZE, COPELAND DEPOSIT, SOUTHWESTERN BIG BURRO MOUNTAINS

from the surface to intersect the vein below the shaft and five were drilled laterally from the 45-foot level of the winze.

Cuts and pits expose the vein on the Oxide No. 1, Joy No. 1, and Mary claims. On the Joy No. 3 claim, there are several cuts. On the Jackson claim, the old Indian Hill shaft goes downward to an unknown depth and two diamond drill holes, 51 and 55 feet deep, respectively, were drilled in the vicinity of the shaft.

The Sprouse–Copeland deposits are within an intensely shattered, sheared, and altered zone in quartz monzonite that lies on the footwall side of a fault or a series of en echelon faults striking N. 35°-50° E. and dipping 65° to 85° SE. Near the Copeland and the Sprouse shafts, and at some places between them, granite is on the hanging wall (southeast) side of the fault or faults. The fault or faults forming the southeastern boundary of the zone are well exposed in the adit, winze, and some cuts at the Copeland shaft, as well as in a cut where the Oxide No. 1, Oxide No. 2, and Mary claims meet.

The northwestern boundary of the sheared and shattered zone has nowhere been observed, but the change from intensely altered quartz monzonite to relatively fresh rock occurs within 10 to 20 feet. Mineralized zones, however, are in the quartz monzonite 200 to 600 feet to the northwest.

The granite is comparatively little sheared and altered adjacent to the fault or faults, although the feldspars are slightly sericitized and kaolinized. However, the granite next to the fault contains ore minerals. Copper and iron stains are present in the adit southeast of the winze, and assays show mineable copper. In contrast, the quartz monzonite on the hanging wall of the fault or faults is intensely sheared, shattered, altered, and mineralized for a considerable distance outward from the fault. At the Sprouse shaft, this mineralized zone is 100 feet wide; at the claim intersection of the Oxide No. 1, Oxide No. 2, and Mary, it is 120 feet wide; and at the Copeland shaft, it is in excess of 150 feet wide. North of the Copeland shaft, where quartz monzonite is on both sides of the fault or faults, the zone is narrower.

Isolated slivers of altered diorite are within the altered zone at the Copeland shaft. Lenses of schist and amphibolite are within the granite, also near the Copeland shaft.

The sheared and shattered quartz monzonite has been so intensely sericitized and kaolinized that little is left of its original minerals except quartz. The texture, too, has been obscured. The rock, in addition, has been impregnated with copper, and numerous veinlets which contain sulphides and quartz occur throughout the zone. In some places, as at the Copeland shaft, the veins appear to be wide enough and the metal concentration great enough to constitute a workable deposit.

As already mentioned, copper minerals occur also in granite on the hanging wall side of the fault, and near the Copeland shaft, mineralization continues at least 15 degrees outward from the fault.

At the Copeland shaft, the ore seems to be concentrated in lenses, arranged en echelon within the zone and trending easterly, oblique to the strike of the zone. Chalcopyrite is the dominant sulphide, but a little galena, sphalerite, pyrite, and molybdenite have been observed. Assays show small amounts of bismuth, tungsten, gold, and silver. Oxidized copper minerals are common. Tenorite is especially plentiful, and nodules of azurite and tenorite, with a core of chalcopyrite, are found in the vicinity of this shaft. Malachite and azurite are abundant, especially on the Joy No. 3 claim. Quartz is the usual gangue mineral but calcite is also present.

The deposit was sampled in the winze on the Dot claim, and five diamond drill holes 25 feet long were driven from the 45-foot level in the winze. Samples were also taken in the adit, in the shaft, in cuts, and in diamond drill holes put down from the surface. The position and results of some of these are indicated in Figure 6. A zone in excess of 100 feet wide at the Copeland and the Sprouse shafts is mineralized, much of it carrying copper in excess of 0.5 per cent, plus values in gold, silver, and molybdenum.

Hop Williams shaft (Pocahontas claims). The Hop Williams shaft is on the Pocahontas Extension claim, one of a group of three owned by C. R. Altman, Silver City, and Charles Russell, Tyrone. The shaft is in the NE¼ sec. 19, T. 20 S., R. 15 W. It was sunk in 1916 and 1917 and is 97 feet deep. An adit driven 114 feet northwesterly along the vein cuts the shaft 40 feet below the collar. Pits, trenches, and cuts and shallow shafts are on the three claims. Both diamond and churn drilling were done in the late 1950's to explore the vein at depth, but not much is known about the results. Russell (oral communication) stated that the vein structure was cut in two holes and was 12 and 20 feet wide, respectively. However, neither the angle nor the depth at which the holes cut the structure is known.

The vein is contained within a diabase dike which lies adjacent to a rhyolite dike. The vein is about 1 foot wide but the zone of diabase dike and vein is 7 feet wide. The vein is vertical and strikes N. 75° E. Oxidized copper minerals are on the dump. Assays across the 20 feet of structure in the one drill hole showed 1.5 per cent lead, 0.5 per cent copper, and traces of gold and silver.

Moneymaker fluorspar. The Moneymaker fluorspar deposit, owned by Charles Russell, Tyrone, is in secs. 19 and 30, T. 20 S., R. 15 W. It was described in an earlier publication (Gillerman, 1952) and only brief note is taken of it here. In 1958 and 1959, the property was optioned to The Roberts Associates, Los Angeles, who put down 21 diamond drill holes to explore the vein at depth. Two holes were 110 feet deep; the others were 100 feet deep. Results were reported as encouraging, but the option was not exercised. Several pits, cuts, and shallow shafts also explore the property.

The deposit has been worked by Russell intermittently since 1939. About 300 to 400 tons of fluorspar averaging approximately 50 per cent fluorite have been shipped. Reserves of fluorspar at the property are large, but most of it is siliceous and of low grade (Gillerman, 1952).

The fluorspar is along a fault in granite which strikes N. 60° E. and dips 65° SE. The vein consists of a zone 800 feet long and 2 to 8 feet wide, containing coarsely crystalline fluorite and much quartz, and an adjacent breccia zone to the southeast containing fragments of silicified granite and rhyolite cemented by fluorite and quartz. A fault separates the two zones, and the amount of fluorite in the breccia zone becomes progressively less away from the fault. A silicified zone, probably the eastward continuation of the Neglected vein, is adjacent to the vein on the north. A rhyolite dike is next to the silicified zone both east and west of the fluorspar deposit. Fluorite and quartz are the only minerals present, but small amounts of galena and pyrite occur sparingly in the silicified zone adjacent to the vein.

The Moneymaker deposit is within a long, mineralized belt which includes the Neglected mine and the deposits west of it, the Moneymaker, the Pocahontas, and probably the Sprouse–Copeland. Radioactivity is noted in numerous places along this belt (photo 9).

Photo 9

MONEYMAKER FLUORSPAR MINE AT RIGHT AND THE NEGLECTED MINE (ADIT AND SHAFTS) AT LEFT, ALONG THE NEGLECTED VEIN, OR "DYKE," BIG BURRO MOUNTAINS

Neglected mine. The Neglected mine in the extreme northeast corner sec. 25, T. 20 S., R. 16 W. is owned by Charles Russell, Tyrone. It is next to and west of the Moneymaker fluorspar deposit. The Neglected mine was worked prior to 1900, and Graton (Lingdren, Graton, and Gordon) mentions it as being operated primarily for copper but carrying values in gold. It has been active intermittently since 1900, mostly prior to 1930. In 1948, the Pinos Altos Mining Company leased the property, drilled a diamond drill hole calculated to test the ore body below the westernmost shaft, did some prospecting on the west end of the vein, and then abandoned its lease. In 1958, the mine was again leased. The lessees partly dewatered and rehabilitated the main shaft and constructed some leaching vats, but abandoned the property in June 1959. In 1961, Charles Russell and associates were beginning to work the vein again and planned systematically to sample it. By the fall of 1963, they had dewatered the main shaft and had sampled the 150-foot level.

The deposit is explored by three shafts, an adit, and numerous pits (pl. 6). The Main or New shaft is vertical and 150 feet deep. A 110-foot crosscut runs north from the bottom of the shaft, and a drift goes 215 feet west from near the end of the crosscut. The Old shaft is 80 feet north of the Main shaft. It is sunk on the footwall of the vein and is inclined 70 degrees to the south. It goes downward 61 feet. A 14-foot crosscut is driven southward from the bottom of the shaft. The third shaft, called the West, is 400 feet west of the Main shaft. It is on the hanging wall, is inclined about 70° S, and is sunk 40 feet. From the bottom, a 24-foot-long crosscut extends north to the footwall. About midway along the crosscut is a 10-foot-deep winze, with a drift also at this point driven 12 feet west. The adit is cut westward 314 feet along the zone from a point 280 feet east and 84 feet below the Old shaft collar.

The Neglected mine is along a wide silicified zone that continues for slightly more than a mile westward from the shafts (pl. 6). It is topographically prominent and forms the crest of a series of elongated ridges at the base of the Burro Mountains. Locally, the silicified zone is known as "The Dyke." At the Old shaft, the zone is 8 feet wide but broadens westward and is 30 feet wide at the West shaft. A 10-foot-wide rhyolite dike parallels the zone 15 feet south of the Old shaft. The dike loses its identity to the west, perhaps becoming incorporated within the widened silicified zone. To the east, the reverse occurs. The silicified zone is difficult to identify 150 feet east of the Old and Main shafts, and its place is taken by the rhyolite dike which continues to the adit. At the adit, a narrow silicified zone is adjacent to the footwall of the dike. The dike can be traced 1000 feet farther east to the Moneymaker fluorspar deposit. About 600 feet east of the adit, a silicified zone again appears next to the footwall side of the dike, and it is this zone, containing sparse pyrite and galena, that is alongside the fluorspar vein of the Moneymaker deposit.

Where observed in the shafts, the vein dips 70° to 75° SE. The dike where observed in the adit dips 67° SE. The adit was accessible for about 175 feet, but it is reported by Russell to penetrate the vein shortly beyond this point. The shafts were not accessible at the time I visited the mine. The footwall contact of the silicified zone and the granite is sharp and distinct, but on the hanging wall side, numerous narrow, subparallel veins appear in the granite so that the limits of the zone are not so definite. The granite is little altered along the vein.

Chalcopyrite is the major ore mineral of the vein. Gold is present, and pyrite, bornite, covellite, galena, and sphalerite were observed on the dump. Barite and quartz are the gangue minerals. Old assays in the crosscut at the bottom of the Main shaft showed values of $10 in gold and copper (gold calculated at $20 an ounce and copper at 11 cents a pound). Copper stains were discerned at the western end of the silicified zone, one mile west of the Main shaft, and radioactivity was noted in a pit 150 feet south of the zone. Bismutite also occurs near the western end of the zone.

Deposits west and northwest of the Neglected mine. A number of old shafts, pits, and adits in secs. 15, 16, 22, 23, and 26, T. 20 S., R. 16 W., west and northwest of the Neglected mine, produced small quantities of gold and some copper. The majority of them explore veins along the contact of basic dikes or rhyolite dikes and granite. A few are along sheared and fractured zones in granite. Nearly all the veins trend northeasterly and are steeply dipping. Gold, copper, and in a few places, silver and lead are present, but only the gold was found in amounts sufficient to be commercial. Some of the deposits are radioactive. None of the workings is extensive and all were inactive in 1961.

The major deposits, all but a few owned by Charles Russell, Tyrone, are described below:

Summit deposit. The Summit deposit is near the center of section 23. This is the old Wes Williams shaft sunk from 1920 to 1922 for gold and copper. It is 75 feet deep and contained galena 36 feet below the collar of the shaft. Silver also was present. The vein is along the contact of a basic dike which strikes N. 45° E. and dips 85° SE. The vein is radioactive.

Vertical shaft in section 23. A vertical shaft near the west section line of section 23 is in a 15-foot-wide fracture zone in granite. It is within a few hundred feet of a northeasterly trending quartz monzonite dike. The fracture zone strikes N. 45° E. and dips 70° SE. Azurite, malachite, tenorite, and specular hematite are present.

Barnett shaft. A shaft is on a deposit owned by Mrs. E. Barnett, Silver City, in the N½ sec. 26. The shaft is along the south side of a rhyolite dike and on the westward projection of the Neglected vein, which is exposed 2000 feet to the east.

Shafts on the Wild Irishman No. 5 claim. Two shafts in the NE¼ sec. 26, on the Wild Irishman No. 5 claim owned by Charles Russell, are along the projected strike of the Neglected vein and are 1000 feet west of its westernmost outcrop. A 30-foot-deep inclined shaft follows a vein along the contact of a basic dike striking N. 45° W. and dipping 40° NE. The inclined shaft intersects a 75-foot-deep vertical shaft. A ton of ore shipped from the property carried 9 ounces of gold and 0.75 ounce of silver a ton and 3.0 per cent copper. Torbernite is present.

Uncle Jimmy Thwaits mine. A 40-foot-long adit, with a winze sunk at the end of it, is in the NE¼ sec. 26. High-grade stringers a few inches in width carried as much as 2400 ounces of gold a ton.

Russell gold. Near the center of section 26, along the Gold Gulch Road, a 61-foot-deep shaft, now partly filled, has a drift trending west 53 feet at the bottom. The shaft is along the contact of a rhyolite dike which strikes N. 55° E. and dips 80° SE. Almost a ton of ore shipped in 1915 and 1916 carried 27 ounces of gold a ton.

Two adits in section 15. Two adits are near the south section line of section 15. These are driven along basic dikes which strike N. 35° E. and N. 45° E., respectively. The granite is altered and shows copper stains.

Gold Gulch placers. Placer deposits in Gold Gulch were being operated prior to 1884 (Jones), but no record of the extent of the placers or of the amount of gold recovered is extant. In the early 1930's, the Sunset Gold Fields Company of Boston (in which a number of local citizens were interested, including Otto Forster, Doc Gardner, Adolph Schutts, William Swampell, and Charles Ray) operated the placers for about two and a half years. Large shovels and other heavy equipment were used to move the gravel, and the operation is reported to have been very successful. In the late 1940's and early 1950's, small-scale placer mining was done by L. L. Barnett and others.

The placer deposits lie along Gold Gulch for about one mile in secs. 21 and 22, T. 20 S., R. 16 W. The gold-bearing gravels are recent deposits that include reworked Gila Conglomerate and pebbles, boulders, and sand probably derived directly from the nearby granite and volcanic rocks. The placers occur where Gold Gulch traverses Gila Conglomerate within the Knight Peak graben.

John Malone, Lost Frenchman, and nearby deposits. The John Malone shaft in the NE¼ sec. 16, T. 20 S., R. 16 W. was sunk prior to 1900. It is inclined 70° SE and is more than 80 feet deep. Drifts on the 20-foot level go 30 feet northeast and 10 feet southeast. Short 10-foot drifts are on one other level between 20 and 80 feet. On the 80-foot level, a long drift runs northeast.

The shaft is sunk along a 4-foot-wide vein in granite at its intersection with a basic dike. The vein strikes N. 35° E. and dips 70° SE. The dike strikes northwest and is offset slightly along the vein. Oxidized copper minerals, hydrous iron oxides, and argentite are on the dump. The mine is reported to have produced high-grade silver ore.

About 400 feet southeast of the shaft, an adit, known as the Lost Frenchman Tunnel, is excavated 40 feet N. 10° W. into the hillside. Twenty-five feet from the portal, it cuts a northeast-trending vein that contained high-grade silver ore.

About 1000 feet south of the John Malone shaft, a vertical shaft has been put down adjacent to a small tributary of Arrastre Gulch, in the SW¼ sec. 15, T. 20 S., R. 16 W. The depth of this shaft is not known; water now stands to within 60 feet of the collar. The shaft is on a vein which strikes N. 50° E. Pyrite and oxidized copper minerals are on the dump.

Numerous narrow veins traverse the area between the vertical shaft just mentioned and the John Malone shaft, and to the west and southeast of these shafts. The majority contain copper and silver minerals. Some of the veins to the southeast contain specular hematite. Fluorescent calcite is in veins next to some of the diabase dikes in the area between the two shafts.

The John Malone, the Lost Frenchman, and the vertical shaft just mentioned appear to be along a major structure which strikes N. 45° E. This structure lines up remarkably well with the distinct Austin–Amazon fault zone and may be its southwest continuation. A silicified zone or dike along a fault can be traced from near the John Malone shaft northeastward for more than one and a half miles, or more than halfway to the Austin–Amazon mine. The zone offsets a conspicuous diabase dike 4500 feet northeast of the John Malone fault.

Moody workings. Two shafts on some claims owned by Mr. Moody, Silver City, in the N½ sec. 8, T. 21 S., R. 16 W., are on the west side of Road Canyon about one mile above its junction with Thompson Canyon. The southern of the two shafts is about 25 feet deep and has been sunk since 1950. The vein at this shaft is vertical and strikes N. 60° E. Pyrite, specular hematite, and malachite are on the dump. The other shaft is only 20 feet deep. Across Road Canyon, pyrite and selenite are on the dump of a pit.

The shafts and pit are in volcanic rocks, part of the Knight Peak series. Immediately south of the workings, white, soft material cropping out on the hillside may be a tuffaceous bed in the sequence or may be an altered zone along the Taylor fault which forms the contact between granite and younger rocks at this locality (Ballmann).

In the next side canyon north of the Moody workings, there are additional shallow diggings, and on the ridge north of this side canyon, an old inclined shaft is sunk along a vein which strikes north and dips 45° to 50° E. The shaft is at least 50 feet deep. Massive specular hematite, limonite, pyrite, and oxidized copper minerals are on the dump.

White Signal District

The White Signal district includes almost all of T. 20 S., R. 14 and 15 W. and a small area in the southeastern part of R. 16 W. (pls. 3, 4, and 7). It centers around the White Signal store in sec. 23, T. 20 S., R. 15 W. and encompasses the southeastern part of the Big Burro Mountains and the isolated hills and rolling plains south and southeast of the mountains. Some deposits west of White Signal, discussed in this report under *Southwest and Central Burro Mountains,* are sometimes included in the White Signal district.

Fluorspar, uranium, radium, gold, copper, silver, lead, bismuth, turquoise, garnet, and ocher have at various times been produced from the district. Deposits of hematite are present, and rare-earth-bearing pegmatites occur in the western part of the area. Mining started in the 1870's or 1880's, but for much of its history the district has been dormant or has supported only a few small operations. The latest period of activity was during the uranium boom of the late 1940's and early 1950's. The district has been essentially idle since 1956.

Geology

Precambrian granite of the Burro Mountain batholith constitutes the country rock in the district (pl. 8). Included in the granite are small xenoliths of quartzite, schist, and amphibolite. Small rhyolite plugs south and southeast of White Signal and numerous dikes of different ages and compositions intrude the granite. The Tyrone quartz monzonite stock crops out along the northwestern edge of the district.

The granite is essentially homogeneous throughout the area, but in places both coarse- and fine-grained variants are found. Near the Timmer mine, in the extreme eastern part of the area, fine-grained granite intrudes the coarse-grained rock and is itself intruded by pegmatitic granite. Pegmatites, consisting primarily of quartz and microcline but with segregations of muscovite, are common in the eastern part of the district. Local differences in color, texture, mineralogical composition, degree of alteration, and weathering of the granite are noted, but no attempt has been made to statistically analyze these differences nor to separately map and study the variations.

The plugs, which are topographically prominent and form the isolated hills south and east of White Signal (photos 2 and 7), are rhyolite in composition and range in texture from felsitic to porphyritic. Rhyolite breccia is widespread, both within the central parts of the plugs and near their borders. The rhyolite autoliths are angular to subangular and usually show flow banding. Many dikes extend from the plugs into the surrounding rock, and other dikes intrude the granite elsewhere.

In addition to the rhyolite dikes associated with the plugs, other rhyolite dikes (some of which are garnetiferous), diabase, dacite, andesite, latite, quartz latite, and monzonite and quartz monzonite dikes intrude the granite.

Diabase dikes are most numerous south and west of White Signal and are intimately associated with the uranium deposits. They are up to 50 feet wide and some can be followed for more than a mile. Locally, they widen into irregular-shaped masses. The dikes generally show good diabasic texture, but in others the texture is poorly developed or absent; they are essentially equigranular. Variation may be seen within the same dike. The diabase is almost black when fresh but alters to a greenish gray or brown. Pyroxene and andesine (An_{34}) comprise most of the rock, but magnetite and apatite are important accessory minerals. The diabase alters readily and many of the dikes crop out as masses of chlorite, hydrous iron oxide, epidote, and clay minerals.

Quartz monzonite porphyry dikes, which locally grade into monzonite porphyry, latite, and quartz latite, are frequent, particularly in the northern part of the district. Many of these dikes can also be traced for more than a mile and are as much as 50 feet wide. They are genetically associated with the Tyrone stock and are thus considered Early Tertiary or Late Cretaceous. Identical dikes are abundant elsewhere in the Big Burro Mountains. Besides the granite, the quartz monzonite is the only local rock type that can with certainty be correlated with rocks outside the district. It is distinctive as to physical appearance and is important in dating other faults and other dikes, thus working out the sequence of geologic events.

The quartz monzonite porphyry is a light gray, pink or buff, holocrystalline rock with phenocrysts making up 50 to 75 per cent of the rock. The phenocrysts are two to six millimeters in length. They consist of clear, euhedral, equidimensional quartz crystals, which have the rhombohedral faces developed essentially to the exclusion of the prism faces, and euhedral to subhedral feldspar crystals, most of which are orthoclase. Some of the larger feldspar crystals are zoned. Plagioclase feldspar is chiefly oligoclase ($An_{12\text{-}22}$). Biotite and small amounts of hornblende are present. Apatite is an important accessory mineral, and the dikes are high in phosphorus pentoxide.

Andesite, dacite, and garnetiferous rhyolite dikes are less common than the dikes described in detail. The garnets in the latter occur as phenocrysts and are locally abundant. They are distinguished from quartz by their reddish brown color and dodecahedral form. The garnetiferous dikes are concentrated in the area north of White Signal.

Faults transect the White Signal district in two principal directions, east-northeast and north-northwest. Dikes parallel the trend of the faults, many being intruded along fault planes. Some of these may well have developed in Precambrian times. The most conspicuous faults are the Blue Jay, the Walnut Creek, and the Uncle Sam, the latter two being along the same structural trend. The alignment in an easterly direction of the plugs and dikes south of the Blue Jay fault defines an additional line of weakness.

Mineral Deposits

Except for the placer deposits at Gold Lake and the minor concentration of rare-earth-bearing minerals in pegmatites, the mineral deposits of the White Signal district either are fissure-filled veins within simple fractures or wide breccia and fracture zones or are veins resulting from impregnations of wall rock adjacent to fractures. The veins trend northeast to east and northweast to west, similar to the fault pattern of the district. The location of the White Signal district as a mineralized area, was primarily determined by its position at the intersection of structural trends, and the position of the individual deposits within the district is a reflection of this. The majority of the deposits are near the intersection of north-northwesterly and east-northeasterly dikes, fractures, and faults.

Nearly all the deposits are small, the veins often consisting of pods up to 50 feet long and 3 feet wide spaced along a fracture like a string of lenticular beads. Others, however, are of constant widths throughout their known length. Rarely can the veins be traced for more than 500 feet. Major exceptions are the Uncle Sam and Apache Trail veins. These are on the edges of the district and are not typical of the area. Widths of the veins seldom exceed 10 feet, except for the broad breccia and fracture zones, and most deposits are 2 to 3 feet wide.

A number of the veins fill fractures that were previously intruded by dikes. Mineralizing solutions impregnated and altered the dike rock so that the original character of the rock is unrecognizable, and a separation between dike and vein is difficult to make.

None of the deposits has been explored to depths greater than 260 feet; the workings average less than 100 feet deep. Unaltered pyrite or the water table, both indicative of the lower limits of the zone of oxidation, effectively limited the extension in depth, since the primary ores were of too low grade for economical mining. Gold concentrations are confined to within 60 feet of the surface, and oxidized silver, copper, and uranium minerals did not go much deeper. As a consequence, little information about the primary character of the veins is available. Only in the lower levels of the Merry Widow mine was the unoxidized vein observed. Other deep shafts, and in fact almost all the workings, are inaccessible. Information was obtained from examination of dumps, outcrops, old records, and from personal communications with individuals who had mined in the area.

Veins. The numerous veins in the district are grouped into four categories: quartz-pyrite, quartz-specularite, high-silver or lead-silver, and turquoise deposits.

The quartz-pyrite veins are characterized by quartz, pyrite, chalcopyrite, and gold. Other primary minerals are hematite, magnetite, sphalerite, galena, probably uraninite, bismuth, and silver. These are the veins known locally as "gold veins" and they are the most numerous. The bulk of the mining has been done on these veins, which have produced almost all the gold, copper, and uranium mined. All are small, and no single vein has been traced more than a few hundred feet. Limonite, resulting from the oxidation of the pyrite, characterizes the outcropping parts of the veins. Other minerals in the oxidized zone are the ore minerals malachite and azurite, gold, torbernite, and autunite. Bismutite occurs at a number of deposits, and iron phosphates are in the upper sections of the Merry Widow mine.

The quartz-specularite veins are dominantly specular hematite, which normally constitutes 75 to 90 per cent of the vein. Magnetite is abundant locally. Quartz is a minor component; it is invariably present and is intimately mixed with the hematite and magnetite. Small amounts of gold and bismutite are in some of the veins. Torbernite and autunite are in the oxidized zone and may be indicative of uraninite in the unoxidized parts of the deposits. Most of these veins are small and appear to be abundant around Saddle Mountain. Outstanding, however, is the Apache Trail vein in the northern part of the district, which can be traced for more than a mile and is as much as 10 feet wide. The veins are simple fracture fillings plus wall rock, normally granite, that is replaced and impregnated with quartz and specularite.

The high-silver or lead-silver veins are all inaccessible, and individual deposits are classified solely from inspection of dumps and from old records and reports. Seven deposits are placed in this group. All but one, the Red Dodson mine on the south side of Tullock Peak in the central part of the district, constitute the most easterly and southeasterly deposits in the district. Cerargyrite was the principal ore, and only at the Dodson mine is there a report of metals other than silver being produced. Here copper was mined as well as bismuth and lead. Argentite was observed on the dumps of the Blackman and Uncle Sam mines, and barite is reported to have been a gangue mineral at the deposit in the extreme eastern part of sec. 31, T. 20 S., R. 14 W.

Primary minerals are postulated as being chiefly galena and argentite in a gangue of quartz and sometimes barite, with locally small amounts of bismuth and chalcopyrite. Gold was negligible. Uraninite was probably present, as some of the deposits contain secondary uranium minerals.

The Mose Trimmer mine, described later, is about four miles southeast of the Uncle Sam and the Tullock silver mines but is outside the limits of the White Signal district as herein defined. The mineralization of silver-bearing galena in barite and quartz gangue at the Mose Trimmer mine, however, is identical to that postulated for the high-silver group of deposits; thus it probably belongs with this group.

Uranium deposits. Uranium and radium minerals were first identified in the White Signal district in 1920 (F. I. Leach). Torbernite was mined at the Merry Widow, California, Acme, Shamrock, and other properties and was shipped for use in making "radioactive water," "radioactive face powder," and radium salts for medicinal purposes, and for the extraction of radium. The radium boom lasted until the late 1920's. Renewed activity in the late 1940's resulted in extensive prospecting and exploration and culminated in the shipment in 1954 and 1955 of four carloads of uranium ore averaging between 0.1 and 0.2 per cent U_3O_8 from the Floyd Collins and Inez deposits. The total amount of uranium and radium recovered is unknown.

Uranium is found in the district as concentrates of secondary phosphates along fractures in altered granite and dike rocks and as disseminations scattered through the altered rocks within the zone of oxidation. The concentrations of secondary phosphates are usually along or within dikes of diabase or intermediate composition. Some, however, are in fractures in granite in proximity to such dikes, and a few deposits are in granite with no apparent relationship to any dikes. The dikes with which the secondary uranium deposits are associated have a high phosphorus content.

The deposits are zones of closely spaced fractures coated or filled with autunite or torbernite. The fillings are rarely more than one millimeter thick. The richer concentrations are in zones in altered granite or dike rock where the fractures are more closely spaced and where, in addition, the uranium minerals are disseminated through the altered rock. Some zones are several feet thick and, in places, as at the Floyd Collins and Inez deposits, comprise the entire width of the dike.

Most of the deposits can be traced for only short distances, but a few can be followed for more than 500 feet along the strike. The more persisent deposits, with few exceptions, trend northwest. Except for the Apache Trail, the major uranium deposits are associated with quartz-pyrite veins as a rule at or near the intersection of the quartz-pyrite veins and northwest-trending diabase dikes.

Acme–Utah–California. The Acme–Utah–California deposit is in the SE¼ sec. 22, T. 20 S., R. 15 W. on claims owned by A. G. Hill, Colorado Springs, Colorado, and A. A. Leach, Lordsburg. Two inclined shafts, respectively 18 and 35 feet deep, a shallow pit, and an open cut constitute the workings on the Acme claim. Numerous pits are on the Utah claim, and four shafts, the deepest not more than 40 feet, and several pits are on the California claim. Four diamond drill holes have also explored the vein, and State Highway 180 crosses the Utah claim and exposes part of the mineralized zone.

Diabase and rhyolite dikes traverse the granite at the deposit. The diabase dikes trend northwesterly from the southernmost shaft on the California claim to the Acme shafts. The dikes dip 50 to 90 degrees southwest and are as much as 65 feet wide. The diabase is extremely altered near the shafts and consists mostly of limonite, chlorite, and clay. North-northwest-trending and east-trending faults cut the diabase dikes.

Uranium mineralization is scattered through a zone that extends northwesterly from the southern boundary of the California claim to the Acme shafts and is coincident with the zone of northwest faulting and diabase dikes. The deposits are localized where the diabase dikes are cut by north-northwest-trending faults. The veins which fill the faults consist of quartz, hydrous iron oxides, and locally torbernite. Uranium minerals also occur disseminated in the altered diabase, and at the Acme shaft, a 10-foot-wide diabase dike is radioactive across its entire width. The most intense radioactivity, however, and the greatest concentration of torbernite, is along the contact between the granite and diabase.

Torbernite also fills fractures in the western end of the highway cut on the Utah claim and, more abundantly, in a 40-foot-wide zone of shattered granite in the eastern end of this cut (photo 10). Drill holes in this

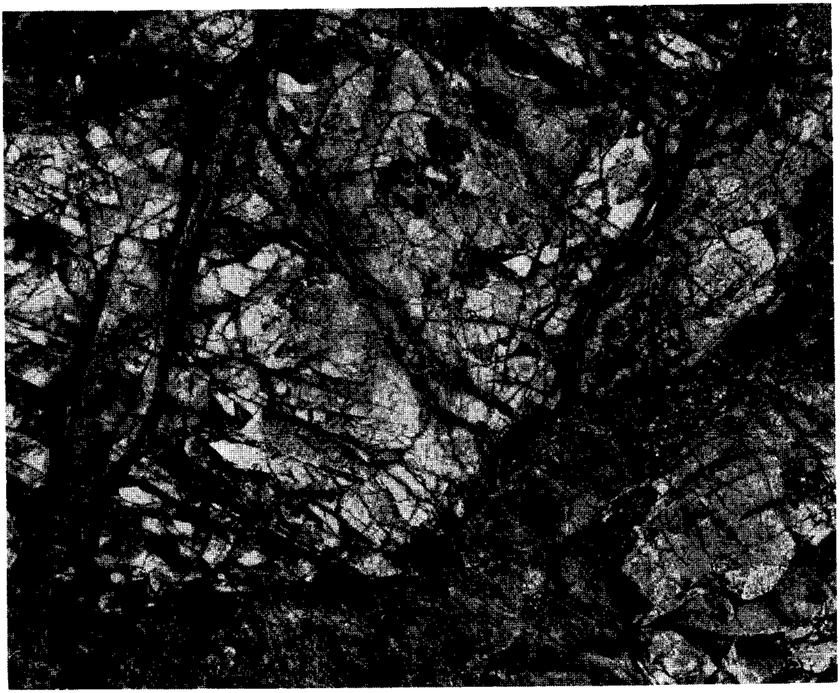


Photo 10

FRACTURED GRANITE, THE FRACTURES CONTAINING SEAMS AND COATINGS OF TORBERNITE

South side of State Highway 180 on the Utah claim 0.9 mile west of the White Signal store. The 1- to 2-inch dark-colored alteration zones in the granite adjacent to the fractures are characteristic of fractures at this locality that contain radioactive material.

area showed radioactivity at intervals to a depth of 165 feet. An east-trending fault, obscured by the highway, cuts the granite at this locality.

Apache Trail. The Apache Trail deposit is about three miles north of the White Signal store in the NE$\frac{1}{4}$ sec. 2, T. 20 S., R. 15 W. It is owned by Charles Russell, Tyrone, and Mrs. Elsie R. Wiley, Los Angeles.

The claim was originally located for copper about 1890, but early production is not known. Between 1915 and 1920, five carloads of copper ore averaging 5 per cent copper and 5 ounces of silver a ton were shipped. In the 1920's, about 50 tons of ore containing 1.5 ounces of gold a ton and 4 per cent bismuth were shipped from a pit near the old shaft. In 1944, radioactive material was identified in the vein and in an adjacent dike. A 200-foot-deep vertical shaft with levels at 100 and 200 feet, an old caved inclined shaft, and numerous pits explore the property.

At the mine, a quartz-specularite vein which strikes east and dips 60 to 65 degrees north cuts the Burro Mountain granite (fig. 7). It can be traced for more than a mile west and more than 2000 feet east of the shaft. It averages 3.5 feet wide but in places is as wide as 8 feet. Paralleling the vein, and cut by it in at least two places on the surface, is a diabase dike. The vein consists essentially of specular hematite, hematite, magnetite, and quartz. Locally, gold, bismuth, copper carbonates, limonite pseudomorphs after pyrite, fluorite, lead minerals, and uranium minerals are present.

In the mine, a fault which strikes north 65 to 75 degrees west is exposed on the 100-foot level. The copper mined was along this fault. A brecciated zone along the fault contains fragments of the quartz-specularite vein. The diabase dike is exposed near the west end of the drift.

Torbernite was recognized only within and adjacent to the dike in the west end of the 100-foot drift, but in numerous places on the surface, the quartz-specularite vein is radioactive. The torbernite occurs as well-developed, green, transparent crystals, individually and in clusters, in vugs and along fractures.

Intense sericitic alteration of the granite along both copper and quartz-specularite veins has locally converted the granite to a white, fine-grained, powdery mass of quartz and sericite. In places, this alteration extends as much as five feet from the vein. The diabase dike is chloritized and altered to a soft brownish rock adjacent to the quartz-specularite vein. At one locality, fibrous crystals of bronzite more than six inches long have developed along the margins of the dike.

The Apache Trail deposit represents a potentially large deposit of high-grade iron ore, although detailed mapping, sampling, and core drilling are needed to prove an economical resource. Impurities may detract from its desirability. The gold, bismuth, and uranium content of the vein is apparently not great, but no thorough exploration has been made.

Blue Jay. The Blue Jay deposit is described in detail by Granger and Bauer (1950) and Lovering. It is in the N½ sec. 26, T. 20 S., R. 15 W., three fourths of a mile south of the White Signal store and 400 feet west of State Highway 169. In 1961, the claim was owned by C. O. and Fred Prevost, White Signal. It is explored by numerous pits and trenches.

The deposit lies along the east-northeast-trending Blue Jay fault, which at this locality is resolved into several closely spaced subparallel faults and dikes intruded along the faults (fig. 8). Isolated segments of dikes occur within the shear zone. The dike rocks are so intensely altered that their original character is difficult to discern; clay and hydrous iron

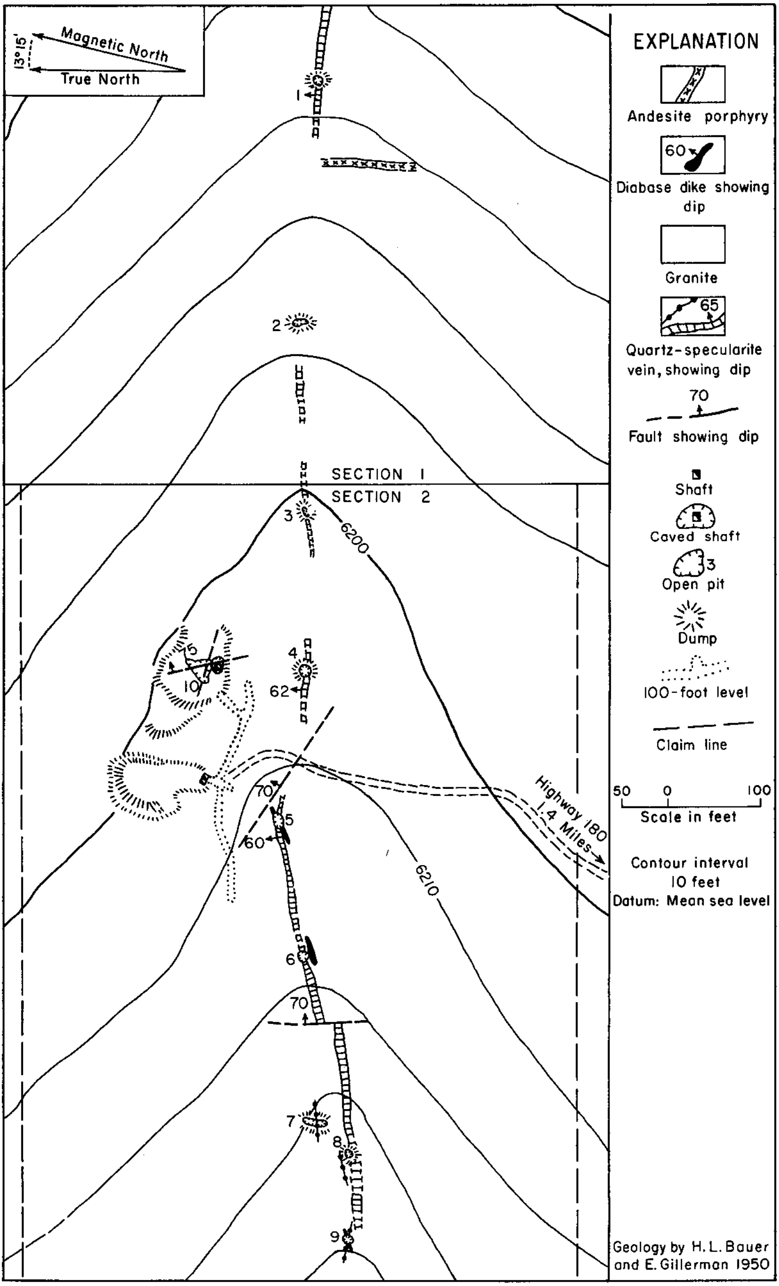
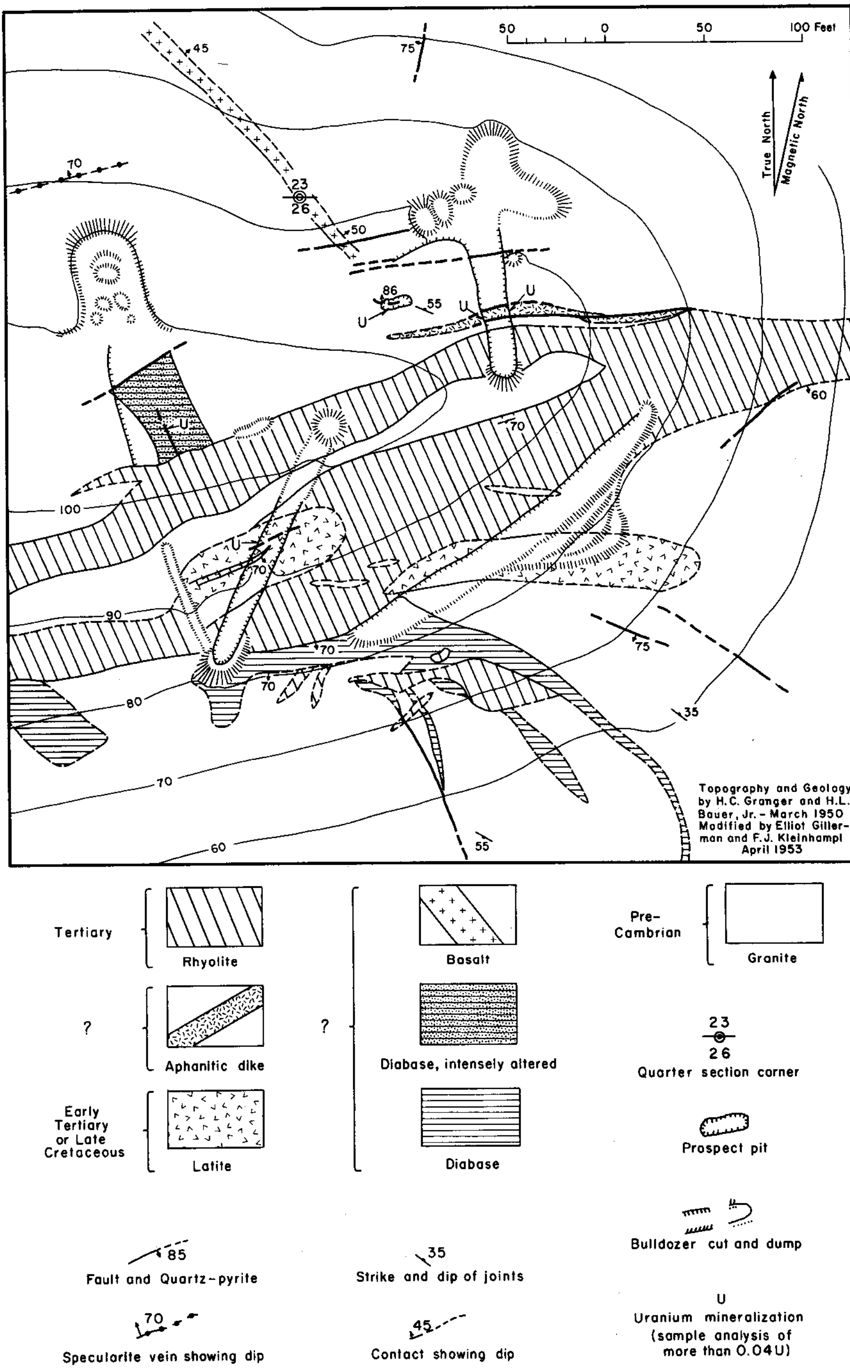


Figure 7

GEOLOGIC MAP OF THE APACHE TRAIL DEPOSIT, WHITE SIGNAL DISTRICT


50 0 50 100 Feet
True North
Magnetic North
Topography and Geology by H.C. Granger and H.L. Bauer, Jr. - March 1950 Modified by Elliot Gillerman and F.J. Kleinhampl April 1953
100
90
80
70
60
Tertiary
Rhyolite
?
Aphanitic dike
Early Tertiary or Late Cretaceous
Latite
?
Basalt
Diabase, intensely altered
Diabase
Pre-Cambrian
Granite
23
26
Quarter section corner
Prospect pit
Bulldozer cut and dump
85
Fault and Quartz-pyrite
35
Strike and dip of joints
U
Uranium mineralization (sample analysis of more than 0.04U)
70
Specularite vein showing dip
45
Contact showing dip

oxides are now the major constituents. The granite country rock is sericitized. Small quartz-pyrite veins, the pyrite oxidized to limonite, fill some of the faults and are bordered by argillized and sericitized wall rock.

Uranium minerals were seen at only a few places along the zone. They are most abundant in the eastern part of the deposit. Torbernite and autunite coat fractures and impregnate an altered dike rock, probably originally latite, which is intruded along the fault. A nearby rhyolite is unmineralized and relatively unaltered. Pitchblende also was identified from this locality, the only known occurrence of an unoxidized uranium mineral in the White Signal district. Sample analyses across a five-foot width of the dike showed 0.12 per cent uranium.

The Blue Jay is one of the most promising uranium deposits in the White Signal district, but additional exploration, including drilling, needs to be done to adequately test grade and extent of mineralization.

Banner. A caved shaft and two prospect pits on the old Banner patented claim in the NW¼ sec. 26 and NE¼ sec. 27, T. 20 S., R. 15 W. are sunk along a vein which strikes N. 70° E. and dips 70° SE. The vein is along the Blue Jay fault, half a mile west of the Blue Jay deposit. Pyrite is on the dump of the old shaft, and the dump and ore in the pit contain radioactive material. This is undoubtedly a western extension of the Blue Jay deposit.

Floyd Collins. The Floyd Collins deposit, owned by A. A. Leach, Lordsburg, is in secs. 21 and 22, T. 20 S., R. 15 W. It was opened first in 1920 or 1921 for radium, and, unlike most other deposits in the district, neither gold nor copper minerals are present. Autunite and torbernite were mined in the 1920's and processed into radium salts by A. A. and F. I. Leach. No production figures are available. In 1944, the deposit was mapped and studied by Union Mines Development Company (S. B. Keith, unpublished report). In 1954, the property was leased to the Atrimas Mining Company, and two carloads of ore assaying between 0.1 and 0.2 per cent U_3O_8 were shipped to the mill at Bluewater, New Mexico. Operations ceased in 1955, but in 1959, the mine was reopened by the owner and shipments resumed. It was idle in 1961.

The mine is developed by two inclined shafts, respectively 40 and 80 feet deep, with drifts, pits, and open cuts.

A 15- to 20-foot-wide diabase dike traverses Burro Mountain granite, striking N. 20° W. and dipping steeply northeast (fig. 9). Subparallel faults form the hanging and footwalls of the dike, or traverse granite within a few feet of the contact. Within the mineralized area, the diabase is altered to a soft, earthy, yellow-brown mass of clay, iron oxides, and hydrous oxides.

The major mineralized zone is confined to the altered diabase where the fault forms the footwall or lies within 20 feet of the dike. The adjacent granite is only slightly mineralized. The mineralized zone is 20

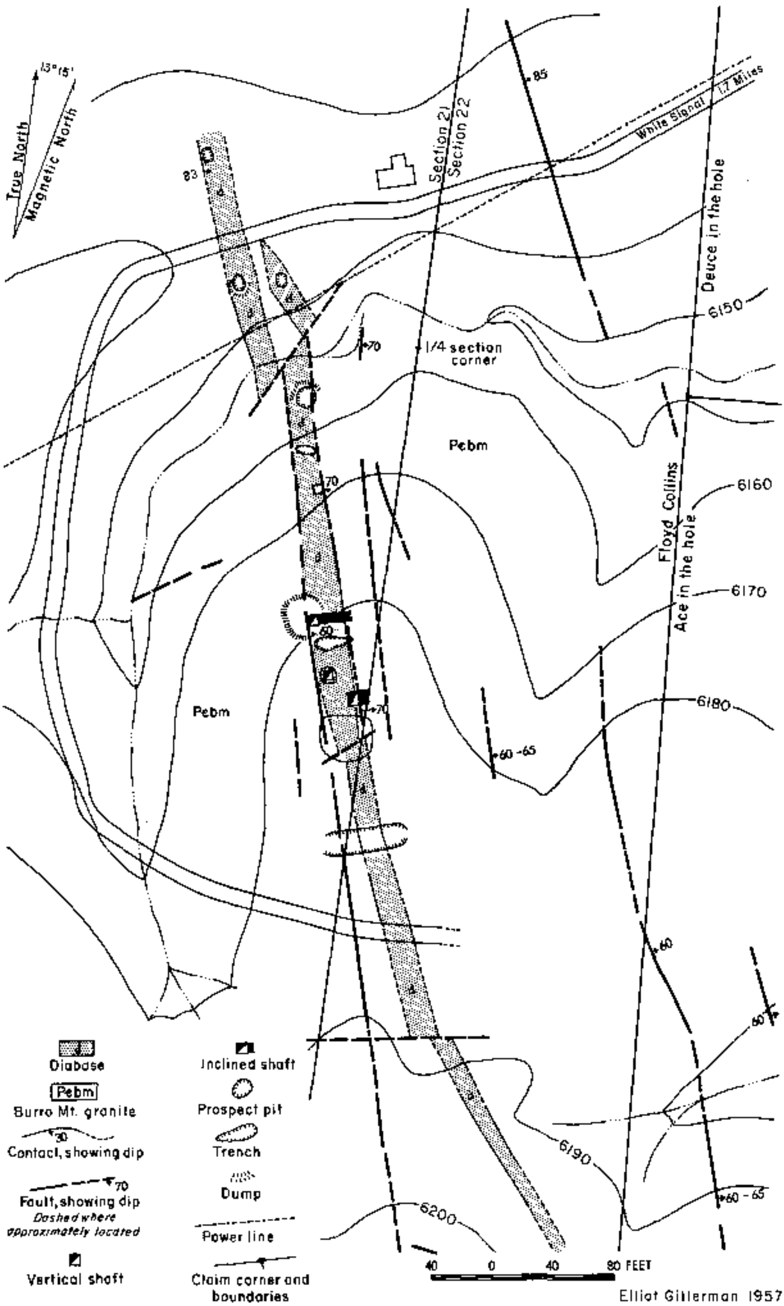


Figure 9

GEOLOGIC MAP OF THE FLOYD COLLINS DEPOSIT, WHITE SIGNAL DISTRICT

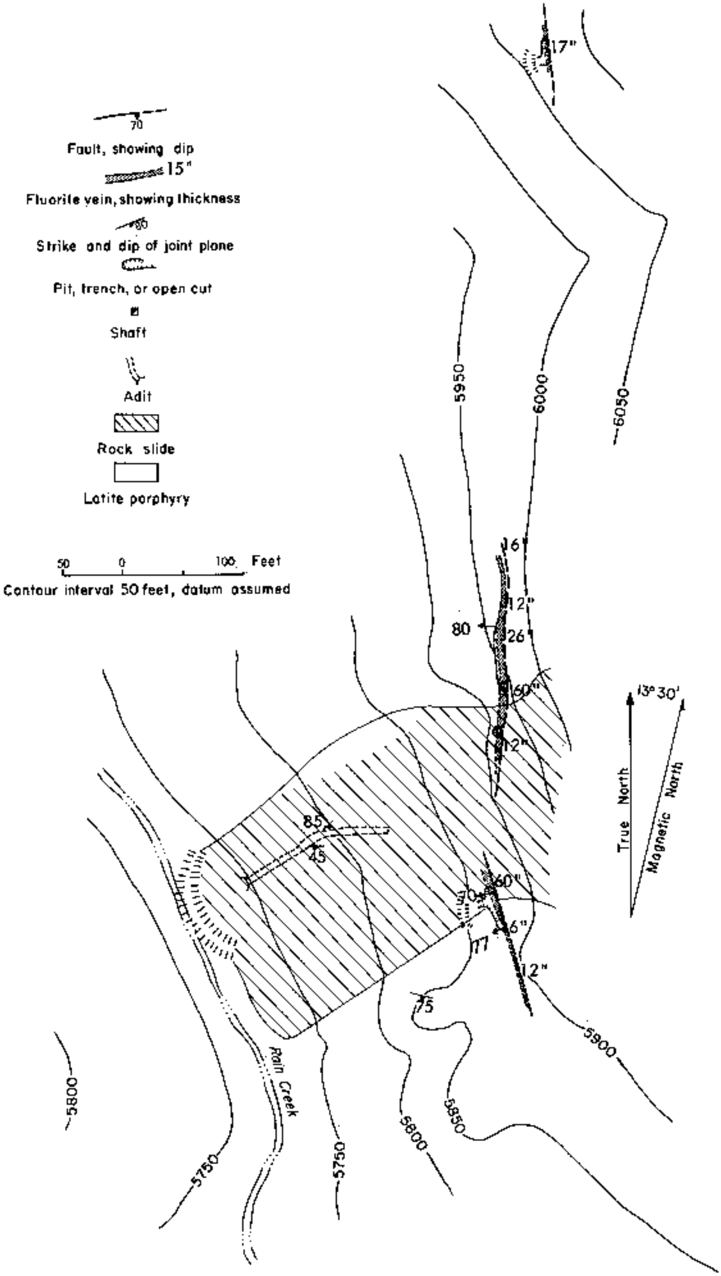


Figure 30

GEOLOGIC MAP OF THE RAIN CREEK (GOOD HOPE) FLUORSPAR DEPOSIT, SACATON MESA AREA

feet wide at the shaft and extends more than 400 feet along the strike. Radioactivity is present elsewhere along the zone. Autunite and torbernite are the ore minerals. Quartz, secondary iron minerals, and altered wall rock are the gangue. Pyrite occurs on the dump.

The uranium minerals fill small cavities and form numerous irregular veinlets, 0.1 to 0.5 millimeter wide, which traverse the intensely altered and fractured diabase. Slightly wider veinlets contain black and brown limonitic material, clay and locally a few crystals of torbernite. The close spacing of the veinlets in some parts of the zone results in a high concentration of uranium, with values up to 0.77 per cent U_3O_8. The mineralized diabase is similar to the "ore" at the Blue Jay, California, Inez, and other deposits, differing only in the greater density of veinlets and resulting higher concentration of uranium.

Inez. The Inez uranium deposit is in the SE¼ sec. 24, T. 20 S., R. 15 E. on a patented claim owned in 1959 by R. L. and C. A. Shipp, Mathis, Texas. The deposit was found by A. J. Gude III and me during the course of a radiometric survey of the White Signal district in 1961 for the U.S. Geological Survey. In 1954, the deposit was leased to Phil Tovrea, White Signal, who shipped two carloads of ore averaging 0.2 per cent U_3O_8. Workings consist of open cuts, an adit level, and some pits that extend 200 feet along the vein to a maximum depth of 40 feet. The deposit was also explored by diamond drilling (fig. 10).

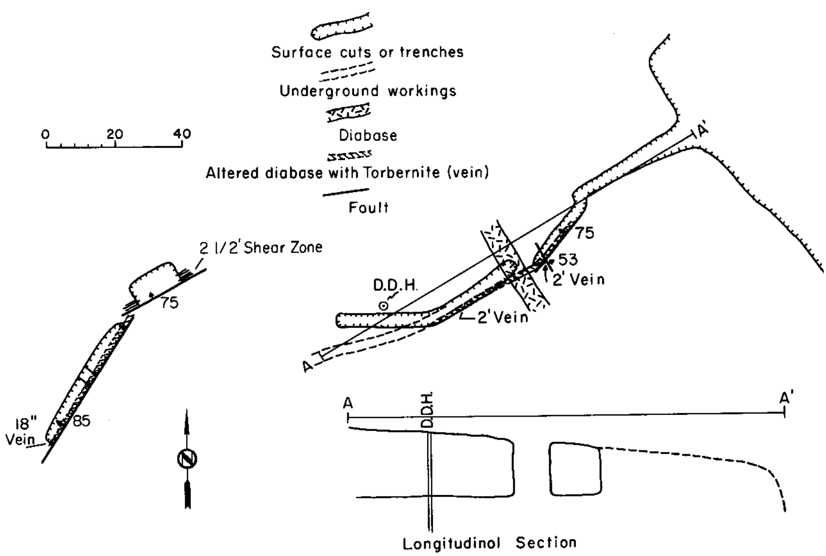


Figure 10

GEOLOGIC MAP AND SECTION, INEZ DEPOSIT, WHITE SIGNAL DISTRICT

A northeasterly trending vertical diabase dike traverses granite and is intensely altered to chlorite, epidote, and hydrous iron oxides. Torbernite impregnates the dike rock, probably filling minute veinlets as at the Floyd Collins. At the workings, the dike is 2 to 5 feet wide. Cross faults displace the dike. Other diabase dikes are in the vicinity but are not radioactive. The deposit is about 1200 feet north of the Blue Jay fault and near the southern extension of the western branch of the Walnut Creek fault, both major faults in the area.

The original Inez shaft, mined for gold, is about 500 feet north-northwest and the Hummer shaft, also mined for gold, is 1200 feet south along the Blue Jay fault. Radioactivity was recorded at both these localities.

Merry Widow. The Merry Widow deposit is undoubtedly the best known and most widely publicized uranium deposit in the White Signal district. It was extensively studied by Granger and Bauer (1952), by Lovering, and by Keith (unpublished report, 1945). Uranium minerals were first discovered in the district in 1919 (F. I. Leach) on old dumps at the Merry Widow mine, and most of the radium produced in the district was from ore mined at the Merry Widow. Torbernite, radioactive clay, and sericite were mined and processed into face powder and other products during the "radium boom" of the 1920's. The deposit was opened originally for gold in 1910. The 150-foot shaft is one of the deepest in the district and one of the few places where primary ore minerals have been observed. Levels at 40, 60, 90, and 130 feet explore the ore body (pl. 9). It was accessible in the 1940's.

The Merry Widow shaft is sunk along an east-trending fault near where it cuts and displaces two diabase dikes (pl. 10). A latite(?) dike is intruded along the fault. Dike and wall rock are brecciated and the fractures are filled with quartz and pyrite. The main vein can be traced for about 100 feet east and 200 feet west of the shaft.

Gold, in narrow streaks on the upper levels, is associated with bismite, bismutite, and hematite. No gold was found in the deeper parts of the mine. Ore minerals consist of chalcopyrite, pyrite, hematite, and magnetite. Siderite and quartz are the gangue minerals. Autunite, torbernite, and an iron-uranium phosphate are the uranium-bearing minerals identified. The autunite is present only in the upper few feet of the deposit, and the iron-uranium phosphate was found only in the lower levels. The uranium minerals coat fractures, project into small cavities, and are disseminated in the granite, diabase, and latite(?). The greatest concentrations were on the upper levels near the shaft. Diamond drill holes cut a radioactive quartz-pyrite vein 520 to 550 feet below the collar of the shaft. The pyrite was partly oxidized and the granite altered and iron-stained. No uranium minerals were identified from the vein, but the radioactive material consisted of amorphous dark green and black minerals which contained 0.2 per cent effective uranium.

Detailed analyses of the vein by Keith (unpublished report, 1945) and by Granger and Bauer (1952) indicated that the concentration of uranium minerals within the mine is erratic. The greatest concentrations are in the upper levels where ore containing 0.25 per cent uranium is present. On the lower levels, only a few samples contained more than 0.1 per cent uranium.

Alhambra–Bluebell No. 2. At the Alhambra–Bluebell No. 2 deposit in the NE¼ sec. 21, T. 20 S., R. 15 W., a diabase dike strikes N. 20° W. and dips northeast. The dike is much shattered, with closely spaced fractures parallel to the borders near the hanging and footwalls. Torbernite is abundant on the fracture surfaces and in the adjacent granite. Two shallow shafts explore the property, and radioactivity can be identified intermittently along the dike for 400 feet.

Shamrock. The Shamrock deposit in SE¼, sec. 23, T. 20 S., R. 15 W. is owned by C. O. and Fred Prevost, White Signal. Two diabase dikes strike N. 40° W. and are cut by several northeast-trending quartz-pyrite veins which contain gold and copper. Pits, trenches, and shafts have been excavated along the veins. Uranium mineralization occurs in a shaft at the intersection of the largest dike and the major quartz-pyrite vein. It is concentrated in the dike, along the fault, and in adjacent granite. Weak radioactivity was recorded at quartz-pyrite veins north of the shaft.

Eugenie. The Eugenie mine in the NW¼ sec. 26, T. 20 S., R. 15 W. was opened by C. O. and Fred Prevost in 1913 and operated by them intermittently until 1925. High-grade copper and gold were mined, and according to C. O. Prevost (oral communication), two carloads of ore shipped in 1913 and 1914 averaged 29.6 per cent copper, 12.6 ounces of gold a ton, and 14 ounces of silver a ton. Also, 500 pounds of torbernite were shipped to San Francisco in the early 1920's.

An 80-foot-deep vertical shaft is sunk along a quartz-pyrite vein that strikes N. 55° E. and is almost vertical. Drifts 30 to 40 feet long run in each direction from the bottom of the shafts. Stoping adjacent to the shaft reaches almost to the surface. About 40 feet southwest of the shaft, a diabase dike striking N. 45° W. and dipping 45° NE intersects the vein.

Fine-grained, sooty chalcocite is reported to have been the chief copper ore. Torbernite is found on the mine dump.

Paddy Ford. The Paddy Ford shaft is in SE¼ sec. 23, T. 20 S., R. 15 W. on a group of patented claims owned by the Fritz Buck Estate (Mrs. Alvina Pillar, Stanton, Nebraska, administrator). The claim was located and the shaft sunk in the 1900's by a Dr. Mueller. It was retimbered and leased to C. O. and Fred Prevost in 1914, who shipped two carloads of ore averaging 16.8 per cent copper, 10 ounces of gold a ton, and 8 to 10 ounces of silver a ton (C. O. Prevost, oral communication). It has been idle since the early 1930's.

The shaft is 120 feet deep, with drifts 25 to 30 feet long in each direction from near the bottom. The vein is stoped almost to the surface. Water was encountered at 120 feet when the shaft was sunk.

The shaft is along a vein which strikes N. 85° E. and dips 80° S. A few feet east of the shaft a conspicuous rhyolite dike strikes north and dips 85° W. One hundred feet north of the shaft, a fault along a diabase dike striking N. 65° W. displaces the rhyolite dike 100 feet eastward. A subparallel vein about 200 feet north of this fault is exposed on both sides of the rhyolite dike. In the Paddy Ford shaft, the vein is 1 to 2 feet wide, and according to C. O. Prevost (oral communication), ore occurred along it in pods.

Radioactivity was recorded at the Paddy Ford along the vein north of the shaft and in other nearby prospect pits.

Calamity. The Calamity mine in the SE¼ sec. 23, T. 20 S., R. 15 W. was originally located by a Mr. Jackson about 1900. A vertical shaft 100 feet deep is sunk along a vein striking N. 75° E. and dipping 85° S. Several pits and trenchs also explore the vein for 500 feet both east and west. In 1955, the entire area was bulldozed in the exploration for uranium.

Jackson shipped copper and gold from the property between 1900 and 1908; in 1917, it was reactivated and additional gold and copper produced. Oxidized copper minerals and pyrite are on the dump, and radioactivity was recorded at the shaft and along the vein. The vein is one foot wide at the shaft. A diabase dike intersects the vein less than 100 feet west of the shaft, and the rhyolite dike adjacent to the Paddy Ford to the north intersects the vein about 500 feet west of the shaft.

New Years Gift. The New Years Gift mine was first located by Judge Deming in 1884 and was one of the first deposits opened in the district. He shipped $8000 worth of ore. The mine was relocated in 1913 by C. O. and Fred Prevost, who still own the patented claim. The two shafts on the property were filled in 1948 or 1949, and the present roadbed of State Highway 180 was built over them. The claim is in the S½ sec. 23, T. 20 S., R. 15 W.

The mine was worked in 1914 by Warnock and Walters, who shipped about a carload of ore, assays of which showed 8 to 10 ounces of gold a ton and 6 to 8 per cent copper (C. O. Prevost, oral communication). In the late 1920's and early 1930's, C. E. Elayer, a Mr. Metcalf, and others operated the mine. At least one carload of ore was shipped, mostly from the second shaft which was sunk during this period to a depth of 122 feet. The original shaft was 84 feet deep. Ore from the deeper shaft averaged 16 to 18 per cent copper and 15 to 20 ounces of gold a ton. C. O. Prevost estimates that a total of 30 tons of ore averaging 8 to 10 ounces of gold a ton and 6 to 8 per cent copper were shipped after 1913.

The two shafts were on separate veins, both of which strike about due east. The veins were 100 feet apart on the surface. They dipped toward each other, the vein in the deeper shaft dipping steeply south, that in the shallower shaft steeply north.

The veins were both typical quartz-pyrite, and besides gold and copper minerals, bismutite and torbernite are recorded.

The claim adjoins the Merry Widow on the south, and the two parallel diabase dikes which extend south from near the Merry Widow shaft intersect and are displaced by the New Years Gift veins. The shafts were probably near these intersections; cover and highway fill make observation of this impossible.

Red Bird. The Red Bird mine in the extreme southwestern corner of sec. 23, T. 20 S., R. 15 W. was opened prior to 1905. It is reported to be about 200 feet deep. The shaft is sunk on a quartz-pyrite vein adjacent to a rhyolite dike. Both vein and dike strike S. 75° E. and dip 80° S. The vein is about 1.5 feet wide at the collar of the shaft.

Abundant pyrite and limonite are on the dump. The yellowish red oxidized material which constitutes most of the large dump is radioactive. According to C. O. Prevost (oral communication), no metallic minerals were mined, and assays of the dump are negative regarding copper and gold. Several tons of material were shipped as ocher for use by paint companies, and tests by the Williams Paint Company, St. Louis, in the 1930's indicated the suitability of the material for this purpose.

Bisbee. The Bisbee mine in the SE¼ sec. 27, T. 20 S., R. 14 W. is explored by two shafts, one adit, and a number of pits. The mine was worked by Thomas Carter about 1895 and by George Bisbee between 1905 and 1910. The shafts are 80 to 90 feet deep, and the adit goes for 100 feet along the vein. The vein strikes N. 65°-85° E. and is nearly vertical. At the adit it is three feet wide. A basic dike intersects the vein near the main shaft. Many subparallel rhyolite dikes are within a few hundred feet north of the vein.

Gold reported to have been high grade (C. Russell, oral communication) was the major metal produced. The vein is radioactive at the main shaft and elsewhere, but no uranium minerals were observed.

Edmonds shaft. South of the Bisbee mine in the center of sec. 34, T. 20 S., R. 15 W., Long and Edmonds sank a shaft in the late 1930's on a vertical vein in granite that strikes S. 85° E. A fault striking N. 35° W. intersects the vein a few feet from the shaft. Galena, pyrite, and what may be sphalerite are on the dump. Gangue minerals are principally carbonates. Silver is reported in the ore and is said to have been the major metal mined.

Paymaster and adjoining properties. The Paymaster claim, owned by the Fritz Buck Estate (Mrs. Alvina Pillar, Stanton, Nebraska, administrator), is in the southwestern corner of section 21 and the northwestern corner of section 28. Two shafts, one near each end of the claim, some pits, and an adit are excavated upon two separate veins. The northern shaft is on a vein that strikes N. 85° E., dips steeply, and is along the north contact of a rhyolite dike and granite. Basic dikes are within a few feet and on both sides of the rhyolite dike just east of the shaft. Shaft exposures are reported to contain lead and silver. The vein is radioactive at the shaft.

At the southernmost shaft, the vein strikes N. 80° E. and dips 70° NW. It is on the south side of a 50-foot-wide quartz monzonite porphyry dike. Pits and a shallow shaft explore a parellel vein traversing granite a few feet north of the quartz monzonite porphyry dike. The veins were mined for gold.

South of the Paymaster claim, an old shaft and some pits explore two veins which strike N. 85° E. and S. 80° E. and dip 70° and 65° N., respectively. They are near a basic dike. The veins are reported to have been mined for gold and copper in the 1900's. Both are radioactive.

The Silver Lode claim in the SE¼ sec. 21 also belongs to the Fritz Buck Estate. An old shaft is sunk along a 3-foot-wide vein on the south side of a 2-foot-wide basic dike. Dike and vein strike east and dip 85° N. The dike is much altered. No information is available as to the mineral content of the ore.

Hummer and Inez mines. The Hummer mine (also called the Good Luck) is in the SE¼ sec. 24, T. 20 S., R. 15 W. on one of a group of three patented claims that include the Inez uranium deposit, owned by R. L. and C. A. Shipp, Mathis, Texas. The mine was originally opened by a Mr. Copeland, probably about 1900.

The shaft is excavated on a quartz-pyrite vein lying adjacent to a 75-foot-wide rhyolite dike. Both dike and vein strike N. 70° E., are vertical, and are within or very close to the Blue Jay fault zone. The depth of the shaft is presumed to be in excess of 100 feet.

Pyrite and limonite were observed on the dump, and radioactivity was recorded in the shaft for a depth of 50 feet and at some pits west of the shaft. No copper minerals were found. The deposit was mined for gold; an old arrastre once existed near the shaft.

The Inez shaft, about 600 feet north of the Inez uranium deposit, is along a vein on the hanging wall wide of a basic dike trending N. 5° W. and dipping southwest. It, too, was mined for gold. No radioactivity was recorded at this shaft.

Combination. The Combination mine is in the NE¼ sec. 23, T. 20 S., R. 15 W. about 1000 feet south of the White Signal schoolhouse. Ben Lazwell operated the property between 1910 and 1915. Between 1931 and 1943, Charles Russell shipped 10,000 tons of ore containing gold and silver. In the 1940's, Bob Crosby operated the property and still owned it in 1961. It has been idle since the early 1950's.

Three shafts and many pits explore a series of parallel veins which strike N. 45° E. One shaft is 130 feet deep, another 60 feet deep. Copper and gold, the latter averaging 10 to 12 ounces a ton, were mined by Lazwell. Russell and Crosby shipped gold ore. Nearly all the veins are radioactive.

Copper Glance. The Copper Glance deposit is in the NE¼ sec. 23,

T. 21 S., R. 15 W. about 1000 feet southwest of the Combination mine. A shaft reported to be 85 feet deep with a drift on the 25-foot level is near the northeastern end of the property. A long trench and open cut explored the vein southwest of the shaft.

John Jeffers shipped gold from the open cut in the early 1890's, and Bill Sellers mined and shipped a carload of copper ore from the shaft in the 1920's.

In the shaft, the vein is 3 feet wide and strikes N. 45° E. A rhyolite dike intersects it a few feet south of the shaft. Radioactivity was recorded at a small pit a few hundred feet northeast of the shaft on a parallel vein.

Golden Eagle. The Golden Eagle shaft was a few hundred yards north of the White Signal store. It was operated about 1905 for gold and copper. The shaft was sunk about 80 or 90 feet to unoxidized pyrite vein material. Gold was in economic concentrations to this depth.

Deposits west of Tullock Peak. Northwest of Tullock Peak, between State Highway 180 and Walnut Creek in the NE¼ sec. 14, T. 21 S., R. 15 W., is an old open cut and some prospect pits that were first opened for gold by a Mr. Brachman in the 1880's. The deposit was worked by Marshall Kuykendahl, Lordsburg, in the 1930's. The ore was high grade but did not extend to depth.

West of Walnut Creek in the NW¼ sec. 14, T. 21 S., R. 15 W. is an old shaft and some pits believed to have been sunk about 1910 or 1912 by a Mr. Hedrick. The shaft is 120 feet deep with a drift cut west 100 feet toward a rhyolite dike. Three to four tons of ore assaying 10 to 12 ounces of gold a ton were found near the surface, but the vein was essentially barren at depth.

Tullock shaft. The old Tullock shaft in the SE¼ sec. 25, T. 20 S., R. 15 W. is on a group of patented claims owned by Mrs. R. D. Tullock, Silver City. The vertical shaft was sunk prior to 1900. It is 260 feet deep, probably the deepest shaft in the district. Drifts are at 200 and 260 feet, but their length or direction is unknown. A crosscut is reported (C. O. Prevost, oral communication) to have been driven from the bottom of the shaft. In 1960, the shaft was accessible for 150 feet, having been recently rehabilitated.

The vein strikes N. 70° W., is vertical, and is 3 to 4 feet wide at the shaft. Copper was mined from the shaft, and chalcocite is reported to have been in the drifts. Pyrite is abundant on the dump, and azurite and torbernite occur. A radioactive vein striking N. 45° W. crops out 50 feet east of the vein. A drift or crosscut on the lowermost level is reported to have intersected this vein and a diabase dike; torbernite was abundant at this locality. Other northwest-trending radioactive veins are in the vicinity.

In 1959, the property was leased to the Micronesia Metal and Equipment Company, Washington, D. C. A small shaft, 80 feet east of the main shaft, was sunk along a nearly vertical vein striking N. 5° W. Azurite was plentiful near the surface, and the ore assayed 9 per cent copper, but it did not extend to depth and work was abandoned at 30 feet. Chalcedony and opal veinlets were abundant in the rhyolite within which the shaft was sunk; locally, the rhyolite was colored brilliant red. About 25 tons of ore were shipped.

Uncle Sam. The Uncle Sam mine in sec. 32, T. 20 S., R. 14 W. is on a group of four patented claims owned by Mrs. Emily H. Hagen, Silver City. The deposit is explored by a number of shafts, pits, and adits extending nearly 4000 feet along a shear zone in granite which strikes N. 45° W. The main shaft is reported to be 100 feet deep with drifts northwest and southeast (C. R. Russell, oral communication). At the main shaft, the vein is 8 feet wide and dips 65° SW, but north of the shaft it is more nearly vertical and narrower. The shear zone is up to 20 feet wide and on or near what is probably a major fault zone, termed herein the Uncle Sam fault.

The deposit was mined for silver in the early 1900's or before by Joe Sheridan and Jack Fleming. The ore was very high grade; one pocket is said to have produced $20,000 worth of ore. It was last operated by Robert Crosby in the 1940's. Cerargyrite was the major ore mineral, but galena, argentite, pyrite, and wulfenite are present. Quartz is the major gangue mineral. Unidentified radioactive minerals were recorded at several places along the vein for more than 2000 feet. The deposit is described by Lovering.

Silver properties near the Uncle Sam mine. A number of old silver properties lie northwest and west of the Uncle Sam mine.

In the W½ sec. 32, T. 20 S., R. 14 W. across Walnut Creek from the Uncle Sam claims are two shafts and several pits sunk along a N. 45° W. vein which dips 75° SW and parallels the Uncle Sam vein. This is the old Tullock silver mine, operated in 1885 and 1886, from which high-grade cerargyrite was produced in quantity.

The old Sellers mine is northeast of the Uncle Sam mine and Tullock silver mine in the SW¼ sec. 30, T. 21 S., R. 14 W. on the southeastern side of Saddle Mountain. It also was worked for silver, probably cerargyrite. Copper is reported to have been found.

V. Tullock in 1937 shipped two carloads of silver from a property less than half a mile west of the old Tullock silver mine, in the E½ sec. 31, T. 21 S., R. 14 W. The ore averaged more than 70 ounces of silver a ton and contained barite.

Red Dodson adit. About 1910, Red Dodson shipped 25 to 30 tons of high-grade silver ore assaying $200 to $300 a ton from a property in the E½ sec. 14, T. 20 S., R. 15 W., on the southwest side of Tullock Peak. An adit, now caved, was driven 200 feet into the hill, and an old shaft, now filled, was sunk 60 to 80 feet. The ore was cerargyrite, but a streak of high-grade, silver-bearing galena was present in the adit. Bismuth occurred in the ore and some copper.

Timmer mine. The Timmer mine in SE¼ sec. 15, T. 21 S., R. 14 W., almost on the south section line, is five miles east of White Signal. Two shafts and an open cut are just a few hundred feet north of the White Signal–Whitewater road. The mine was worked in the 1890's for silver and belonged to the Morrell Estate.

The shafts are at least 50 feet deep. The vein in the eastern shaft strikes N. 50° W. and dips 85° S.; that in the western shaft strikes N. 80° W. and is vertical. The vein zone is 5 to 6 feet wide. Argentite was found on the dumps, but cerargyrite was undoubtedly the major ore mineral.

Blackman mine. The Blackman mine consists of shafts and pits in the NE¼ sec. 26 and NW sec. 25, T. 21 S., R. 14 W. in the extreme eastern part of the White Signal district. The mine was worked about 1910. Galena and silver minerals were mined, the silver occurring as argentite and cerargyrite.

Pits and shafts have been sunk along a continuing vein for more than 1000 feet. The vein strikes N. 80° E. and dips 85° SW. Limonite-stained quartz, with manganese stains, is abundant. No ore minerals were observed. Fluorite with calcite is in a parallel vein 500 feet south of the Blackman. Quartz-feldspar pegmatites are numerous in the area.

Deposits near the 7XV ranch house. A few hundred feet south of the 7XV ranch house, between it and Walnut Creek, in the SE¼ sec. 24, T. 21 S., R. 15 W. are many shafts, pits, and adits. These include the Bouncing Bet and others mined about 1900 by Messrs. Newcomb, Alexander, Spence Hill, and others. All were gold properties. A mill was built in the vicinity in the 1890's. The subparallel veins and dikes throughout these workings strike N. 25°-30° E. and contain considerable iron-stained quartz. At the southern of the two shafts, malachite is found on the dump, and the vein is slightly radioactive.

At the adit and open cut on the north bank of Walnut Creek, a 7-foot-wide zone of altered rock and fault gouge strikes N. 60° E. and dips 85° S. Part of the altered rock appears to be a dike. This, too, is radioactive. The deposits are close to the southward projection of the west branch of the Walnut Creek fault and are just north of the intrusive contact of the Saddle Mountain rhyolite.

Gold Lake placer. The Gold Lake placer deposit is in the S½ sec. 20, T. 20 S., R. 14 W., just below the dam creating Gold Lake and in the side arroyo north of Gold Lake. Gold, bismuth, and pyrope garnet have been recovered from the gravels. Bill Sellers mined gold and native bismuth between 1900 and 1910, and Tullock mined about $3500 worth of gold in 1931 and 1932.

The gold is in small quartz veinlets in a small knob of granite which protrudes through the alluvium at this locality. The veinlets also carry iron and silver minerals. Attempts to produce gold from the veinlets were not very successful, and almost all production was from the gravels in the arroyo. The bismuth occurred as nodules up to a quarter of an inch in diameter. Most of the gold was fine.

Pyrope garnets, one-eighth to one-fourth inch in diameter, recovered from the gravels were shipped for jewel bearings to the Elgin Watch Company and to Czechoslovakia. About ten pounds were produced.

Chapman turquoise mine. The Chapman turquoise property is on the southeast side of Saddle Mountain in sec. 25, T. 21 S., R. 15 W., almost on the east section line about midway north and south. It is two miles southeast of White Signal. Chapman mined high-grade turquoise between 1890 and 1900 from a shaft and glory hole. Later, Tullock drove an adit below the shaft looking for copper. The adit extends north and connects with the shaft.

Two diverging veins trend N. 62° E. and N. 53° E. and dip 72° and 85° N., respectively. They are about 20 to 25 feet apart and the glory hole lies between them. The shaft lying within the glory hole was sunk along the steeper and more southern of the veins, which is 2 feet wide and shows copper stains at the west end of the glory hole. The adit cut a number of subparallel veins, one of which is 2 feet wide and has been stoped to the surface. An altered dike, possibly diabase, is also cut by the adit. It trends parallel to the veins. The glory hole and shaft are excavated in rhyolite, and granite is exposed just a few feet east and south of the portal of the adit. The deposit is along the contact of the Saddle Mountain rhyolite plug and granite, just within the plug.

Pyrite and copper stains are abundant on the dump, and radioactivity was recorded along the veins and on some of the dump material. No turquoise was seen; it probably occurred in pockets along the veins and in fractures in the shattered area which is now occupied by the glory hole. The rhyolite is kaolinized and sericitized.

This is the locality listed by Zalinski (1907) in the Cow Springs district.

Red Hill turquoise. The Red Hill turquoise deposit is two miles northwest of White Signal in the NE¼ sec. 16, T. 21 S., R. 15 W. When examined in 1951, the deposit consisted of three pits and an adit, one of the pits probably having once been a shaft. When revisited in 1961, two of the pits had been filled and a large open cut excavated into the hillside south of the adit and original shaft and on the site of the third pit. A small adit was opened ten feet in from the face of the cut. The property is owned by Mrs. Ruth McBride, Central, New Mexico.

A steeply dipping fault trending N. 60°-65° E. occupies a saddle near the end of a long ridge. North of the fault, the hill is a reddish brown, coarse-grained granite with profuse quartz segregations. South of the fault, a 100-foot-wide zone of rock is so intensely altered to sericite and clay minerals that nothing but quartz remains of the original rock. This wide altered zone is shattered and fractured, with many narrow veinlets and seams of talc, clay, quartz, and turquoise filling the fractures.

The turquoise generally is soft and greenish, but a few nodules of hard blue turquoise of good color have been found. A dike or sill-like mass of extremely altered diorite or monzonite is included within the zone of altered rock along the fault.

The shattered and fractured zone containing the turquoise veins is radioactive, but no uranium minerals were recognized.

Other deposits. Numerous other gold, copper, and uranium prospects and mines are in the White Signal district, but a description of all the smaller deposits is not practical, nor would it add value to this report. The major deposits described are typical of the district.

Old shafts, adits, trenches, and pits abound, particularly in secs. 22, 23, 24, and 26. Others are scattered throughout the district. The majority of these were early worked for gold and copper, a few for silver. In the 1940's and 1950's, prospecting for uranium resulted in additional work at some of the old deposits and in the sinking of many new pits and shafts. Some of the latter contain torbernite, autunite, or other radioactive minerals, but none proved commercial.

Deposits of rare-earth minerals. Segregations of rare-earth minerals are in pegmatites within the Burro Mountain granite in the western part of the White Signal district. Those observed include a deposit in the NW¼ sec. 28, T. 20 S., R. 15 W., 800 feet west of the Paymaster shaft and less than 1000 feet east of the Russell ranch house, and some deposits in the NE¼ sec. 20 or the SE¼ sec. 17. Shallow pits expose the deposits. There has been no commercial production.

At the deposit in sec. 28, crystals of euxenite up to four inches long are found with muscovite, microcline, and quartz in a pegmatitic segregation (or "quartz blowout," as they are locally termed) in granite. The euxenite is associated especially with the muscovite. Only a few small pods, totaling less than 100 pounds, are in the exposed pegmatite. The euxenite is very radioactive, but prospecting with a Geiger counter did not uncover additional material.

At the deposits in secs. 17 and 20, euxenite is more plentiful, being in scattered localities over an area of several hundred square yards. The euxenite is in pods and segregations in quartz-muscovite-microcline pegmatitic segregations in granite, identical to that in sec. 28. It is more abundant here, and several hundred pounds have been located by prospecting with a Geiger counter. The euxenite occurs as euhedral crystals up to several inches long. Some crystals weather free and are found in the soil around the pegmatites.

The deposit in sec. 28 is owned by Charles Russell. Those in secs. 17 and 20 are on claims owned by a Mr. Wheatly.

These deposits are similar to the pegmatitic deposits in the Gold Hill area which have been exploited for their rare-earth minerals. Similar segregations may exist in other pegmatites of the area.

LITTLE BURRO MOUNTAINS

The Little Burro Mountains are an isolated range of hills 18 miles long and 1 to 2 miles wide lying 10 miles southwest of Silver City and 1 mile northeast of Tyrone (pl. 1). The range is separated from the Big Burro Mountains by the Mangas Valley. Its steep southwestern side contrasts sharply with the gently sloping northeastern side that merges into the rolling, gravel-covered hills extending to Silver City. The mountains are 6500 feet above sea level and rise 500 to 700 feet above the surrounding area. State Highway 180 cuts across the southern part of the range, and U.S. Highway 260 skirts the northern end.

Mining probably began in the Little Burro Mountains in the 1880's shortly after copper and turquoise were found across the Mangas Valley in the Big Burro Mountains. Early records were not obtainable. Gold, silver, copper, lead, zinc, and manganese were the principal commodities mined, but small amounts of building stone and clay have been produced and noncommercial deposits of fluorspar and uranium are present. Extensive mining was not done; most of the deposits are small. There has been no active mining since 1944.

With reference to ownership, the metalliferous deposits of the Little Burro Mountains are divided into three groups. All deposits southeast of Indian Peak, known as the Bostonian and Montezuma groups, are on patented land belonging to the Phelps Dodge Corporation, with the exception of three claims which belong to Mrs. R. D. Tullock, Silver City (pls. 3 and 4). Northeast of Indian Peak, a group of 34 patented claims, known as the Mystery, Silver King, and Contact, belong to Mrs. Earle S. Patten and Clyde R. Altman, Silver City. Northwest of these, the deposits are on land formerly owned by C. S. Woodward which was sold to the Western Land and Cattle Company in 1960. The nonmetalliferous deposits, all in the northern half of the range, are on land owned by W. Woodward.

The Little Burro Mountains are a tilted fault block of Precambrian Burro Mountain granite and Bullard Peak metamorphic rocks, overlain by Cretaceous sedimentary rocks and a thick sequence of Tertiary volcanic rocks (photo 5). The block is tilted northeastward and the sedimentary and volcanic rocks dip 10° to 25° NE. An intrusive mass of altered quartz monzonite and monzonite porphyry, probably genetically related to the Tyrone stock, makes up the southern part of the range. The northwest-trending Mangas fault, which dips 60° to 80° SW forms the southwestern boundary of the range, separating it from the gravel-filled Mangas Valley. Pleistocene gravels of the Mangas Valley abut against the southwestern or downthrown side of the fault. Displacement along the fault cannot be determined, but Edwards (p. 42) estimated that the Little Burro Mountain block was uplifted at least 1500 feet.

Mineral deposits in the Little Burro Mountains include both metallic and nonmetallic deposits. Copper deposits in the southern part of the range are similar to the copper deposits of the Tyrone district across the Mangas Valley to the southwest. In the central part of the range, filled fissure quartz veins which contain gold, silver, copper, lead, and zinc occupy northeast-trending fractures and faults. The minerals present include gold, galena, chalcopyrite, sphalerite, pyrite, probably argentite, and their oxidized equivalents. Pyrolusite and psilomelane are common, and one deposit has been mined for manganese. Small deposits of fluorspar, uranium, clay, and dimension stone are also present in the mountains.

Metallic Deposits

Bostonian–Montezuma. The Bostonian group in the northwest corner sec. 18, T. 9 S., R. 14 W. and NE¼ sec. 13, T. 19 S., R. 15 W. and the Montezuma group primarily in the SW¼ sec. 18 and northwest sec. 19 comprise most of the deposits in the southern Little Burro Mountains. Numerous old shafts, shallow pits, and adits explore the veins. The country rock is monzonite porphyry and quartz monzonite porphyry which has been intensely altered, particularly in the vicinity of the Bostonian group.

Only a few of the workings were accessible in 1960. The shafts are apparently shallow, but according to old records of the Phelps Dodge Corporation, some are more than 500 feet deep. No information on the extent of the workings, production, or grade of ore is available. Most of the mines were excavated for copper, and oxidized copper minerals and pyrite can be found on the dumps. The veins are narrow and cannot be followed for more than a few hundred feet. They strike generally northeast and are vertical or steeply dipping, although at the Bostonian shaft and at some of the shallow pits the strike is N. 25° W. Three of the deeper shafts have been sunk along or in proximity to the Mangas fault. The deepest and most extensive workings along this fault appear to be in the southeast corner sec. 13, T. 19 S., R. 15 W., a few hundred feet east of State Highway 180.

Tullock property. The three shafts on the Tullock property have also been sunk along narrow veins of limited extent. At the two northernmost, the vein strikes N. 70° E. and dips 75° NW. Minor amounts of copper carbonate were observed on the dumps. At this locality, and also in the extreme northeast corner sec. 13 and southeast corner sec. 14, a well-bedded, well-consolidated, red conglomerate overlies the monzonite porphyry. The fragments are both angular and well rounded and are as much as six inches in diameter. At the west shaft of the two mentioned, the unconformity at the base of the conglomerate cuts the vein, and mineralization does not continue into the conglomerate.

Silver King–Mystery group. The Silver King and Mystery groups, consisting of 25 claims in secs. 2 and 11, T. 19 S., R. 15 W., are contiguous and are described together. The major deposits of this group include the Illinois, the Afternoon, and the Silver King.

At the Illinois deposit, a number of parallel veins striking N. 30° E. and dipping steeply southeast crop out through a zone 400 feet wide. A 200-foot adit trending N. 60° W. cuts some of the veins which are as much as 4 feet wide. Twenty assays taken in 1957 showed a maximum of 0.04 ounce of gold and 2.70 ounces of silver a ton, and 3.6 per cent lead, 0.50 per cent copper, 0.8 per cent zinc, and 6.35 per cent manganese.

At the Afternoon deposit, a shaft inclined 45 degrees slopes downward N. 37° W. to an unknown depth (fig. 11). Water stands in the shaft 150 feet down the incline from the collar. At 125 feet, short drifts are driven northeast and southwest; on the 60-foot level, one extends 50 feet northeast. Samples cut in 1957 assayed a maximum of a trace of gold, 0.6 ounce of silver a ton, 7.7 per cent lead, 4.5 per cent zinc, and 0.51 per cent copper. An assay of about 25 tons of ore on the dump showed 0.01 ounce of gold and 1.5 ounces of silver a ton, and 14.0 per cent zinc, 1.33 per cent copper, and 12.6 per cent lead. The vein averages less than 2 feet wide.

The Silver King deposit is explored by an adit and an old shaft (fig. 12). The vein strikes N. 50° E., and in the vicinity of the shaft, the rock southeast of the vein is altered and contains malachite. The shaft is sunk in this altered rock, samples of which from the 60-foot level across widths of 3 to 4 feet showed a maximum of 5.8 ounces of gold a ton and 1.52 per cent copper. Water stands at 70 feet in the shaft. The adit goes southeast for 220 feet with a crosscut 175 feet from the portal proceeding east about 150 feet. A number of small veins were exposed.

Contact group. The Contact group of nine patented claims, owned by Mrs. Earle S. Patten and Clyde R. Altman, and the adjacent area to the northwest, owned by the Western Land and Cattle Company, includes four subparallel veins trending generally north called, from east to west, the Contact, Wyman, and Casino, with the westernmost having no name. This is the group of deposits described by Paige (1911) as being included in the claims of the Woodward Mining Company. These deposits have produced the bulk of the ore mined in the Little Burro Mountains, and they also show the most promise for future production. The veins are all quartz-filled fissure deposits along north-northeast-trending tear faults.

The Contact vein is explored by the Contact shaft, the Virtue shaft, and the Virtue tunnel.

The Contact shaft is 225 feet deep and was last worked in 1944. Although originally sunk for gold and silver, it was worked in 1939 for its base-metal content, and 150 tons of ore were shipped by Strong and Harris, Vanadium. Mining was resumed in 1942, when Yacomo and Fuller leased the property. Between 1942 and 1944, 2121 tons of ore con-

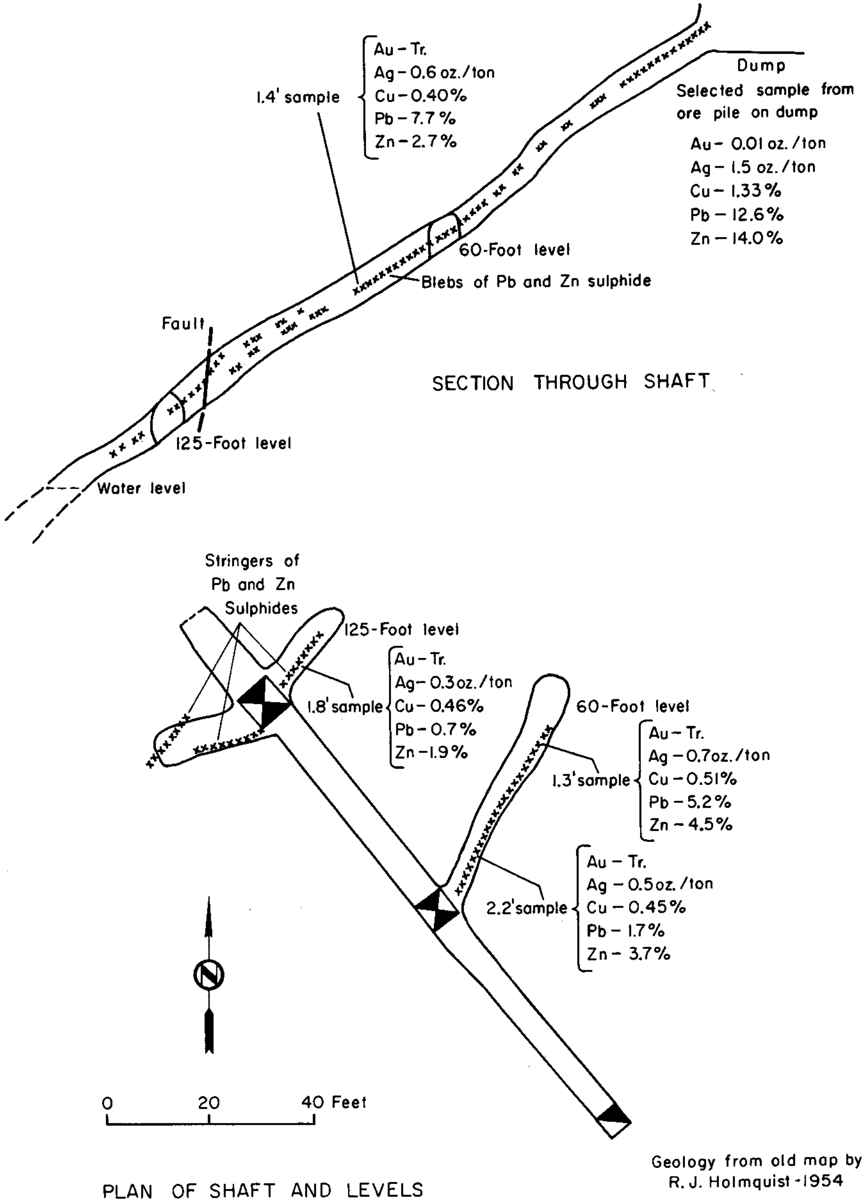


Figure 11

UNDERGROUND GEOLOGIC SKETCH MAP OF THE AFTERNOON MINE, LITTLE BURRO MOUNTAINS

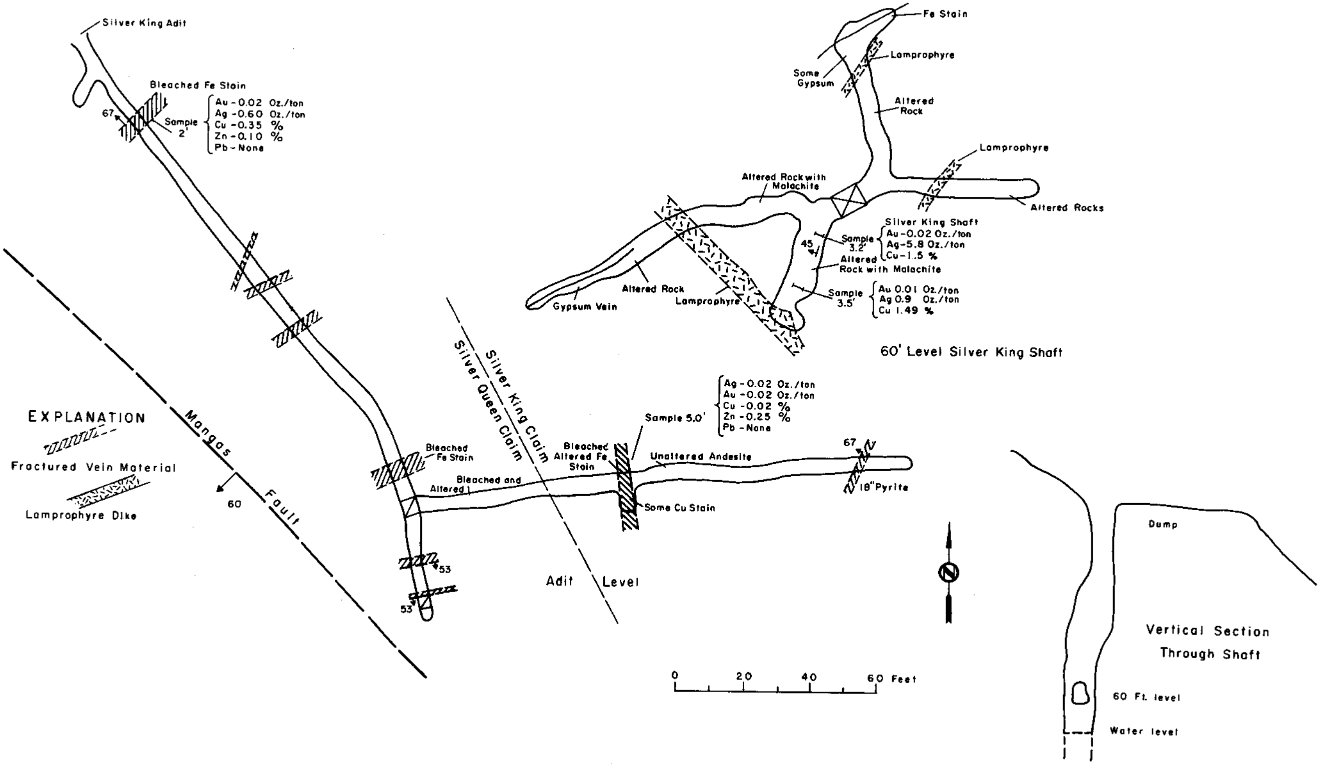


Figure 12

UNDERGROUND GEOLOGIC SKETCH MAP OF THE SILVER KING MINE, LITTLE BURRO MOUNTAINS taining 6 to 7 per cent combined lead and zinc, 2 ounces of silver and 0.02 to 0.03 ounce of gold a ton, and 0.25 per cent copper were shipped. According to Fuller (oral communication), the ore in the bottom of the shaft was 10 to 14 feet wide, with a stope 50 feet down leading southwest from the shaft. A sample analysis taken from the shaft in 1952 showed 0.01 ounce of gold and 5.15 ounces of silver a ton, 15.25 per cent lead, and 5.20 per cent zinc.

In 1943, C. S. Woodward mined manganese oxide at the Contact mine from a cut excavated along the east side (hanging wall) of the vein, a hundred yards east of the shaft. About 140 tons of ore averaging 20 per cent manganese were shipped.

The Virtue shaft was sunk along the vein for 170 feet, with drifts at various levels. It is inclined 70° SE. From the bottom of the shaft, drifts are cut northeast and southwest. From near the end of the south drift, a 120-foot winze connects with the Virtue tunnel where the tunnel caved in 1960.

The Virtue tunnel was accessible in 1960 for 500 feet inward from the portal. The portal is in gravel, east of the Mangas fault. The tunnel (or adit) is cut N. 50° E. for 300 feet where it turns for an additional 100 feet N. 30° E. At this point it splits. One drifts runs 45 feet N. 75° E., then turns S. 85° E. and continues for 50 feet. The other drift goes N. 35° E. for 40 feet, intersects the vein, and turns N. 85° E.; 105 feet beyond this turn, the drift is caved. Here, a stope is on the northwest side of the drift, and it is probable that this is where the winze sunk from the lower level in the Virtue shaft connected with the tunnel. The tunnel intersects the Mangas fault 180 feet from the portal. The fault dips 70 degrees and strikes N. 40° W. A breccia and gouge zone 10 to 12 feet wide characterizes the fault. Chalky white kaolin, which appears to be almost pure kaolinite, is exposed in a strip more than 2 feet wide. Brick-red clay is also evident.

The vein strikes N. 60° E. and dips 70° SE at the Virtue shaft and strikes N. 20° E. and dips 75° SE at the Contact shaft. It can easily be traced between the two shafts and is 5 to 6 feet wide in a cut a few hundred feet south of the Contact shaft. At the Contact shaft, granite is on the west or footwall side of the vein, but andesite is on the east side; at the Virtue, granite forms both walls of the vein. Silicified fractures crop out south of the vein at the Contact mine and subparallel to it. Manganese oxide is abundant at the Contact shaft.

Paige (1911) states that the ratio of silver to gold values in the Contact mine is about 4:1. The values of gold and silver have changed since 1911; based upon the present values of these metals, the ratio in 1960 would be slightly greater than 3.5:1. Paige also states that the ore at the bottom of the Virtue shaft contained 42 ounces of silver and 0.25 ounce of gold a ton. At other localities, presumably in the shaft, he states that values were as high as 126.8 ounces of silver and 0.64 ounce of gold a ton.

Just how much ore was shipped from the Contact vein when it was operated for its gold and silver content is unknown.

The Contact vein is composed of quartz with a little pyrite, chalcopyrite, an abundance of manganese oxides (both psilomelane and pyrolusite), argentiferous galena, and sphalerite.

The Wyman vein is explored by a multitude of shallow pits and shafts, all of which were inaccessible in 1961. At an old shaft 700 feet west of the Contact mine, the vein strikes N. 10° E. and dips 75° SE. It is 3 to 4 feet wide, with intensely altered granite on the hanging wall side; granite also forms the footwall. Paige (1911) stated that this vein was worked along strike for 500 feet but to depths of only 100 feet, and that the best ore, some of which was cerargyrite, was above 40 feet. Base metals increased with depth.

The Casino vein dips steeply east. In 1960, all workings along it were inaccessible. Paige noted that locally much country rock was mixed with the quartzose vein material in alternating bands, the whole being impregnated with sulphides. Near the south end, a 110-foot shaft explored the vein, and at this locality an old stope exposed vein material up to 10 feet wide. Values were highest in the brecciated vein matter, and up to 20 ounces of silver and 0.25 ounce of gold a ton over widths of 5 feet are reported. Northward along the vein, the base-metal content increased as the precious-metal content decreased. The old Copper Sulphide shaft, near the north end of the vein, was 100 feet deep and was mined for galena and chalcopyrite. Gold and silver values were low. Paige (1911) reports an assay from the shaft as containing 0.04 ounce of gold and 4.7 ounces of silver a ton, 5.9 per cent lead, 10.2 per cent zinc, and 2.1 per cent copper. The property was last worked in 1942 by Yacomo, who opened a 40-foot-deep shaft. The ore was of too low grade, however, and only 61.35 tons were shipped. This assayed as follows: 0.008 ounce of gold and 1.24 ounces of silver a ton, 4.4 per cent lead, 4.5 per cent zinc, and 0.305 per cent copper.

Woodward property. The Full Moon in the extreme northwest corner of sec. 2, T. 19 S., R. 15 W. is not on the Contact group of claims but on land owned prior to 1959 by C. S. Woodward. Two shafts, sunk on separate veins, explore the property. The western shaft is 40 feet deep and along a vein which strikes N. 40° E. and dips 85° E. The eastern is 125 feet deep with a 100-foot-long drift extending southwestward from the bottom of the shaft (M. Fuller, oral communication). This shaft is sunk along a vein striking N. 25° W. and dipping 65° SE that may be the northern extension of the Wyman vein. The vein averages 4 feet in width. The property was last worked during 1941 and 1942, when Yacomo and Fuller leased it from Woodward. According to Fuller, 500 tons of ore averaging several ounces of silver and 14 to 15 per cent combined lead and zinc were shipped. In 1925, C. S. and Walt Woodward shipped three carloads of ore carrying about 10 ounces of silver a ton and 25 to 30 per cent lead. The silver-to-lead ratio was consistent at about 1 ounce of silver to 3 per cent lead (C. S. Woodward, oral communication).

The Snowflake and Jersey Lily deposits are on the southwest-facing front of the mountains in the central part of sec. 34, T. 18 S., R. 15 W. one mile northwest of the deposits described above. They are on land owned prior to 1959 by C. S. Woodward. The Snowflake is explored by a shaft, the Jersey Lily by a shaft and two adits. Both deposits are in granite along north-trending fractures and are 100 feet below the Beartooth Quartzite. About 1907, $25,000 worth of silver, mostly as cerargyrite but with some argentite, was shipped from the Snowflake. Some of the ore contained 350 ounces of silver a ton. At about the same time, $10,000 to $15,000 worth of silver was shipped from the Jersey Lily. This was all cerargyrite and ran as high as 700 ounces of silver a ton. In 1930, C. S. Woodward and Jack Stewart shipped 60 tons of ore averaging 50 to 60 ounces of silver a ton from the Jersey Lily. The properties are now abandoned.

Torbernite and other secondary uranium minerals are found in granite and in Beartooth Quartzite in secs. 27, 28, and 34. Shallow, bulldozed trenches, pits, and drill holes explored the area in the early 1950's, but the uranium minerals are in only small amounts in fractures and small faults, and none of the deposits is considered commercial or potentially commercial.

Nonmetallic Deposits

Clay and building stone have been produced from the central part of the Little Burro Mountains. In the 1940's, clay in Colorado Shale was quarried from a deposit in the E½ sec. 27, T. 18 S., R. 15 W. on the northeast side of Redrock Canyon. It was shipped to the Kennecott Copper Company, Hurley smelter, where it was used for refractory purposes.

Dimension stone and flagging have been sporadically quarried from tuff beds at a small quarry in the SE¼ sec. 27. The tuff is thin-bedded at this locality and is an attractive pink and white color. It is used locally in Silver City.

A small fluorite deposit, the Ace High, lies in the NE¼ sec. 28, T. 18 S., R. 15 W. south of Redrock Canyon near the foot of the range and just southeast of the Mangas fault. It is described by Gillerman (1952), who incorrectly stated that it occurs in Colorado Shale; it is in granite. In 1948, the property was owned by R. Y. Chambers; in 1960, it was abandoned. A few shallow pits explore the deposit.

MALONE DISTRICT

The Malone district, two miles long and half a mile wide, lies along the Malone fault in secs. 17, 18, 19, 20, 29, and 30, T. 20 S., R. 15 W. on the western side of the range of volcanic rocks extending north from Knight Peak (fig. 1 and pl. 1). About $300,000 in gold and a little silver has been produced from the district. Of this, about $50,000 was produced since 1925, the balance prior to 1900.

John B. Malone discovered gold in the district in 1884, although placer gold mining was being conducted in nearby Gold Gulch and Thompson Canyon for a number of years prior to that date. The Malone mine, principal producer of the district, was opened soon after the discovery and most of the other shafts shortly afterward. In 1904, Fred B. Malone, S. J. Wright, and John Brown made new discoveries one mile west of the old Malone mine; about the same time, gravels in many of the gulches in the area were being worked as placers (Jones). In the 1930's, renewed interest in the district resulted in new workings and the extension of some of the older ones. Since the early 1940's, mining has been desultory and intermittent.

In 1961, the district was covered by 13 unpatented claims owned by Albert A. Leach (who lives at Malone, but whose mailing address is Bin U, Lordsburg).

The Malone fault strikes N. 20° W. and dips 70° NE within the Malone district. Rhyolite tuffs, perlite, and agglomerate are on the hanging wall side of the fault and Burro Mountain granite on the footwall side. The volcanic rocks are within the Knight Peak graben and are part of the sequence described in detail by Ballmann. The granite is mostly coarse- to medium-grained, but a fine-grained variety is present. A. A. Leach (oral communication) states that higher-grade ore is associated with the fine-grained granite.

Numerous fractures cut the granite adjacent to the fault (fig. 13). They trend mostly N. 45°-85° W. Most are confined to the granite but one, and possibly two, offset the Malone fault and extend into the rhyolite.

Many of the fractures are mineralized, and in some areas of closely spaced fractures, the granite between them is also mineralized. Mineralization was recognized as far as 1000 feet southwestward from the Malone fault, but it is most intense near the fault. Mineralization was not observed along the fault itself.

The veins are fissure fillings of gold-bearing quartz and pyrite. Chalcopyrite, galena, and sphalerite are sparingly present and were observed on the surface of the dump at the old Patanka shaft, apparently being derived from the deeper workings. The gold is exceedingly fine and can be detected only by analysis. Silver probably occurs with galena. Sericitization, kaolinization, and hematitic alteration of the granite adjacent to the veins is characteristic. The hematitic alteration especially is associated with high gold values.

The workings are all shallow, none being more than 100 feet deep.

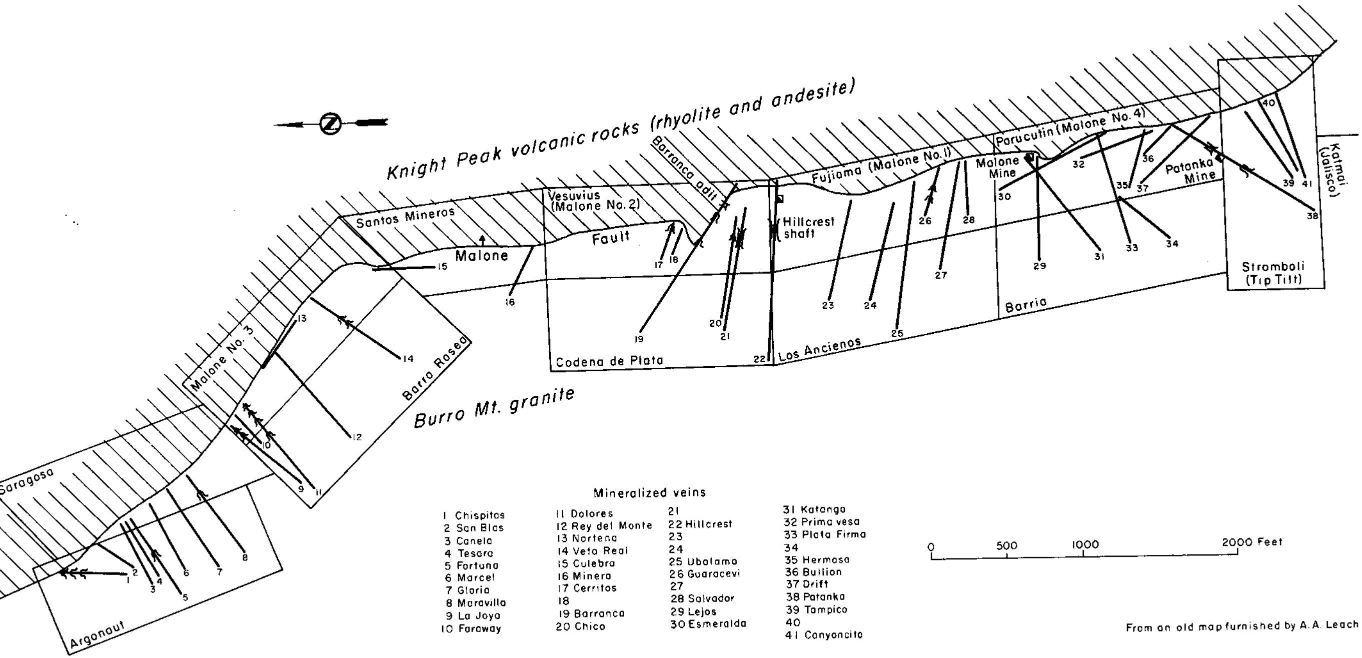


Figure 13

VEIN PATTERN IN THE MALONE DISTRICT, KNIGHT PEAK AREA, BURRO MOUNTAINS

The principal mines are in the southern part of the district. Except for the Patanka, all are inaccessible.

Malone. The Malone mine, a 90-foot-deep vertical shaft, is sunk along the Esmerelda vein. The vein is stoped to near the surface. A 36-foot inclined shaft on the vein connects with the main workings. Drifts were cut in both directions from the shaft, which is near the granite-rhyolite contact. Most of the values in the 1880's and 1890's came from this shaft.

Hillcrest (Young Man). At the Hillcrest mine, the vein strikes N. 85° W. and is nearly vertical. An old shaft is 100 feet deep, with drifts east and west along the vein; much of the ground is stoped to the surface. A new shaft sunk in 1938 near the east end of the vein is close to the granite-rhyolite contact, and a crosscut was driven 75 feet south. In the shaft, the vein averaged 5 feet in width and ore assayed $16.50 a ton. The vein can be traced for 1000 feet west from the rhyolite-granite contact, but apparently the grade of the ore becomes progressively lower away from the fault.

Patanka (Gold Coin). The Patanka vein (fig. 14) is the exception in the southern part of the district in that it strikes N. 35° E. instead of northwest; it dips 85° SE. An old vertical shaft 100 feet deep is inaccessible, but base-metal sulphides were observed on the dump. Southwest of the shaft, shallow trenches and caved shafts explore the vein, and rich lenses of gold ore were reported to have been mined in them. In 1947, a 50-foot-deep shaft and an adit were excavated along the vein about 100 feet northeast of the old shaft. Winzes, raises, and stopes connect the adit level and the 50-foot level driven northeast from the bottom of the new shaft. The adit runs 150 feet and the 50-foot level about 250 feet northeast along the vein.

Between 1933 and 1935, three and one half tons of ore shipped from the Patanka vein were valued at $6000, of which 60 per cent was for gold and 40 per cent for silver. Between 1934 and 1936, 11 tons of ore shipped were valued at $600, of which 70 per cent was gold and 30 per cent silver. In 1947, the workings were systematically sampled. Although some of the samples were very good, they showed that the ore was spotty and that high-grade pods were small. Thirteen samples showed an average vein width of 3 feet and contained 0.788 ounce of gold and 25.55 ounces of silver a ton. This excluded three analyses of selected specimens and of grab samples. One of the grab samples, however, was from the ore sacks and showed 0.70 ounce of gold and 19.30 ounces of silver a ton, comparable to the results from the other sampling.

Barranca. The Barranca vein is along a fault which strikes N. 40° W., dips 70° NE, and offsets the Malone fault. Granite forms the footwall and rhyolite the hanging wall. Old shafts, adits, and pits explore the vein, but all are inaccessible. A sample cut in the adit in 1947 across a

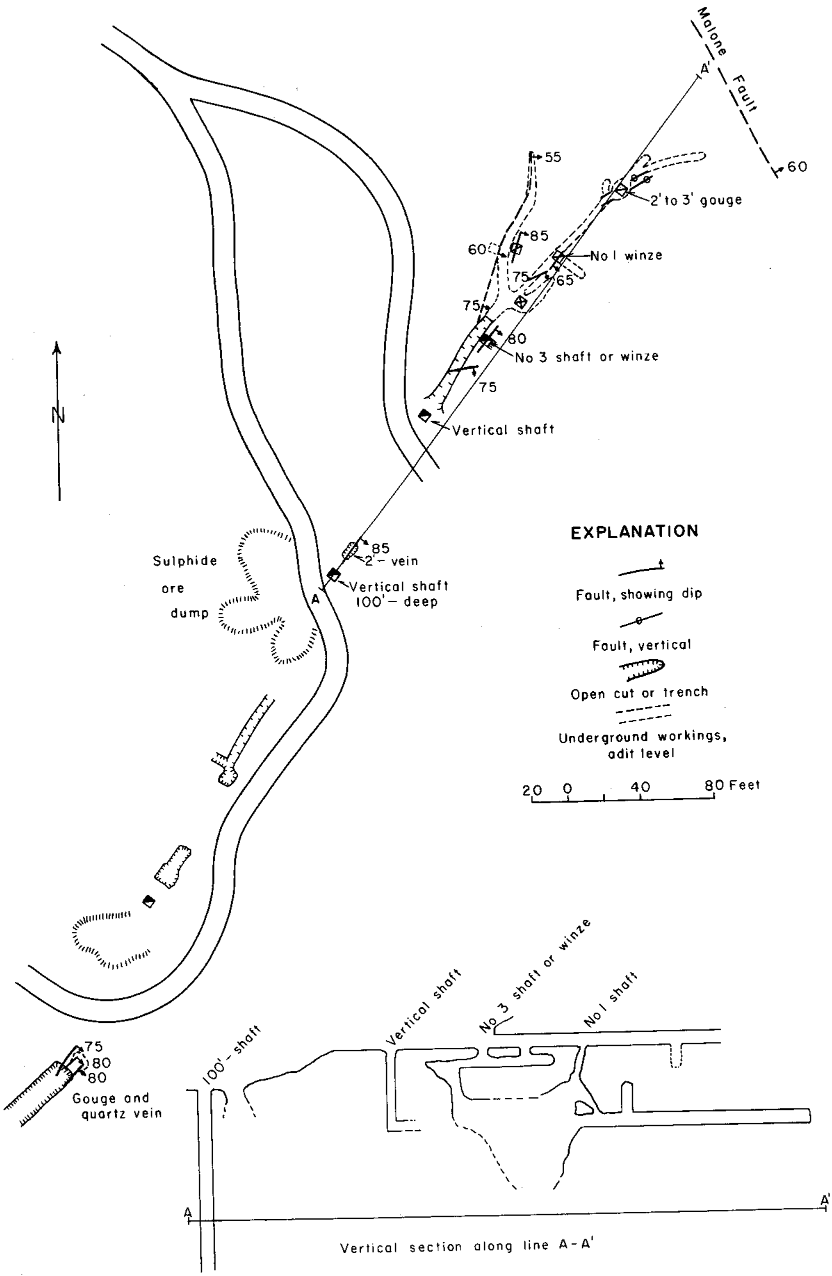


Figure 14

PLAN AND VERTICAL SECTION, PATANKA MINE, MALONE DISTRICT vein width of 2.8 feet showed 0.03 ounce of gold and 2.75 ounces of silver a ton.

Deposits occur also along the Requesa, Bullion, Ubalama, Chico, Plata Firma, Culebra, Barrio, and other veins. Few, however, produced appreciable ore, the bulk of the values coming from the mines described above.

GOLD HILL

The Gold Hill district, 25 miles southwest of Silver City, is on both sides of the Grant–Hidalgo county line in T. 21 and 22 S., R. 16 W. and T. 21 S., R. 17 W. (figs. 1 and 15). Gold-bearing quartz veins are in a belt nine miles long and five miles wide on the southwestern side of the hills. Silver and minor amounts of base metals are in the eastern and southern parts of the belt. Rare-earth-bearing pegmatites are on the northeastern side of Gold Hill. Although most of Gold Hill is in Grant County, much of the productive part is in Hidalgo County. Only those deposits in Grant County are discussed in this report.

History

According to Jones, David Egelston, a veteran of the 1849 gold rush, found gold on the Gold Chief claim in 1884. A year later this claim, together with the adjoining Standard, California, Noonday, Eighty-five, and Little Charlie, was acquired by Foster and Company which patented the property and erected the Standard mill in 1886. The Standard soon became the most productive mine in the district. Many other claims were staked and mining reached its peak in the 1890's when the town of Gold Hill had a population of some 500 people.

By 1900, the free-milling oxidized ore had largely been exhausted, and the district declined rapidly. Shortly after 1900, Frank G. Cline acquired many of the better mines and prospects and worked them sporadically until his death in 1940.

Between 1920 and 1926, several hundred tons of high-grade silver ore were mined and treated in a flotation mill at the Good Luck (Co-op) mine by the Co-operative Mining Company. Between 1932 and 1940, a revival of interest in gold mining resulted in $18,934 worth of gold being produced from the district, of which $10,008 came from the mines in the Grant County part of Gold Hill. Except for sporadic prospecting, the district has been idle since 1940. Recent activity involved attempts at producing rare-earth minerals from pegmatites in the early 1950's and development work at the Never Fail mine from 1958 to 1960.

Important mines in the area according to Graton (Lindgren, Graton, and Gordon, p. 327) were the Standard, California, Reservation, and Snyder. Jones (p. 63) lists the Beta and Gamma, Never Fail, Western Belle, and Rattlesnake. Some of these cannot be identified today.

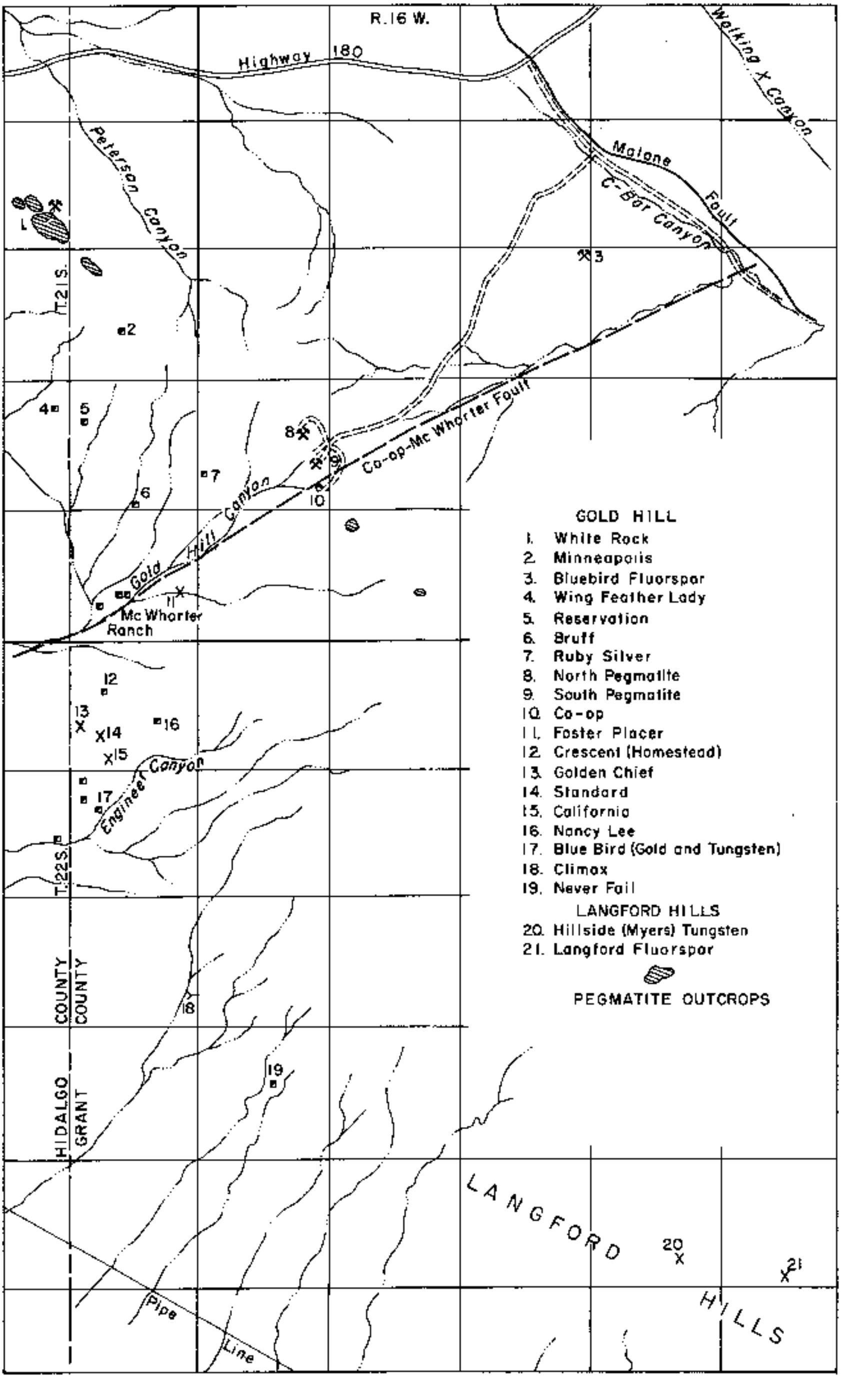


Figure 15

LOCATION OF MINERAL DEPOSITS IN GOLD HILL AND LANGFORD HILLS

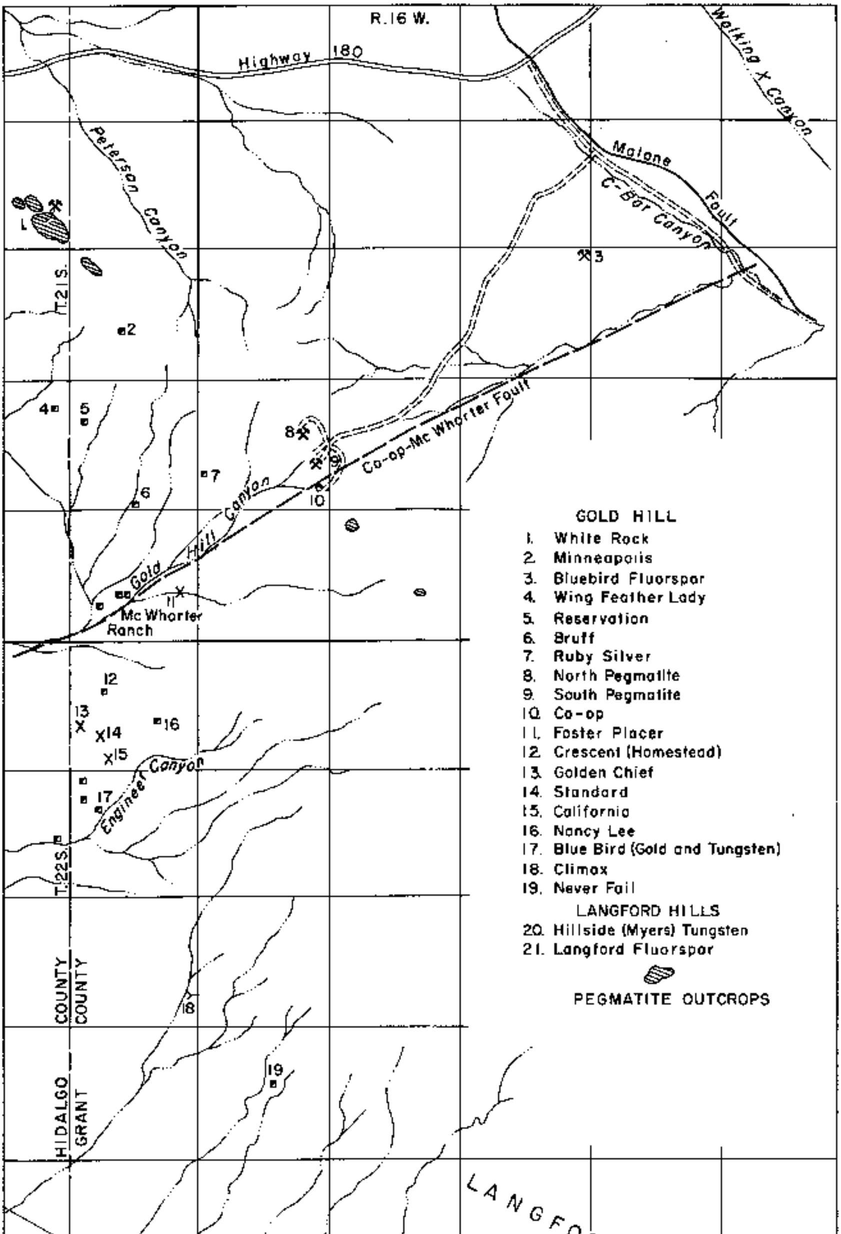


Figure 15

LOCATION OF MINERAL DEPOSITS IN GOLD HILL AND LANGFORD HILLS

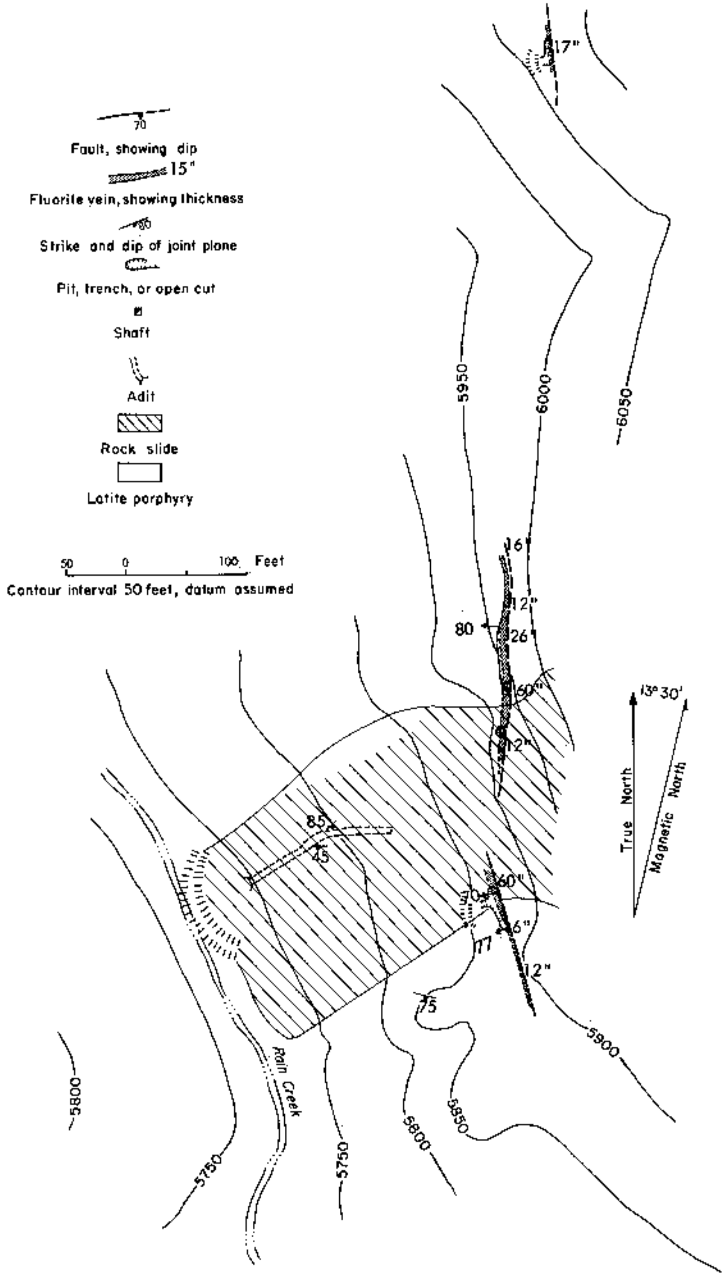


Figure 30
GEOLOGIC MAP OF THE RAIN CREEK (GOOD HOPE) FLUORSPAR DEPOSIT, SACATON MESA AREA

Geology

Gold Hill has a N. 20° W. structural and topographic trend. Together with the Langford Hills, a southeastward prolongation of Gold Hill, it is part of the Burro Mountain batholith, although it is separated from the Big Burro Mountains by the Knight Peak graben. It is comprised mostly of Burro Mountain granite, but on the southwestern side included masses of schist, gneiss, and migmatite of the Bullard Peak series represent remnants of the original rock invaded by the granite. Acidic and basic dikes transect the Precambrian rocks (pl. 1).

The biotite schist, sericite schist, muscovite-garnet schist, amphibolite, quartzite, gneiss, and migmatite which crop out in the western part of the area are similar to rocks described by Hewitt. Several varieties of granite are present, differing in grain size and in the amount of biotite contained. Some of the granite is identical to varieties observed in the Big Burro Mountains.

Aplite and pegmatite intrude the granite. The pegmatites vary in size from small pods a few inches in diameter to lens-shaped bodies several hundred feet long and almost as wide. The larger pegmatites are zoned. A coarsely crystalline quartz core is surrounded by one or more zones consisting of microcline, plagioclase, and quartz, with local segregations of coarse muscovite, biotite, magnetite, fluorite, garnet, and rare-earth minerals. The quartz cores of the pegmatites crop out in numerous places in the area.

Rhyolite, quartz monzonite, diabase, and various other rock types that intrude the Precambrian rocks as dikes and small pluglike masses are similar to rocks in the White Signal district to the east, and trend in the same direction.

Gold Hill lies at the intersection of northwest structural elements and the east-northeast zone of fracturing which extends across western Grant County. Northwest structural elements are indicated by numerous diabase dikes trending N. 30° W. and by drainage patterns. Most striking is the alignment of major pegmatite bodies, paralleling the almost ruler-straight course of Peterson Creek a few hundred yards northeast. This alignment suggests a Precambrian zone of northwest fracturing along which the pegmatites were intruded.

Numerous basic and acidic dikes occupy the east-northeast fractures, and this, too, is reflected by the alignment and parallelism of drainage. The Co-op–McWhorter fault, which strikes N. 70° E., extends along Gold Hill Canyon and a side canyon at C-Bar Canyon. It crosses the crest of the range near the Co-op mine and the north and south pegmatite deposits. The Co-op mine is at the intersection of this fault and the pegmatite lineament.

MINERAL DEPOSITS

Mineral deposits in Gold Hill are of two main types, hydrothermal veins and pegmatites. The veins are mostly gold-bearing quartz, but silver and base metals are major constituents of veins in the eastern and southern parts of the area. Fluorspar veins occur on the eastern side of Gold Hill. The pegmatites, in the northern part of the district, contain rare-earth-bearing minerals. The gold-silver-base-metal veins, the fluorspar veins, and the pegmatites are discussed separately.

Gold-Silver-Base-Metal Veins

Gold-bearing quartz veins are the most numerous in Gold Hill and were the sites of nearly all mining operations. A few veins were worked for silver. Mining was limited to the oxidized zone above the water table, and little information is available as to the character of the primary ore. The mines were inaccessible in 1961, but limonite and pyrite were the most abundant minerals found on the dumps. Pyrite was observed in a few places, galena and sphalerite on the dumps of the Co-op mine, and galena and ruby silver(?) on the dumps of smaller properties in the eastern part of the district.

The veins are simple fracture fillings with banded and drusy textures indicative of formation at shallow to moderate depths. Almost all the gold-bearing veins are localized by mafic rocks. Commonly, they are along the contact of the rock (basic dike, biotite schist, amphibolite) and granite or granite gneiss. The majority follow contacts which dip less than 45 degrees. The veins are irregular, narrowing and widening every few feet. At the outcrop, they are a few inches to 2 feet wide; exceptionally, 4 to 5 feet wide. Most can be traced for 200 to 300 feet. Their persistence with depth is unknown, since the water table stands about 100 feet below the present surface.

The gold content is variable but low. Graton (Lindgren, Graton, and Gordon, p. 327) states that the value of the ores averaged $15 to $40 a ton, but that ore valued at $125 a ton was found in some mines. Frank G. Cline's assay book showed values of 0 to $50 a ton, but most were below $20 a ton (W. Elston, written communication, 1962). When gold was worth $35 an ounce in the 1930's, 650 tons of ore mined in the Grant County part of the district had an average value of $15.41 a ton, whereas 355 tons mined in the Hidalgo County part had an average value of $25.41 a ton.

The silver-base-metal veins in the eastern and southern part of the district consist of primary argentiferous galena, pyrite, and sphalerite in a calcite and quartz gangue. Cerussite, native silver, and limonite are in the oxidized parts of the veins. At the Co-op mine, the highest silver values were associated with abundant galena and pyrite in the sulphide zone, with cerussite and limonite in the oxidized zone.

A zonation of the hydrothermal metallic deposits is suggested, but the lack of information about the character of the primary ores in the central part of the district makes any definitive statement conjectural. Apparently, gold and pyrite are the only metallic constituents of the veins in the central part of the district. The amount of gold decreases and the amount of silver increases toward the periphery of the district, especially toward the south, east, and northeast. Galena is associated with the silver minerals. Sphalerite is associated with both galena and silver minerals in the northeastern part of the district. This zonation, if present, may reflect a depth zonation and be important in future prospecting in the district.

Co-op mine. The Co-op mine, also known as the Good Luck, is in the SE¼ sec. 29 and SW¼ sec. 28, T. 21 S., R. 16 W. at the head of a small draw just west of the crest of the range. It is the northeasternmost of the metalliferous deposits in the area. The mine was operated in the 1920's by the Co-operative Mining Company but is now abandoned, and the owners in 1961, if any, were unknown. Total production is not recorded, but according to Lasky and Wootton, the value of ore and concentrates shipped during 1920 and 1921 was $43,000. It is reported (A. A. Leach, oral communication) that $60,000 worth of native silver was taken from stopes above the 150-foot level.

Workings consist of two adits, numerous levels, and stopes (fig. 16). The upper adit is inclined downward 10 to 15 degrees and goes southeast 150 feet along the incline. Short drifts are at 50 and 100 feet. The lower or main adit is inclined 40° S. 30° E. and is excavated along the vein. It slopes downward 475 feet on the incline, with levels at 90, 150, 200, 300, 375, and 450 feet. The drifts reach a maximum length of 300 feet southwest and 125 feet northeast of the shaft. Most of the stoping is above the 300-foot level. Only the upper adit was partly accessible in 1961. The remains of an old mill are on the property.

Native silver was the chief ore mineral, argentiferous galena, cerussite, sphalerite, and pyrite also being found. The highest grade of silver ore was associated with abundant galena and pyrite in the sulphide zone and with cerussite and limonite in the oxidized zone (Lasky and Wootton). Gold was insignificant. Vein material on the dump, probably from the lower levels, consists of fractured quartz with segregations and fracture fillings of pyrite, sphalerite, galena, and calcite. Below the water table, ore values were lower. This is one of the few deposits in the district which penetrated the sulphide zone.

The Co-op mine is unique among the major deposits in Gold Hill in that silver and base metals are the primary constituents of the vein, while gold is negligible. It is possible that this represents a distinct phase of mineralization, or perhaps an entirely separate period of mineralization.

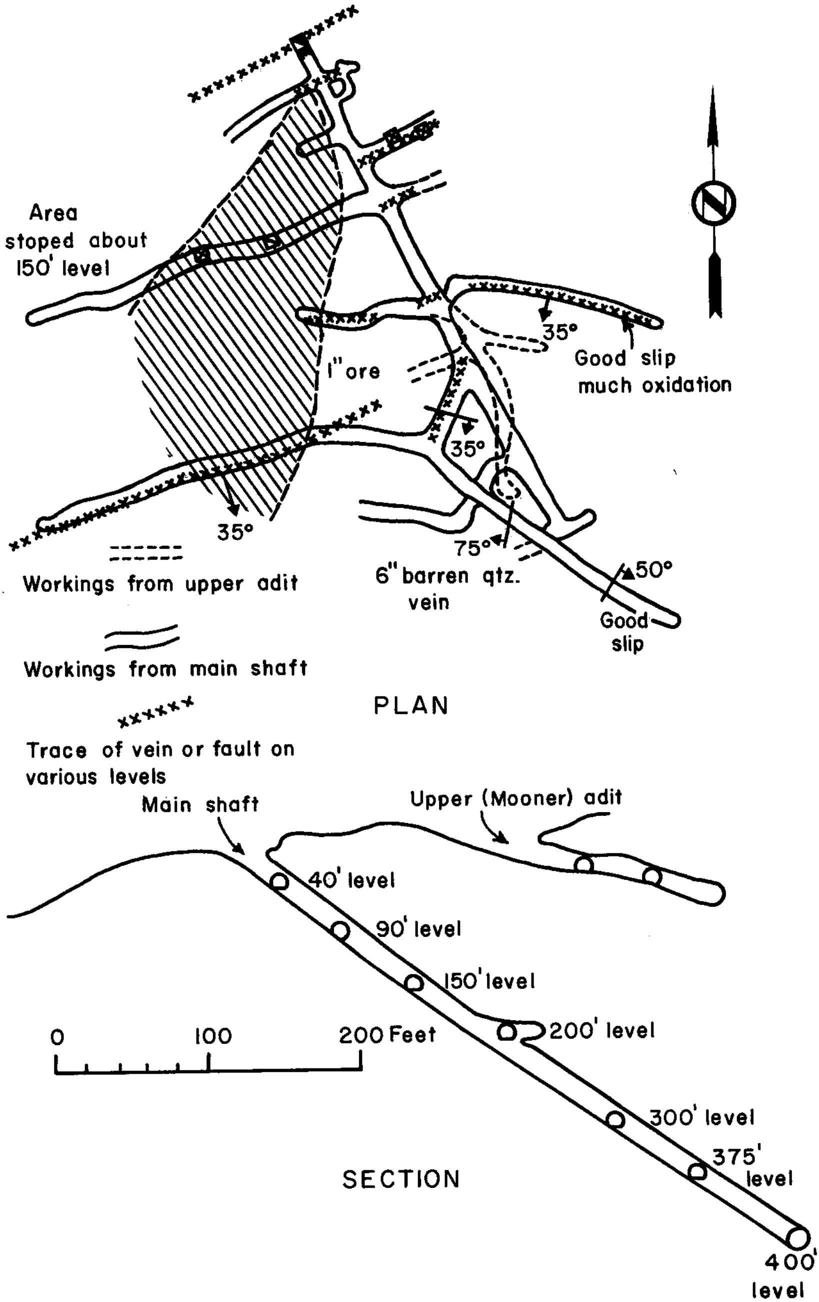


Figure 16

UNDERGROUND WORKINGS, CO-OP MINE, GOLD HILL

Also of interest is the position of the deposit at the intersection of two lineaments in the area, the N. 40° W. lineament marked by the pegmatite deposits and the well-defined N. 70° E. Co-op–McWhorter fault. The favorable position of the deposit and the known presence of sulphide warrant further exploration.

Reservation mine. The Reservation mine is in the NW¼ sec. 30, T. 21 S., R. 16 W. in the northern part of the area. The major workings are on the Reservation patented claim owned by A. A. Leach, Lordsburg, but the vein runs northeast beyond the boundaries of the claim and some of the workings are on the adjacent unpatented Gold Bullion claim (fig. 17). The Reservation was listed by Graton as one of the principal mines of the area (Lindgren, Graton, and Gordon).

On the Reservation claim, two old vertical shafts 100 to 150 feet deep with drifts and much stoping have been sunk in the footwall of the vein. An adit was driven northwest to intersect the vein from a point 75 feet below the collar of the shafts. From the adit, drifts run 100 feet southwest and 200 feet northeast along the vein, with a 30- to 40-foot-deep winze at the northeast end. These workings are extensively stoped to the surface but are not connected to those off the shafts.

On the Gold Bullion claim, an upper adit along the vein for 100 feet is connected to the surface by a 60-foot shaft adjacent to the boundary of the Reservation–Gold Bullion claims. Farther northeast, a lower adit was driven along the vein for 100 feet, with a 30- to 40-foot-deep shaft at the portal. Stopes exist above both adits. The workings explore the vein horizontally for 2000 feet and vertically for 200 to 250 feet.

The vein strikes N. 45° E. and dips 60° SE at the shafts, but flattens to the southwest. It is 4 to 6 feet wide in places, contains some silver, and is reported to have averaged 1 to 3 ounces of gold a ton in many of the stopes. The country rock is largely hornblende and mica schist, with garnet gneiss nearby. Locally, an andesite dike is adjacent to the vein.

Numerous smaller veins in the vicinity trend subparallel to the Reservation vein. The most noteworthy of these crops out on the crest of the ridge northwest of the Reservation. An old 50-foot-deep shaft and some pits have been sunk along it. The vein is in granite and is 4 to 6 feet wide. Gold and silver were present in about equal values at the shaft, but the silver content of the vein increases toward the northeast. In a small pit west of the shaft, quartz veins lie on both sides of an extremely altered andesite dike.

Bruff. The Bruff deposit in the S½ sec. 30, T. 29 S., R. 16 W. is along a vertical quartz vein which strikes N. 70° E. and traverses coarse microcline granite. Pyrite and calcite were observed in the vein material. The shaft, on the bank of a small stream, is said by F. McWhorter (oral communication) to be about 200 feet deep. A number of pits explore the vein for 500 feet northeast of the shaft. The deposit was last worked for gold in 1940.

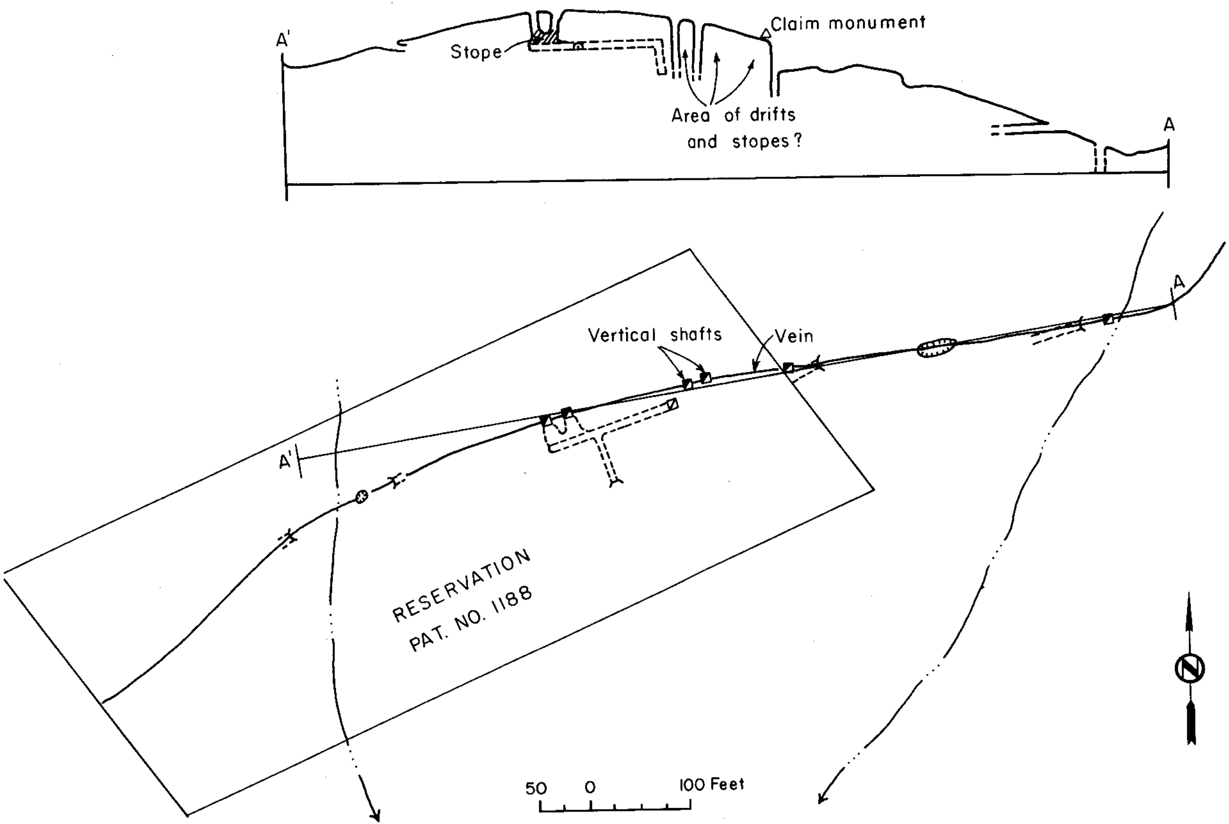


Figure 17

SKETCH MAP AND LONGITUDINAL SECTION, RESERVATION MINE, GOLD HILL

Several pits and shafts explore subparallel veins north and northwest of the Bruff. Some of these are along the contact of basic dikes and granite. All are quartz-pyrite-calcite veins of similar character.

Ruby Silver. The Ruby Silver deposit in the SW¼ sec. 29, T. 21 S., R. 16 W. is explored by a shaft 50 to 60 feet deep. The vein strikes N. 75° E., dips 80° NW, and is along the contact of a basic dike and gray, medium-grained granite. The granite is slightly sericitized next to the vein. Pyrite, quartz, calcite, and argentiferous galena were observed on the dump, and specimens of what might have been ruby silver were found. The deposit was mined for its silver rather than its gold content. Smaller shafts and pits are west of the Ruby Silver deposit.

Standard. The Standard in the SW¼ sec. 6, T. 22 S., R. 16 W. was the largest mine in the district. The vein strikes west-northwest and dips 45° S, cropping out on the side of a steep hill that dips in the same direction as the vein. Because of this, the vein is just a few feet below the surface for several hundred feet below the outcrop. Two adits cut the ore body near the bottom of the hill, and the ore shoot was stoped to the surface.

The vein was from 6 inches to 5 feet wide. Schist forms the footwall; the hanging wall appears to be diabase. The vein consisted of quartz and limonite with disseminated grains of gold. A small amount of ore reputedly remains in the workings, but the mine was virtually mined out prior to 1900.

California, Golden Chief, Minneapolis, and other deposits. Many of the deposits which were worked in the productive days of the district are no longer identifiable. At others, the workings are caved, filled, or otherwise inaccessible, and no information is available from old reports. Only brief mention, therefore, is made of these deposits.

The California is immediately south of the Standard. Workings consist of a few small pits near or adjacent to diabase dikes. No mineralization was observed.

The Golden Chief, the original claim located by David Egelston, consists of a crosscut adit with drifts north and south along the vein. The vein traverses schist.

The Crescent (Homestead) is along a vein which strikes west-northwest, dips 40° SW, and traverses schist. An inclined shaft gave access to the workings. A subparallel vein is exposed in some pits nearby.

The Nancy Lee is on a patented claim formerly owned by A. A. Leach. The vein strikes northwest, dips northeast, and is in schist. Two vertical shafts gave access to the workings.

The McWhorter homestead is on three patented claims. The house is on the Hoboken claim, the windmill occupies the shaft of the Contention claim, and the Gold Tunnel claim is on the hill west of the house. The Contention vein strikes east, is vertical, and is in schist. The Gold

Tunnel vein strikes northeast and dips 40° SW. An adit explores the deposit.

The Minneapolis mine is on a patented claim belonging to A. A. Leach. It is near the head of a tributary draw of Peterson Canyon on the northeast side of Gold Hill, near the center of sec. 19, T. 21 S., R. 16 W. It is explored by an adit and a shaft, both inaccessible. Workings are reported by Leach to have been extensive. Gold was the principal metal.

Bluebird. The Bluebird deposit in the NW¼ sec. 7, T. 21 S., R. 16 W. is adjacent to the Grant–Hidalgo county line. It is an old gold property and was worked through several shafts and pits. At the bottom of an old incline rehabilitated in 1954, scheelite and minor amounts of wolframite occur sporadically in a narrow quartz vein at its intersection with a cross fracture (Dale and McKinney, 1959). Scheelite also was observed on the dump and in a narrow quartz vein at the portal of an old adit 500 feet to the west. Other instances of scheelite in the area are indicated by its presence in the alluvium of the first large canyon east of the Bluebird. For a more complete description of the wolframite and scheelite occurrence, the reader is referred to Dale and McKinney.

Climax and nearby deposits. The Climax deposit, covered by a patented claim owned by F. McWhorter, is in the SE¼ sec. 18, T. 22 S., R. 16 W. A small adit is driven 20 feet S. 60° E. into the hillside across the creek from a windmill. The vein, striking N. 30° W. and dipping 20° SE, is in granite, but diabase, biotite schist, and a large, prominent quartz monzonite dike all crop out below the adit on the hillside. The vein contains gold and argentiferous galena, quartz, and calcite. Small prospects to the north and to the southeast contain argentiferous galena in high-grade pods 8 to 10 feet in diameter.

Shafts northwest of the Climax deposit have explored two separate veins. One vein strikes N. 45° W., dips 50° SW in granite, and is explored by a 30- to 40-foot vertical shaft and some shallow trenches. The other vein strikes about N. 30° E.; a pit and a shaft inclined 30° S. 20° E. have been sunk on it. A diabase dike forms the footwall of this vein; the hanging wall is granite. Biotite schist crops out between the two shafts. The veins carried high-grade galena, probably with good silver values, and possibly some gold. Quartz is the dominant gangue mineral.

Never Fail mine. The Never Fail mine, now the Connie Lynn, in the NE¼ sec. 20, T. 22 S., R. 16 W. is an old gold property that was reopened in 1956 by the Three Bells Mining and Milling Company, controlled by John Bailey, Lordsburg, L. J. Regan, El Paso, and Arthur Hamilton, Dallas. The deposit is covered by six claims. The main workings consist of a shaft inclined 40° S. 15° W. which is sunk 90 feet on the incline, with drifts at 72 feet. Much of the vein above this level, within 50 feet either side of the shaft, is stoped out. Other shafts (all inaccessible in 1961) and shallow pits and cuts explore the vein for 2000 feet. The main shaft was reopened and a small cyanidization plant constructed between 1956 and 1958, but the operation was shut down in 1959. No ore was shipped.

The vein is along the hanging wall contact of an altered diabase dike traversing granite. It strikes N. 65°-75° W. and at the main shaft dips 35° to 40° SW. It can be traced for more than 2000 feet. Limonite-stained quartz is all that shows on the dump or where the vein is exposed in cuts, but at a small pit 1000 feet southeast of the main shaft, fragments of the vein material show excellent banding, with chlorite and epidote next to the wall and calcite, quartz, and pyrite forming the vein proper. Mr. Regan reports that the ore assays averaged 3.5 ounces of gold and 19.0 ounces of silver a ton, with 8 to 9 per cent lead, but that in the mine the vein is only 8 to 10 inches wide.

Fluorspar Deposits

Fluorite occurs with quartz and drusy coatings and fillings of small fractures in the SE¼ sec. 29, T. 21 S., R. 16 W. on the crest of the range a few hundred feet east of the south pegmatite. It also occurs as a vein filling a large fracture at the Bluebird mine on the northeast side of Gold Hill in the NE¼ sec. 22 and NW¼ sec. 23, T. 21 S., R. 10 W. within half a mile of the Malone fault, which bounds the Gold Hill block on the northeast.

Bluebird mine. The description of the Bluebird fluorspar deposit by Gillerman (1952) is reprinted here. No mining has been done at the deposit since 1945.

> The Bluebird fluorspar deposit, referred to as the Friday prospect by H. E. Rothrock (1946, pp. 78-79), is in the NE¼ sec. 22 and the NW¼ sec. 23, T. 21 S., R. 16 W., southwest of the Burro Mountains. . . . A dirt road 2 miles long leads to the deposit from State Highway 180 at a point about 26 miles southwest of Silver City. A reported 3,000 tons of fluorspar averaging 50 percent CaF_2 was shipped from the deposit prior to 1944, and small shipments of an unknown amount have been made since that date. The property was operated by Victor Bonnefoy of Albuquerque in 1944 and 1945, but from 1946 to 1949 the property was owned by J. W. Alsop and J. H. Winslow of Lordsburg. Numerous narrow stopes that open to the surface, shafts, and shallow pits have been excavated along the vein for a total distance of 2,050 feet.
>
> The fluorspar occurs in stringers and veins 1 inch to 2 feet wide, in a breccia and sheeted zone 2 to 8 feet wide, in pre-Cambrian granite. The zone strikes N. 85° W. to N. 75° E. and dips 70° to 80° N. Fluorspar is present at intervals of 3,000 feet along the strike of the zone, the ore shoots occurring as lenses 30 to 50 feet long and extending downward 40 to 50 feet. Adjacent to the mineralized zone the granite is sheeted and sheared parallel to the strike of the zone, and the frac-

tures are filled with quartz. In the eastern part of the area three parallel veins are present. Faults and breccia within the fluorspar indicate postmineral movement.

White, green, violet, and purple fluorite occur as coarsely crystalline masses associated with quartz and silicified wall rock. Crystals with cube, octahedron, and dodecahedron faces are common. Limonite is present in the eastern part of the deposit, and calcite, pyrite, and possibly some gold occur at the small deposit about 1,000 feet south of the main mineralized zone.

Neither the fluorspar zone nor the fault can be traced west of the workings, but to the east, small fluorspar stringers occur along the zone to within 1,000 feet of C-Bar Canyon. The Malone fault, which at this place forms the boundary between the Tertiary volcanic rocks to the northeast and the pre-Cambrian granite and schists to the southwest, extends down this canyon.

Pegmatites

In the early 1950's, the interest in uranium and radioactive deposits resulted in the discovery of rare-earth-bearing minerals in some of the pegmatites of the Gold Hill area. Prospecting and development of a few of the larger pegmatites took place between 1952 and 1955, but the amount and concentration of rare-earth minerals was so small that work was soon stopped. Apparently efforts were made to produce mica simultaneously from the same deposits, but the grade and amount of muscovite was also too low. The deposits have been abandoned since 1956.

Three major pegmatites were investigated as part of this study; two separate bodies on the crest of the range in the SE¼ and the NE¼ sec. 29, T. 21 S., R. 16 W. about 800 and 2000 feet, respectively, north of the Co-op mine, referred to hereafter as the South and North pegmatites, and the White Rock deposit in the SE¼ sec. 13, T. 21 S., R. 17 W. on the north side of Gold Hill. This latter deposit is in Hidalgo County, within a few thousand feet of the Grant–Hidalgo county line. Large pegmatite masses are also southeast of the White Rock deposit, southeast of the Co-op mine, and in the NE¼ sec. 27, T. 21 S., R. 16 W. These were not studied and are explored only by small pits. Smaller pegmatite deposits are common in the area.

Minerals in the pegmatites include quartz, microcline, albite, muscovite, biotite, magnetite, garnet, fluorite, and rare-earth-bearing minerals. Of the latter, allanite, euxenite, samarskite, and cyrtolite have been reported (Boyd and Wolfe, 1953). The massive milky quartz which constitutes most of the core of the pegmatites is especially conspicuous on the outcrop and as float.

The pegmatites studied are zoned. The core is coarse quartz with small segregations of microcline. Surrounding this is a quartz-perthite zone with muscovite and biotite. At the North pegmatite, this zone can be subdivided into an inner zone free of mica and an outer zone containing altered biotite. Small crystals and subhedral masses of magnetite and garnet are within the quartz-perthite zone. Surrounding the quartz-perthite zone is a quartz-albite-muscovite or quartz-albite-microcline-muscovite zone. The outermost zone is quartz-microcline. Massive green fluorite, found at the South pegmatite, probably occurs in the quartz-albite-muscovite zone.

The major, and many of the minor, pegmatite masses are aligned in a N. 40° W. direction (fig. 15). This direction parallels other lineaments and is marked also by drainage. The elongation of the individual pegmatite masses is parallel or subparallel to the trend of the zone.

The pegmatite bodies are small and do not appear to have commercial possibilities. The mica is not of commercial grade, and the rare-earth minerals are scarce. Quartz could be mined profitably for silica if a market were to develop nearby for this commodity. The deposits are similar to pegmatites in the western part of the Big Burro Mountains, about eight miles northeast of Gold Hill.

White Rock. The White Rock pegmatite deposit in the SE¼ sec. 13, T. 21 S., R. 17 W. in Hidalgo County, less than 2000 feet west of the Grant–Hidalgo county line, was owned in 1961 by Dinwiddy and Morenes, Lordsburg. In 1955, when the property was being actively explored, it was under the control of A. C. Bosworth, Silver City, John L. Spunk, and Fred Lyons.

The deposit consists of three pegmatite masses each exposed on small hills. On the surface, these are separate and distinct bodies. Although they may connect in the subsurface, the cores of two diamond drill holes of unknown depth that were sunk in the area between the surface outcrops show nothing but granite and metamorphic rocks. Workings consist of a number of small pits on the northern two masses and a 150-foot long trench cut completely through and across the southernmost and largest of the masses. The maximum depth of the cut is 12 feet.

As exposed in the cut, the pegmatite is composed of a coarse-grained quartz core in which are scattered masses of microcline (fig. 18). This is surrounded by a perthite-quartz zone containing some muscovite, with biotite filling fractures in the quartz and feldspar. Magnetite and garnet and rare-earth minerals are scattered through this zone as widely separated grains and crystals. Many of the fractures filled with biotite have a central filling of quartz and magnetite. Surrounding this is an albite-quartz-muscovite zone containing some microcline. The muscovite occurs as discrete books and crystals up to 2 inches across and as much as 4 inches long. No distinct border was observed, but locally a 3-foot-wide zone of bleached granite containing numerous disseminated muscovite flakes adjoins the quartz-albite-muscovite zone. This latter zone dips 65° NE.

The other two pegmatite masses are not so well exposed and the

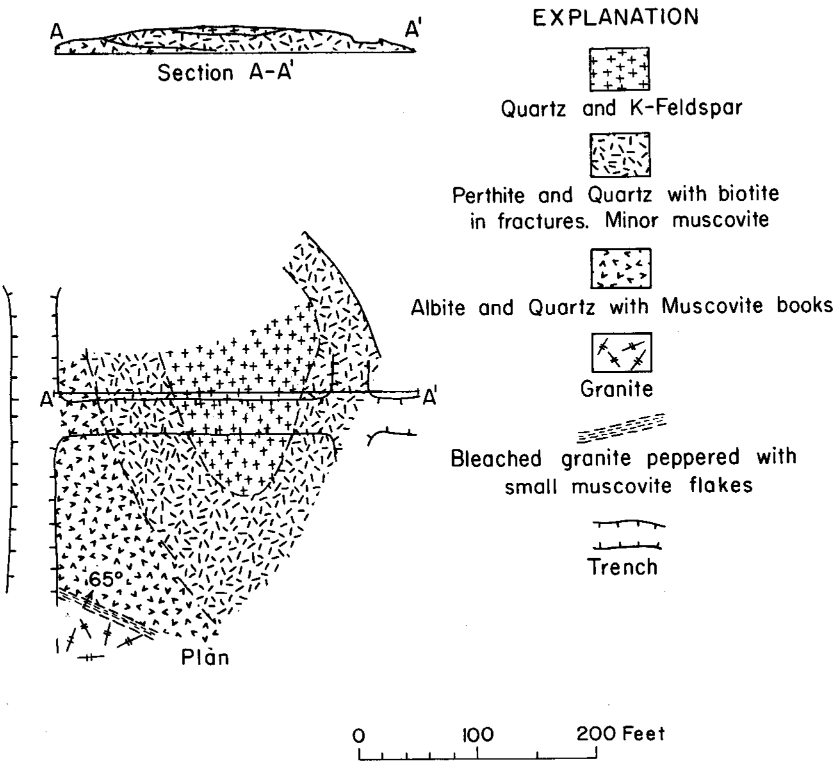


Figure 18

GEOLOGIC SKETCH MAP AND SECTION, WHITE ROCK DEPOSIT, GOLD HILL

internal structure cannot be ascertained so completely, but both appear to have at least a quartz core with a quartz-perthite zone around it. The granite-pegmatite contact on the southeast side of the smallest mass dips 45° N. 30° W.

North and South deposits. The North and South pegmatite deposits are on the crest of the range in the SE¼ sec. 29. Both can be reached from State Highway 180 by going south one mile on the C-Bar Ranch road, and then about three miles southwest on the Gold Hill road to the crest of the range and the deposits. The deposits were worked from 1955 to 1956 by the Cherry Mining Company of Texas, but the owners in 1961 were unknown.

Both deposits crop out as knolls. At the North, a large cut on the southwest side has resulted in removal of about half the outcrop to a depth of 20 feet. At the South, a 20-foot-deep shaft and some small pits on the crest of the knoll and a 40-foot-long adit on the southeast side of it constitute the workings.

Apparently, small amounts of rare-earth minerals were recovered from the North deposit. At the South deposit, rare-earth minerals and muscovite appeared to be of interest. The operations were not economical.

The North pegmatite shows a coarse quartz core containing some microcline, surrounded by a quartz-microcline-biotite zone (fig. 19). The biotite is much altered and bleached to a light brown, opaque material. Small magnetite crystals are common, and it is probably within this zone that the rare-earth minerals occur, although none was observed. This

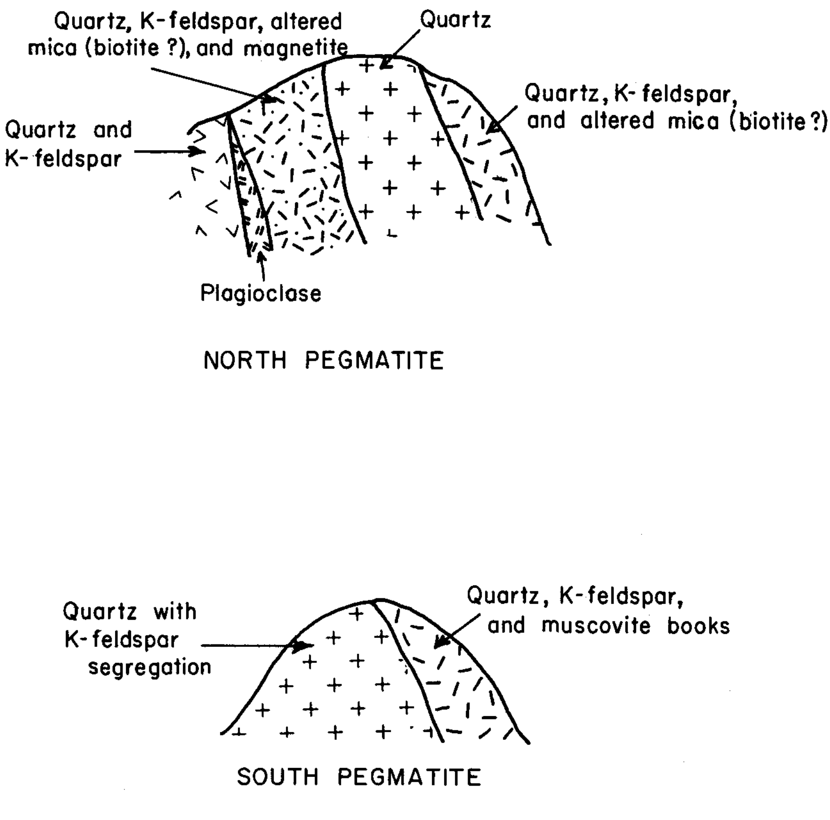


Figure 19

DIAGRAMATIC CROSS SECTION THROUGH THE NORTH AND SOUTH PEGMATITES, GOLD HILL zone forms the surface on the east side of the deposit, but on the west side, a wedge of albite separated it from an outer quartz-microcline zone. No muscovite was observed at this deposit.

At the South deposit, zonation was not so apparent (fig. 19). The core is coarse quartz with small segregations of microcline. This is enclosed by a zone of microcline, quartz, and muscovite. The muscovite occurs as large, foliated masses in pockets and lenses and also as crystals up to 3 inches long in the quartz and feldspar. Small red garnets, usually less than one millimeter in diameter, are scattered through the massive muscovite. Massive green fluorite, observed only on the dump, probably is concentrated in masses in the feldspar. No albite, biotite, or magnetite was observed.

LANGFORD HILLS

The Langford Hills are the southeastward extension of Gold Hill, both topographically and geologically (fig. 1). They are low hills forming a narrow range less than two miles wide, trending southeast, and occupying eight to ten square miles in T. 22 S., R. 16 W. Granite is the dominant rock type but small, isolated masses of schist are present, and diabase and acidic dikes, similar to those in Gold Hill, cut the older rocks. The diabase dikes trend northwesterly and the acidic dikes northeasterly. Known deposits are limited to the Myers tungsten-gold-silver deposit and a small uranium-bearing fluorspar prospect (fig. 15). Both have been described (Dale and McKinney; Gillerman, 1952). I visited neither during the course of this study, but both were examined in 1950.

Hillside (Myers) tungsten. The Hillside deposit in sec. 26, T. 22 S., R. 16 W. was worked by George Myers for gold and silver for many years prior to 1941. Three shafts, each about 75 feet deep, were sunk. In 1941, wolframite float was found in the vicinity of the shaft, and Myers sank a 40-foot-deep shaft from the bottom of an old open pit on the wolframite ore. A drift was driven from the bottom of the shaft 27 feet along the ore zone. Total production was 650 tons of hand-sorted ore that was shipped to Tombstone, Arizona, with payment on the basis of 12 units of WO_3. Myers died in the late 1940's, and in 1957, the claims were owned by J. H. Winslow, M. R. Hemley, and Y. E. Nichols. The workings are caved and inaccessible, and the deposit has been virtually abandoned since 1946.

According to Dale and McKinney, wolframite and scheelite are in narrow quartz veins filling irregular fractures in coarse-grained gray granite. The veins terminate to the north against a narrow felsite dike which strikes N. 55° E. and dips 70° S. The scheelite-wolframite ratio is estimated to be 5:1. The tungsten minerals occur as scattered bunches and pods in the quartz. Wolframite float is found several hundred feet west of the workings.

Langford fluorspar. The Langford prospect is in the S½ sec. 25 or N½ sec. 36, T. 22 S., R. 16 W. at the northeast base of the Langford Hills. A silicified breccia zone 5 feet wide, probably along a fault, traverses granite. It strikes N. 15° W. and dips 62° NE. Dark purple, fine-grained fluorite is present as incrustations and as veinlets less than one inch wide between the breccia fragments. Quartz and calcite are associated with the fluorite. Uranium minerals, also within the breccia zone, are intimately associated with the fluorite, some of which is radioactive. A few crystals of autunite were observed on the outcrop.

DEPOSITS IN THE VICINITY OF SOLDIERS' FAREWELL MOUNTAIN

Soldiers' Farewell Mountain is in secs. 24 and 36, T. 22 S., R. 15 W. and secs. 30 and 31, T. 22 S., R. 14 W. about fourteen miles south of White Signal (fig. 1 and pl. 1). Fluorspar and fluorspar-gold deposits and a small tungsten prospect are in T. 22 S., R. 14 and 15 W., west of Soldiers' Farewell Mountain; the McDonald perlite property is about two miles north of Soldiers' Farewell Mountain; and the old Mose Trimmer lead-silver mine and a small tungsten and uranium-bearing fluorspar deposit are about eight miles northeast (fig. 20).

American, Continental, Double Strike, and nearby deposits. The fluorspar and fluorspar-gold deposits west of Soldiers' Farewell Mountain are fissure-filled veins, chiefly in Precambrian granite. Some, however, traverse rocks of the Knight Peak volcanic series and rhyolite dikes trending northeastward across the southern part of the area. The deposits are in proximity to and southwest of the graben that extends diagonally southeastward and is filled with Knight Peak volcanic rocks and Gila Conglomerate. Soldiers' Farewell Mountain, which rises above the countryside as a prominent landmark, is part of a late dacite flow within the graben.

The fluorspar deposits are fully described by Gillerman (1952), and only a brief description is given here. The major occurrences are the American, Continental, and Double Strike deposits. The rest are merely small prospects opened by a few small pits or shallow shafts from which production has been negligible. The American and Double Strike deposits were operated for gold in the 1920's and 1930's, and fluorspar was produced during World War I and intermittently since that time. Operations ceased in the district in 1949 when the American mine was shut down.

Although several shafts explore the deposits, none is more than 100 feet deep. The deposits are all along faults which trend north and northwest and dip steeply. At the American, gold- and fluorspar-bearing quartz veins fill many subparallel faults branching off into the granite footwall from the major fault between granite and volcanic rocks. This

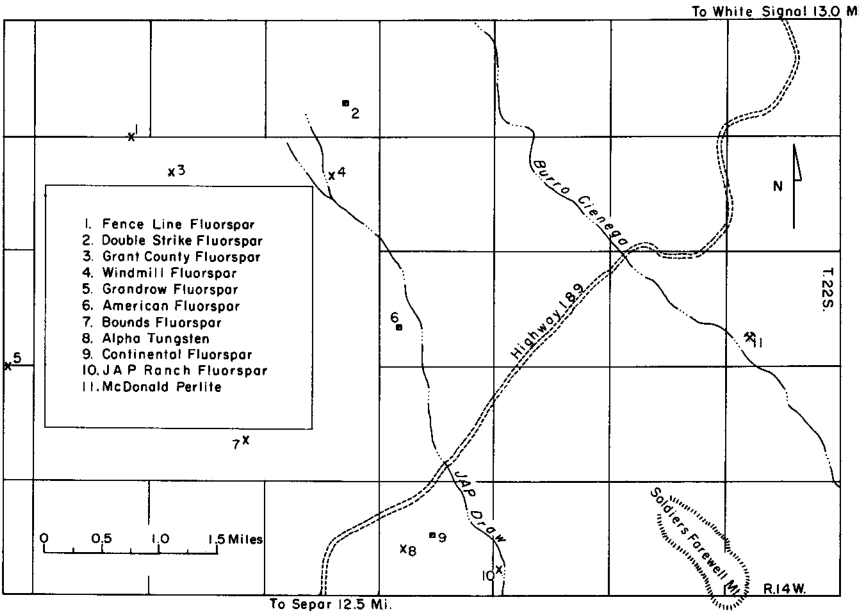


Figure 20

LOCATION OF MINERAL DEPOSITS IN THE VICINITY OF SOLDIERS' FAREWELL MOUNTAIN

fault forms the southwestern boundary of the graben at this locality. Fluorspar is abundant within 300 feet of the major fault and has not been found more than 700 feet from it.

The veins at the American deposit are as much as 3 feet wide, the breccia zones 30 feet wide. Fluorspar makes up about 35 per cent of the breccia zones. Silicified breccia fragments are the chief diluents of the veins and breccia zones.

At the Double Strike deposit (also called the Rocky Trail), fluorspar is in lenses and veinlets in three subparallel, silicified fault gouge and breccia zones. The veins stand up as resistant masses. Two generations of fluorite are present, an early purple or dark green, coarsely crystalline fluorite and a later pale green to white fluorite. Excellent crystals of the late fluorite showing a cubic habit modified by dodecahedrons, and usually also by tetrahexahedrons and hexoctahedrons, are common. Gold is found in small quantities with the fluorite.

At the Continental deposit, fluorspar occurs in places through a distance of 3000 feet along branching faults that locally cut the volcanic rocks and Precambrian schists and quartzite. Quartz is the only gangue mineral visible, but gold is found sparingly. Much of the fluorite is light green to yellow-green, and etched cubic crystals are common.

The JAP Ranch, Windmill, Grandview, Bounds, Fence Line, and Grant County complete the list of known fluorspar deposits. All are small. The first two are near the granite-volcanic rock contact, but the others are more than half a mile southwest of the contact. All are in granite.

Alpha deposit. A small tungsten property, known in 1961 as the Sunday deposit but formerly called the Alpha, is in the W½ sec. 27, T. 22 S., R. 15 W. This deposit is described in detail by Dale and McKinney. Workings consist of two shallow shafts, the deepest about 35 feet, and some small pits.

Scheelite, associated with garnet, epidote, hornblende, calcite, and quartz is found within a small mass of amphibolite and mica schist in granite. The mass is elongated east-west and seems to stand vertically. It could not be traced more than a few hundred feet along the strike and is about 50 feet wide. Only small amounts of scheelite were observed by Dale and McKinney and by the writer, but Dale and McKinney report that 100 tons of ore assaying 1.0 per cent WO_3 were shipped from the property.

The occurrence is identical to that of the scheelite prospects in the Bullard Peak district.

Mose Trimmer mine. The Mose Trimmer mine in the NE¼ sec. 16, T. 21 S., R. 14 W. has been explored by two shafts and a number of pits. The main shaft is reported to be more than 200 feet deep, with several drifts and stopes. It is inclined 75° N. 20° W. The deposit was first opened in World War I or before by a Mr. Hines. In the late 1930's and early 1940's, it was operated by W. A. Trimmer, Oakland, California, who still owns the property.

The vein is in granite and strikes N. 70° E. Specimens on the dump consist of barite and quartz with small blebs of galena. The shaft is reported to have followed a continuous vein of rich, silver-bearing galena, up to 6 inches wide, from the surface to the bottom of the mine (Charles Russell, oral communication). About 900 feet to the southeast, a vertical shaft filled with water to within 35 feet of the surface explores a parallel vein.

The Mose Trimmer shaft is less than 500 feet east of the Taylor fault, which forms the northeastern boundary of the Knight Peak graben. The vein is exposed in a small pit 50 feet southwest of the shaft, but shallower pits farther southwest are in unconsolidated material. These may be west of the fault, which here lies between granite on the northeast and Gila Conglomerate on the southwest. The vein probably terminates against the fault.

Hines property. The Hines uranium-bearing fluorspar and adjacent scheelite deposits in the SW¼ sec. 26, T. 21 S., R. 14 W. (they were incorrectly located previously in the NE¼ sec. 34) were described by Gillerman (1952) and Lovering. Neither is of commercial importance. The fluorspar and the scheelite are in subparallel breccia zones trending N. 85° E. and N. 75° E., respectively, which traverse Bliss Sandstone. Pits explore the two veins and are 90 feet apart. The Taylor fault, bounding the Knight Peak graben with granite on the northeast side and Gila Conglomerate on the southwest side, is less than 500 feet southwest of the fluorspar. The deposits are about two and a half miles southeast of the Mose Trimmer mine.

A detailed description and a map of the Hines deposit is in the report by Lovering.

McDonald Ranch–Thompson Canyon perlite. Perlite occurs at two widely separated localities within the Knight Peak Tertiary volcanic sequence, in Thompson Canyon, sec. 18, T. 20 S., R. 16 W. in the northern part of the Knight Peak Range and along the Burro Cienega on the McDonald Ranch, secs. 18 and 19, T. 22 S., R. 14 W., secs. 2, 3, 11, 13, 14, and adjacent areas, T. 22 S., R. 15 W. About 3000 tons of perlite were shipped from the McDonald Ranch deposit in 1950, but there has been no attempt to exploit the deposits in Thompson Canyon.

Both masses of perlite are within the early rhyolitic rocks defined by Ballmann as the basal unit in the volcanic sequence. The perlite lies above a welded rhyolitic lithic tuff. In most places, the perlite is a shattered mass of thin- to thick-bedded gray glass containing lenses and bands of siliceous material. The lower and upper sections are extremely brecciated and locally are cemented by red, glassy matrix. Ballmann described the perlite in detail and suggested its origin.

The deposit in Thompson Canyon, called the Brock by Ballmann, is a dome-shaped mass about 0.8 mile in diameter and 2000 feet thick. Stony layers are abundant. The inaccessibility and distance from a railroad make it of no commercial importance for the time being.

The McDonald Ranch deposit is much larger than the Thompson Canyon and crops out along the Burro Cienega for six miles northwest and southeast of the White Signal–Separ road. The southern part is in low, rolling country and is accessible by road. The deposit thickens toward the south, and in the vicinity of the McDonald ranch house in sec. 13, T. 22 S., R. 16 W. and sec. 18, T. 22 S., R. 14 W., some of the beds are free enough from rhyolite, chert, and siliceous material to be commercially workable. Production has been largely from a locality about one and a half miles southeast of the ranch house on the northeast side of Burro Cienega. Smaller workings are three quarters of a mile southeast of the ranch house on the southwest bank of Burro Cienega. A good ranch road leads two miles down Burro Cienega from the White Signal–Separ road to the major deposit. From the Burro Cienega, it is sixteen miles by good graded road to Separ and the Southern Pacific Railroad.

A roughly circular quarry 100 feet in diameter and 12 feet in maximum depth constitutes the main workings. Only a few shallow pits are at the other localities. About 3000 tons of perlite were shipped by Wade White, Silver City, between January and July 1950, but operations ceased because unfavorable freight rates made competition with other perlite deposits unprofitable. The deposit has been sampled and examined by various concerns since the workings were closed, but the costs of transportation are still such as to make the deposit uneconomical, even though considerable high-grade perlite is available.

At the main workings, the perlite beds strike N. 40° W. and dip 25° NE. The gray perlite is interbedded with red silicified and vitric lenses and contains nodules filled with opal and chalcedony. It is several hundred feet thick, but production has been only from the lower part of the sequence, where 30 to 40 feet of perlite is free enough from rocky and siliceous material to be of commercial grade. Neither the lateral nor the vertical limits of the high-grade perlite have been determined; extensive reserves of mineable material are undoubtedly present.

BULLARD PEAK AREA

Bullard Peak rises abruptly to 7064 feet, nearly 1000 feet above the surrounding countryside, and dominates the northern part of the Burro Mountains. It is a notable landmark and can be seen from many miles away (photo 1). Its name has been given to the mining district two miles northeast of it. As used in this report, the term *Bullard Peak area,* comprises the country within a radius of about five miles of the peak (fig. 1 and pl. 1) and is part of the area described by Hewitt as the northern Burro Mountains.

The geology of the Bullard Peak area is excellently described by Hewitt and little can be added. A detailed study of the Black Hawk (Bullard Peak) district by Gillerman and Whitebread also describes the geology but is chiefly concerned with the mineral deposits. The reader is referred to these publications for detailed information.

Burro Mountain granite, quartz diorite gneiss (tonalite), and associated rocks of the Burro Mountain batholith constitute the principal rocks of the area. These have been intruded into the Bullard Peak series, a Precambrian metamorphic complex of metasedimentary and metaigneous rocks. Quartzite, amphibolite, and schist and gneiss of various types are present. Dikes and small stocks of post-Precambrian rocks intrude this complex, and Cretaceous sedimentary rocks and Tertiary volcanic rocks overlie it in the northern part.

The mineral deposits (fig. 21) are discussed under two headings, the Bullard Peak tungsten deposits and the Black Hawk (Bullard Peak) district. The former are concentrated south and east of Bullard Peak and are associated with amphibolite xenoliths and pegmatites within the Burro Mountain granite. The latter is northeast of the peak and con-

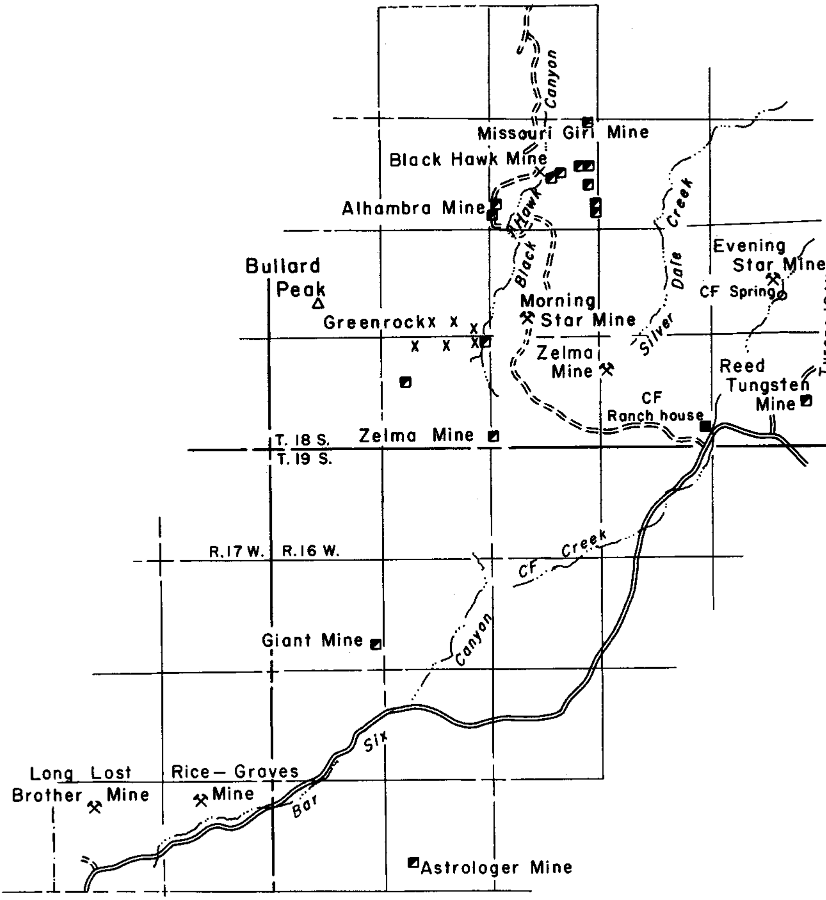


Figure 21
LOCATION OF MINERAL DEPOSITS IN THE BULLARD PEAK DISTRICT

tains silver-nickel-cobalt-uranium deposits that are unique in the United States. They are spatially associated with a Late Cretaceous or Early Tertiary intrusion of monzonite porphyry into the Precambrian rocks.

BULLARD PEAK TUNGSTEN DEPOSITS

Scheelite occurs in many places within a roughly elliptical area south and east of Bullard Peak in T. 19 S., R. 17 W., T. 19 S., R. 16 W., and T. 18 S., R. 16 W. The area is approximately 8 miles long and 4 miles wide, with the long axis trending northeast. Precambrian rocks, including Burro Mountain granite, quartz diorite porphyry, and various metamorphic rocks of the Bullard Peak series (Hewitt), are the surface rocks in the area, aside from a few, small intrusive dikes. The scheelite deposits are associated with pegmatites, amphibolite, or both. Individual deposits are small, discontinuous, lenslike, segregations within and along the pegmatites or in the metamorphic rocks.

Tungsten was first found in this area in 1935 by Neal Pridemore at the southwest end of the Zelma deposit but little work was done. This deposit was rediscovered in the early 1950's and others were found within the next two to three years. The properties were worked in the middle 1950's when the demand for tungsten was greatest. A total of about 4000 pounds of high-grade concentrates containing a minimum of 63 per cent WO_3 and about 200 tons of low-grade ore containing about 2 per cent WO_3 were shipped prior to 1956. Since then, mining operations were negligible, and none of the properties was active in 1961.

In 1959, the U. S. Bureau of Mines published a report on the tungsten deposits of New Mexico (Dale and McKinney). Most of the scheelite occurrences in the Bullard Peak district are described in this report, and the reader is referred to it for details.

Zelma. The Zelma deposit includes two separate prospects, about 6500 feet apart, covered by four unpatented claims owned by Dave Osmer. The southwestern deposit is near the southwest corner of sec. 33, T. 18 S., R. 16 W.; the northeastern deposit is in the NE¼ sec. 32. The original discovery by Pridemore is at the southwest end of the property, at a shaft 500 feet north of the southwest corner of sec. 33, on the section line. After excavating the shaft, Pridemore abandoned the claim, which was relocated in 1951 by Walter Bourland. In 1953, James A. Talbot relocated it again, and in 1956, Dave Osmer obtained a half interest in the property, owning it outright in 1961. From 1953 to 1955, Talbot produced 975 pounds of concentrates assaying 62 per cent WO_3 by hand jigging. Jack Mercer, who leased the property from Talbot, shipped 200 tons of low-grade scheelite ore. All production was from the deposit at the southwest end of the property.

An adit is driven N. 30° E. for 70 feet and at its distal end connects with the bottom of the 25-foot-deep Pridemore shaft. A crosscut runs 6 feet southeast midway along the adit. Southwest of the portal, across a small gulch, another adit is driven 10 feet southwest.

The scheelite is associated with a quartz vein which intrudes Burro Mountain granite. The quartz vein is 2 to 3 feet wide, strikes N. 30° W., and dips 15° NW. In the shaft, it appears to be displaced by a small fault. The quartz and the granite are much fractured. Individual crystals subhedral grains, and small pods of scheelite are disseminated through the quartz and adjacent granite, but they are concentrated along the borders of the quartz vein. Pods as much as 10 inches in diameter were mined from along the contact. L. L. Osmer, Jr. (oral communication) reports bismuth with the scheelite.

The mineralized zone extends about 300 feet, trending N. 30° E. Small pits, trenches, and bulldozed cuts are present in addition to the shaft and adits. No amphibolite was observed in the vicinity.

At the northeastern deposit, a shallow trench 25 feet long and some bulldozed cuts expose an area of mica schist and amphibolite, which is cut by numerous veinlets, stringers, and irregular lenses of pegmatitic quartz and potash feldspar. These pegmatitic segregations have no preferred orientation, but many are N. 50°-60° E. and parallel the schistosity. The veinlets and stringers are 1 inch to 4 inches wide, and some of the lenses are 3 to 4 feet long. Scheelite occurs as small grains, usually along fractures and along the contacts of the pegmatitic veinlets. Some is disseminated in the pegmatitic material and in the amphibolite. Epidote and chlorite are common in the amphibolite. The scheelite and pegmatite zone is about 20 feet wide; it trends N. 60° E. for 200 feet. It has been exposed about 500 feet southeast of the trench by bulldozed cuts.

Morning Star. The Morning Star deposit is covered by five unpatented claims owned by Dave Osmer, who found it in 1953. It lies in the SW¼ sec. 28, T. 18 S., R. 16 W., about one and a half miles south of the Black Hawk mine along the road leading to the Black Hawk district. A 22-foot-deep inclined shaft and shallow trenches and cuts constitute the workings. Osmer shipped 1400 pounds of concentrates containing 73 per cent WO_3 which he obtained by hand jigging and sorting.

The shaft is sunk along a fault which strikes N. 55° E. and dips 45° NW. The country rock is gabbro. A seam of scheelite 2 to 3 inches wide is along the fault on the hanging-wall side of a breccia zone. A dike of quartz latite porphyry 2 inches to 6 feet wide is between the scheelite and country rock. The seam is persistent and continues the entire depth of the shaft. Pods 10 inches in width were seen in places along the vein. L. L. Osmer, Jr. (oral communication) stated that while the shaft was being sunk, the value of scheelite extracted averaged about $90 for every foot of shaft sunk. No drifting was done from the shaft and neither the lateral nor the vertical extent of the scheelite seam has been determined.

About 400 feet south of the shaft, a barren quartz vein 25 to 40 feet wide, striking easterly, marks the southern limit of the gabbro. South of the quartz vein, mica schist and amphibolite cut by quartz-rich pegmatite dikes a few inches to several feet wide crop out. Scheelite, in grains or crystals up to 4 inches in diameter, occurs sporadically in the pegmatite. Seams, veinlets, and pods of scheelite as much as 8 inches wide also are in the fractures and shear zones in the schist and amphibolite. The scheelite covers an area several hundred feet square and is found as float over a much wider zone. Dale and McKinney estimated 1000 yards of high-grade placer material to be on the property.

Greenrock. Three unpatented claims owned by Sherman Harper of Arena Valley cover the Greenrock deposits in the S½ sec. 29 and NE¼ sec. 32, T. 18 S., R. 16 W., one mile southeast of Bullard Peak. The deposits were located in 1953. About 150 pounds of hand-sorted, high-grade scheelite concentrates and 5 tons of low-grade scheelite ore averaging 27 per cent WO_3 were shipped between 1953 and 1955. A 15-foot-deep shaft, a 25-foot-deep shaft, shallow trenches, and a 10,000-square-foot area stripped by a bulldozer constitute the workings. In addition, there is an old, partly filled shaft on the Greenrock No. 2 claim, now 20 feet deep, which exposes a vein striking N. 20° W. and dipping 75° NE that contains lead, copper, and silver.

Dark green to black amphibolite, cut by numerous pegmatite dikes, is the bedrock. The pegmatite dikes strike north N. 60° W. and N. 45° E. They range from a few inches to several feet in width but average between 1 foot and 2 feet wide. They are particularly abundant on the stripped area. Scheelite as grains or crystals up to 1 inch in diameter is in fractures in the amphibolite near or adjacent to the pegmatite, along the pegmatite-amphibolite contacts, and in quartz-rich parts of the pegmatite. It is sparsely distributed but concentrations are present locally. Harper (oral communication) stated that an assay which averaged 2 feet wide across the stripped section contained 0.9 to 2.5 per cent WO_3. Scheelite occurs throughout this stripped area, but much of it may be float weathered from concentrations along the pegmatite dikes. According to Dale and McKinney (p. 9), an examination by ultraviolet light would indicate several pockets of ore assaying in excess of 17 per cent WO_3. Considerable tonnage of low-grade material is probably present.

Small black garnets are in some of the pegmatites on the Greenrock No. 3 claim, near the stripped zone. Coarse muscovite occurs here and elsewhere in the district, notably at a pegmatite a quarter of a mile west of Black Hawk Canyon and about three tenths of a mile N. 15° W. of the southwest corner of sec. 29.

Epidote is common in the amphibolite at the scheelite occurrences, particularly on the Greenrock No. 1 claim, the northeasternmost, where dark green, massive, and coarsely crystalline epidote is abundant in one of the trenches and in bulldozed cuts.

Pacemaker. The Pacemaker deposit is in the SE¼ sec. 35, T. 18 S., R. 16 W. The main workings are 250 feet south of the Redrock road (State Highway 25). The deposit is covered by unpatented claims owned by James L. Reed, Hurley, who located the property in 1954. The workings consist of two shafts 40 to 50 feet deep, one with a 30-foot-long drift and the other with a 60-foot-long drift cut from the bottoms of the shafts; several shallower shafts, pits, trenches; small open cuts; and numerous bulldozed cuts. In 1955, Reed erected a small mill on the property, but in 1961 this had been dismantled. About 1400 pounds of concentrates averaging 68 per cent WO_3 were produced by jigging and were shipped to Tuscon and Douglas from 1955 to 1956 (Reed, oral communication).

Burro Mountain granite containing inclusions of quartz diorite gneiss and migmatite and cut by quartz-rich pegmatite dikes crops out on the property. Scheelite is associated with the quartz and the migmatite as sporadic grains and crystals up to 2 inches in diameter disseminated in these rocks. It is also in fracture fillings with quartz in the gneiss and migmatite. Sparse molybdenite is in a pegmatitic quartz vein 300 feet north of the main workings. The mineralized zone strikes N. 50° E. and dips steeply northwest.

The tenor of the ore is low, Dale and McKinney estimating it at about 0.2 per cent WO_3.

Giant and nearby localities. The Giant scheelite deposit owned by Charles Russell, Tyrone, and Barney Gardner, Albuquerque, was located in 1954 or 1955. It is on an unpatented claim in the southeast sec. 7, T. 19 S., R. 16 W., about three quarters of a mile north of the old Eccles windmill in Bar 6 Canyon along the Redrock road and slightly more than 3 miles south of Bullard Peak. A 25-foot-deep shaft and several shallow pits explore the deposit. A hole 40 feet deep was drilled a few feet east of the shaft.

Burro Mountain granite containing masses of amphibolite and cut by pegmatite dikes is the country rock. Scheelite is found with quartz and feldspar in fracture fillings in the amphibolite. The veins may be a narrow pegmatite dike. The scheelite is sporadically distributed through the veins in grains and crystals about half an inch in diameter. The drill hole, sunk in amphibolite, showed scheelite all the way down, but the hole may have cut a scheelite vein near the surface and was contaminated the remaining distance. The vein strikes N. 15° W. and dips 50° NE in the shaft, but the scheelite is in narrow stringers throughout a zone which seems to strike N. 10° E.

Scheelite is in small concentrations on the hillside north of the Eccles windmill in the NE¼ sec. 17, T. 19 S., R. 16 W., where it is in amphibolite masses in granite, similar to those at the Giant.

Scheelite also occurs within a wide quartz-rich pegmatite dike cropping out on the crest of the hill south of the Redrock road in the SW¼ sec. 16. The quartz dike is more than 25 feet wide. Numerous shallow pits and trenches are at this locality, but how much scheelite, if any, was produced is unknown. Shallow pits along quartz-rich pegmatites are also in the N½ sec. 16 and the S½ sec. 9, north of the Redrock road. No amphibolite is here.

Evening Star. The Evening Star claim is in the NE¼ sec. 26, T. 18 S., R. 16 W. (Dale and McKinney place it in the SW¼ sec. 24, stating incorrectly that it is northeast of the end of an unimproved road, whereas it is west of the end of the road). The claim is owned by Dave Osmer, who located it in 1954, dug a few trenches and pits, and explored it by two 40-foot-deep diamond drill holes.

The scheelite is found in a quartz-rich pegmatite vein as grains and crystals up to one inch in diameter. The country rock is migmatite and quartz diorite gneiss. The vein is 2.5 feet wide, strikes N. 25° E., and dips 75° NW. It can be traced for 300 feet.

The scheelite is sparse and sporadically distributed in the quartz. Some of the quartz fluoresces blue because of minute inclusions of scheelite. According to Dave Osmer (oral communication), the cuttings from the drill holes showed only minor amounts of scheelite but contained good showings of bismuth. The grade of the deposit is low. The strike is along that of the Zelma deposit and about two miles to the northeast.

Rice–Graves deposit (Moneatta No. 2). The Moneatta No. 2 claim, owned by Fayette Rice, Gila, and O. Graves, Florida, and called by Hewitt and by Dale and McKinney the Rice–Graves deposit, is in the NW¼ sec. 24, T. 19 S., R. 17 W. It is on the side of a ridge about a quarter of a mile north of the Redrock road (State Highway 25) and was located in 1955. A 35- to 40-foot-deep shaft, some pits, an open cut, and bulldozed trenches explore the property. There has been no production.

The scheelite occurs with epidote, blue quartz, and mica in a silicified zone or vein in an amphibolite xenolith in Burro Mountain granite. The xenolith is a quarter of a mile long and 100 feet wide. The silicified zone is 5 feet wide and parallels the schistosity of the amphibolite, which strikes N. 60°-70° E. and dips about 80° NW. It consists of veins and masses of quartz, coarse hornblende, and masses of fine- to medium-grained hornblende, epidote, and quartz. Small grains of scheelite are in the quartz veins and in the quartz-epidote-hornblende masses. There are a few segregations of granular scheelite, an inch or two in diameter. Hewitt (p. 324) studied this deposit in detail and made thinsections of some of the ore and vein minerals.

According to Rice (oral communication), the concentrations of scheelite were found near the surface. With depth in the shaft, only sparse, disseminated scheelite was found, and work was abandoned.

This is the westernmost of the scheelite deposits.

Black Hawk (Bullard Peak) District

The unique mineralogy of the Black Hawk district (also referred to as the Bullard Peak district) sets it apart from any other in the county and, in fact, in the state and makes it of particular interest. The combination of native silver, nickel and cobalt arsenides and sulpharsenides, and pitchblende in carbonate gangue is rare among known mineral deposits; representatives of this nickel-cobalt-native silver ore type are relatively few. Because of this, and because of the possible potential of the area, somewhat more space is devoted to it than its size and past production warrant.

The Black Hawk district straddles Black Hawk Canyon about two miles northeast of Bullard Peak in secs. 20, 21, 22, 23, and 29, T. 16 S., R. 16 W. The district is 21 miles by road west of Silver City and is accessible from U.S. Highway 260 by a road up the bed of Black Hawk Canyon (fig. 21).

High-grade silver float was found in the area in 1881 on what is now the Alhambra claim, and prospecting soon resulted in the discovery of the Black Hawk, Rose, Silver King (Hobson), Good Hope, and other mines. Mining continued until about 1893 when the decline in silver prices and the depletion of the rich ores caused the mines to be closed. Nearly all the ore produced was high-grade silver, and shipments assaying as much as 15,000 ounces of silver a ton were recorded (Jones, p. 55).

The mines remained closed until 1917, when the Black Hawk was dewatered and rehabilitated, but no shipments were made and the mine was closed again in 1918. A short-lived interest in the eastern half of the district developed at this time.

In 1949, because of the need for nickel, cobalt, and uranium, interest was revived, and the U. S. Geological Survey made a detailed study of the area (Gillerman and Whitebread). Three 1000-foot diamond drill holes probed the Black Hawk mine with inconclusive results.

In 1957, partly as a result of the U. S. Geological Survey report, the Alhambra mine was reopened by the Alhambra Mining Company, controlled by James MacGregor and Barron C. Kidd, Dallas. The old shaft was rehabilitated, old drifts cleaned out and new drifts excavated, and a small amount of high-grade silver shipped. Operations ceased in 1960.

Silver obtained from the district prior to 1893 is estimated to have been worth $1,000,000 to $1,500,000 (Gillerman and Whitebread). The Black Hawk mine is reported to have produced $600,000 to $650,000 (Jones, p. 55; A. A. Leach, 1916); the Alhambra about $400,000 (A. A. Leach, written communication); the Rose about $140,000; and the Silver King (Hobson) about $40,000 (A. A. Leach, written communication). The balance came from the Good Hope and other prospects. About twice the total amount is estimated to have been produced but not recorded because of the extensive high-grading of the rich ore.

The major mines are the Black Hawk, Alhambra, and Rose. All are covered by patented claims (fig. 22). The Black Hawk group, owned by the Black Hawk Consolidated Mines Corporation, Milwaukee, consists of the Black Hawk, Silver Glance, Surprise, Kent County, Littly Rhody, Chicago, and Extension claims. The Alhambra group, owned by A. A. Leach, Lordsburg, consists of the Alhambra, Good Hope, Pumpkin, Butternut, and Stonewall claims. The Rose is owned by Mrs. Elizabeth J. McCabe, Pasadena, and Elizabeth C. (Mrs. William Howard) Meade, San Francisco. Unpatented claims, valid in 1960, include the Alhambra

Extension, Easy Days, and Hobson, controlled by A. A. Leach, and the Midnight and Missouri Girl, controlled by Barney Gardner and Elliot Gillerman.

The report by Gillerman and Whitebread describes the geology and

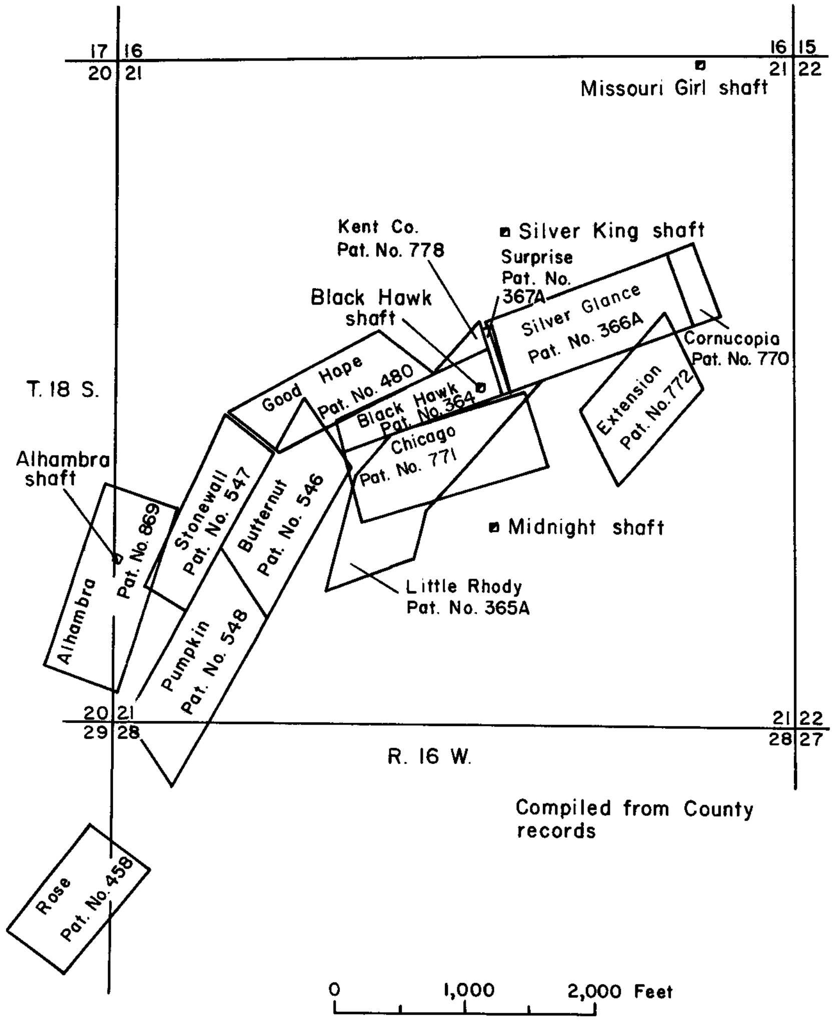


Figure 22

PATENTED CLAIMS, BULLARD PEAK DISTRICT

ore deposits of the districts, and the reader is referred to it for details. Most of the following information is taken from that report. Since it was published, however, the Alhambra mine was reopened; hence, additional information on the Alhambra and other deposits is here included and published for the first time.

The predominant rock in the Black Hawk district is Precambrian quartz diorite gneiss, which is part of a widespread phase of the Burro Mountain batholith that crops out extensively south and southwest of the district. The gneiss is intrusive into older quartzite, schist, amphibolite, and migmatite which are part of the Bullard Peak series (Hewitt). The first three of these crop out in two broad bands in the southern part of the district. The migmatite occupies much of the southeastern part. Mineralogically, it resembles monzonite or quartz monzonite, but relic bedding indicates a sedimentary origin. Large, potash feldspar porphyroblasts and lit-par-lit structure are characteristic.

Burro Mountain granite, syenite, monzonite porphyry, and other rock types intrude the quartz diorite gneiss. The monzonite porphyry forms the Twin Peak stock in the northwestern part of the district (photo 1), and also occurs as dikes and irregular masses. The ore deposits are related spatially and probably genetically to this rock. Beartooth Quartzite, which dips 15 to 20 degrees northeast and is overlain by rhyolite of the Datil Formation, caps the hills on the northeast edge of the district.

Faults and shear zones are abundant. Two prominent fault systems, trending slightly east of north dominate the structural pattern. Each consists of one rather persistent fault from which branching faults split off to the northeast. In the southwestern part of the district, some of the faults trend northwest.

The ore deposits are simple fissure fillings, largely in the quartz diorite gneiss in proximity to bodies of monzonite porphyry. Replacement of wall rock or of fragments of country rock within the vein is of minor importance. Veins are plentiful in an area about 1 mile wide and 2 to 3 miles long contiguous to the southeast side of the Twin Peak stock. The veins vary in width, being wider where they traverse quartz diorite gneiss and narrower within monzonite. They are mostly 1 to 3 feet wide, but in places open into ore shoots up to 10 feet wide. Many can be followed for more than 1000 feet. The greatest vertical extent known is 600 feet.

The veins are inconspicuous on the outcrop and are marked generally by brown-stained carbonate fillings. In places, a crude banding is developed, but commonly the veins lack any definite internal structure. Ore shoots are indiscriminately distributed along the veins, and the boundary between high-grade silver ore and barren vein material is sharp.

Carbonates make up most of the vein material. Calcite and dolomite are common, but siderite is also present. Quartz is rare and occurs as a dull, waxlike, yellow-green chert. Ore minerals are chiefly native silver, argentite, niccolite, skutterudite, and nickel skutterudite. Pitchblende occurs and there are minor amounts of pyrite, chalcopyrite, galena, and sphalerite. Other minerals include millerite, erythrite, annabergite, barite, manganocalcite, ankerite, and various nickel and cobalt sulpharsenides and arsenides. The deposits belong to the rare nickel-cobalt-native silver ore type and are similar to the famous silver and uranium deposits of Cobalt, Great Bear Lake, and Joachimstahl.

Alhambra. The Alhambra is second to the Black Hawk mine in extent and productivity. Between 1881 and 1893, silver valued at about $400,000 was recorded as having been produced, and it is estimated that at least this much more was mined but not recorded. The mine was idle from 1893 to 1957, when it was reopened and rehabilitated and some ore mined. Since 1960 it has been shut down. The reopening of the mine in 1957 was the result of recognition of the district as a possible source of uranium, nickel, and cobalt.

The mine is explored by a 350-foot inclined shaft with drifts at 30, 60, 112, 170, 225, 275, and 325 feet. The maximum extent of the drifts on the lower levels is 160 feet south and 250 feet north of the shaft. Much of the upper part of the mine is caved and inaccessible. An old adit and a 100-foot-deep shaft, with short drifts at 25 and 50 feet, all now inaccessible, explored the southern half of the vein immediately adjoining the accessible part of the mine and formerly connecting with it. The workings are shown in Figure 23.

The ore at the Alhambra is within an open fracture system as much as 15 feet wide on the lower levels of the mine. Within the fracture zone, subparallel slip surfaces coated or marked by clay gouge parallel the boundaries of the zone. These slip surfaces are discontinuous laterally and vertically and form an imbricating network. The boundaries of the zone are not sharp, and no single fracture can be followed on either footwall or hanging wall from the collar of the shaft to the lowermost levels. Cross fractures, both pre- and postore, cut and displace the vein. Many are small, but two, north and south of the main shaft, are of major importance, displacing the vein 30 feet or more.

The host rock is coarse-grained, gneissic quartz diorite porphyry. A dike of monzonite porphyry crops out 50 feet west of the vein, but no monzonite porphyry was observed within the mine. The quartz diorite porphyry has not been greatly altered. Adjacent to the vein, the feldspars are bleached and partly sericitized, the biotite is now chlorite, and small veinlets of pyrite permeate the rock. In many places, the feldspars and biotite are only slightly altered. Breccia fragments within the zone are more intensely altered.

Gangue minerals are principally calcite, dolomite, and siderite. Ankerite and quartz are found in minor amounts, and barite and gypsum have been identified only as small crystals filling vugs.

The ore minerals are native silver, argentite, pitchblende, and nickel and cobalt arsenides, of which niccolite, skutterudite, and nickel skutterudite are the most common. Sphalerite, galena, chalcopyrite, pyrite, and millerite are rare, as are several unidentified silver, cobalt, and nickel arsenides, sulphides, and sulpharsenides. All, including the native silver, are primary with the exception of argentite. Oxidized nickel, cobalt, and uranium minerals were noted on old dumps and in the old upper workings at the mine.

Native silver is the most important ore mineral. It constituted well over half the total weight of minerals mined and a considerably larger fraction of the value. It is present as blebs, flakes, plates, dendrites, and skeletal crystals disseminated through the carbonate gangue or concentrated in sheets and arborescent masses containing 50 per cent silver. The skeletal crystals are rimmed by silvery white cobalt and nickel arsenides or are enclosed in argentite.

The nickel and cobalt minerals are intimately associated. Niccolite is the most common, occurring in small or large masses intergrown with a silvery white mineral, probably nickel skutterudite, and other members of the skutterudite series. The skutterudite minerals form border zones surrounding dendritic masses of silver, enclose individual dendrites, or occur as zoned euhedral crystals.

Pitchblende was observed as blebs and small masses through that part of the ore rich in nickel and cobalt, and also as distinct veinlets and coatings on fracture surfaces.

The ore minerals are in segregations of extremely high-grade ore or are scattered as flakes and small grains in the carbonate gangue. Only the high-grade segregations of native silver have been mined. These range in size from pods 3 inches in diameter to shoots extending 50 feet vertically, 30 feet horizontally, and 3 feet in width. These pods and shoots appear indiscriminately throughout the vein, with no apparent pattern. Segregation boundaries are sharp, and there is little gradation between high-grade ore and barren vein rock, wall rock, or low-grade, disseminated ore minerals. Emplacement of the carbonate gangue was entirely by filling open spaces along fractures and between breccia fragments, and filling high-grade segregations by replacement of the carbonate minerals.

Within the larger segregations, a zonation of ore minerals is characteristic. A core of native silver is enveloped by nickel and cobalt minerals with a thin veneer of pitchblende on the outer margins adjacent to barren wall rock. All or only some of the zones may be present. Within the zone of high silver content, pitchblende is absent and the arsenides rare. In the outer zones, silver is uncommon. The ratio of silver to nickel and cobalt is 10:1 in the inner zone, approaching 1:1 in the outer areas where in many places there is even an excess of nickel and cobalt.

In general, the high-grade segregation has a northward rake within the vein. The vein dips irregularly and known ore shoots are confined to the less steep part. The widest part is on the lowest level where the dip is 80 to 85 degrees.

In the carbonate gangue, the minerals locally are concentrated enough to constitute low-grade ore of economic value, and the future of the mine, and of the district, may depend upon the successful beneficiation of this material. The high-grade shoots, although extremely rich, are spotty, and without a knowledge of the controlling factors that localized these segregations, exploration for them alone is a costly undertaking. The recent unsuccessful attempt to operate a profitable mine is evidence of this. The high-grade segregations were too small and too hard to find, and little attempt was made to determine the feasibility of utilizing the lower-grade material.

Black Hawk. The Black Hawk mine, largest in the district, has a recorded production value of $600,000 to $650,000. The workings are inaccessible, and the shaft, in the bottom of a dry gulch, is filled with sand and debris. Only a few pipes protruding above the bottom of the gulch indicate the location of the shaft. Information on the underground workings and on the character of the vein and the ore is taken from unpublished reports by W. H. Weed, E. D. Lidstone, and A. A. Leach (written communication, 1917).

The shaft, vertical to the second level (100 feet) and inclined 60° N. 20° W. below that level, was sunk 497 feet to the eighth level. A total of 3000 feet of drifts was cut on the eight levels, the majority of the workings being east of the shaft. At the east end of the eighth level, a winze inclined 85° S goes downward 150 feet. The ninth and tenth levels, below the eighth at 50 and 100 feet, respectively, were driven from this winze. The bottom of the winze is 600 feet vertically below the collar of the shaft (fig. 24).

The Black Hawk vein strikes N. 70° E. and dips 60° to 70° NW, the dip flattening with depth. A low-angle fault cuts and displaces the vein on the eighth level. The vein can be traced on the surface northeastward from the shaft for almost 1500 feet, with workings scattered along much of this distance. In the vicinity of the Black Hawk shaft, ore was mined for about 500 feet along the strike and more than 600 feet down the dip. The workings indicate that although ore shoots in the upper levels may not continue downward, other shoots of as great or greater length and width were found on the lower levels (W. H. Weed, written communication). According to E. D. Lidstone (written communication), good ore shows at the bottom of the winze.

The vein consists of a number of imbricating and subparallel fractures with high-grade ore in streaks and pods, usually on the footwall. Native silver constituted 80 per cent of the value of the ore mined. Appreciable quantities of argentite were present, and galena, sphalerite, pyrite, and chalcopyrite were minor constituents. Niccolite and smaltite were recorded, the smaltite probably being skutterudite. Old reports state that the nickel minerals were found only below the 100-foot level (Waller and Moses, 1892). An analysis of a 100-pound sample taken by E. D. Lidstone from the bottom of the winze in 1917 showed 8.92 per cent nickel, 0.90 per cent cobalt, 8.81 per cent zinc, and 2542.00 ounces of silver a ton (Lidstone, written communication). No analysis for uranium was made on this sample, but two samples of high-grade silver examined by the writer were highly radioactive, and pitchblende was found on the dump (Gillerman and Whitebread).

The character of the vein and of the ore, based on descriptions in the old reports, is similar in all respects to that of the Alhambra, so the detailed descriptions of the Alhambra ore and vein can undoubtedly serve as general descriptions of the Black Hawk. The greater depth to which the vein has been followed at the Black Hawk mine is a favorable indication for the depth of mineralization at the Alhambra.

Rose mine. The Rose mine in the southern part of the district has not been operated since 1889, and the shaft is now filled. High-grade silver ore containing nickel and cobalt minerals is reported to be in the lower workings. The mine was operated by means of a shaft sunk at the intersection of two veins, the Red and the Spar. An adit was driven on each. The shaft is 200 feet deep, with levels at 150 and 200 feet on both veins and at 50 and 100 feet on the Spar only. The Spar strikes N. 75° W., dips 75° to 80° NW, and can be traced 700 feet east and 400 feet west of the old shaft. The Red strikes N. 30° E., dips 65° to 75° SE, and can be traced 450 feet eastward from the shaft. The veins are two and a half to four feet wide, with well-defined hanging walls and indefinite footwalls.

About $140,000 worth of silver was shipped from the Rose mine (Gillerman and Whitebread).

Silver King (Hobson). The Silver King (Hobson) mine was worked from a 300-foot-long adit and an inclined shaft. A raise and winze about 200 feet from the portal of the adit explore the vertical extent of the mine. The adit was partly accessible in 1959. The vein is along a fault that strikes N. 50°-65° E., dips 65° NW, and is in quartz diorite gneiss. The fault intersects the Twin Peak monzonite porphyry stock 200 feet northeast and 150 feet southwest of the shaft.

In the adit, the vein lies along a shear zone for 200 feet northeast of the portal and along a series of branching fractures for another 100 feet; its width is 2 to 4 feet. It is reported to have been followed 300 feet down dip. Argentite was the principal mineral mined.

Other Deposits. The Good Hope, Midnight (fig. 25), Missouri Girl, and other deposits are all similar to those described, but smaller and with less extensive workings. The Good Hope shaft was sunk 120 feet, the Midnight about 80 feet with levels at 45, 62, and 74 feet, and the Missouri Girl 90 feet with a level at 55 feet. Information about the other shafts is

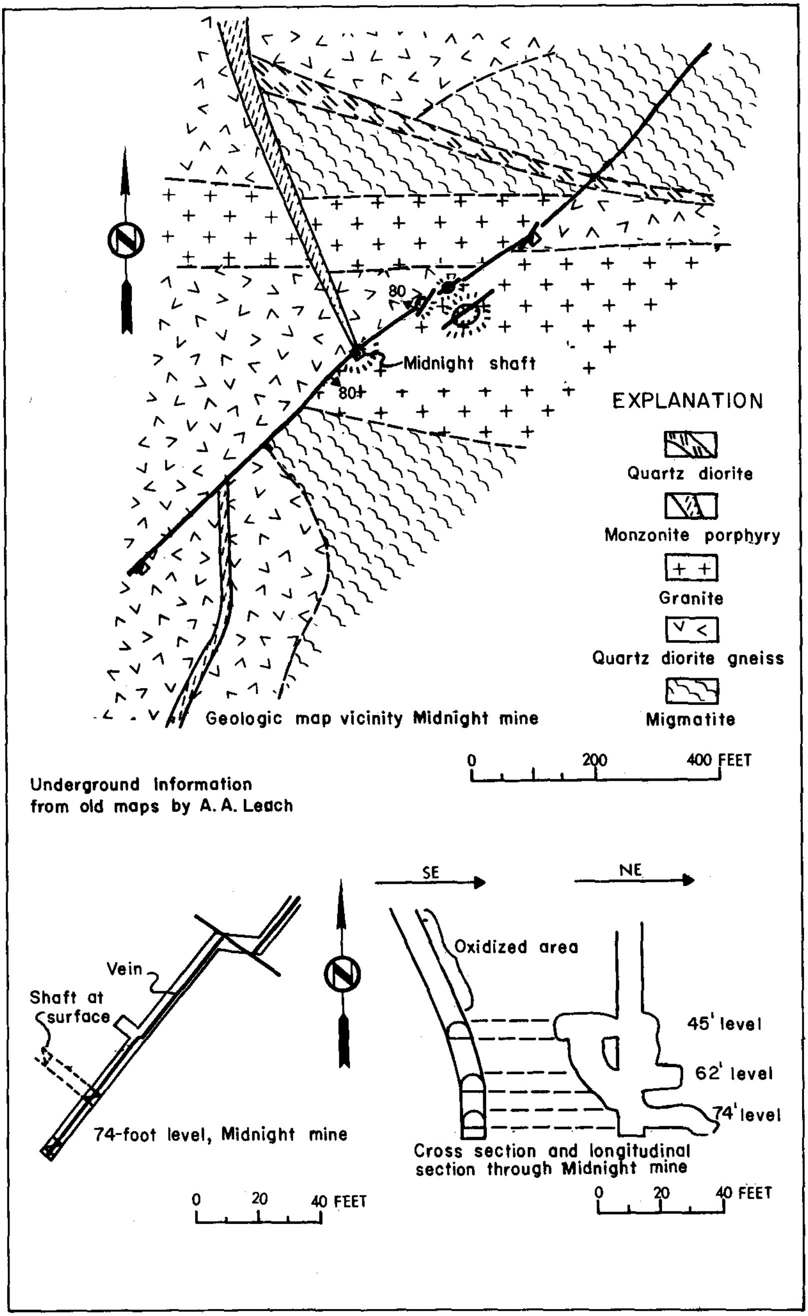


Figure 25

GEOLOGIC SKETCH MAP OF THE MIDNIGHT DEPOSIT, BULLARD PEAK DISTRICT

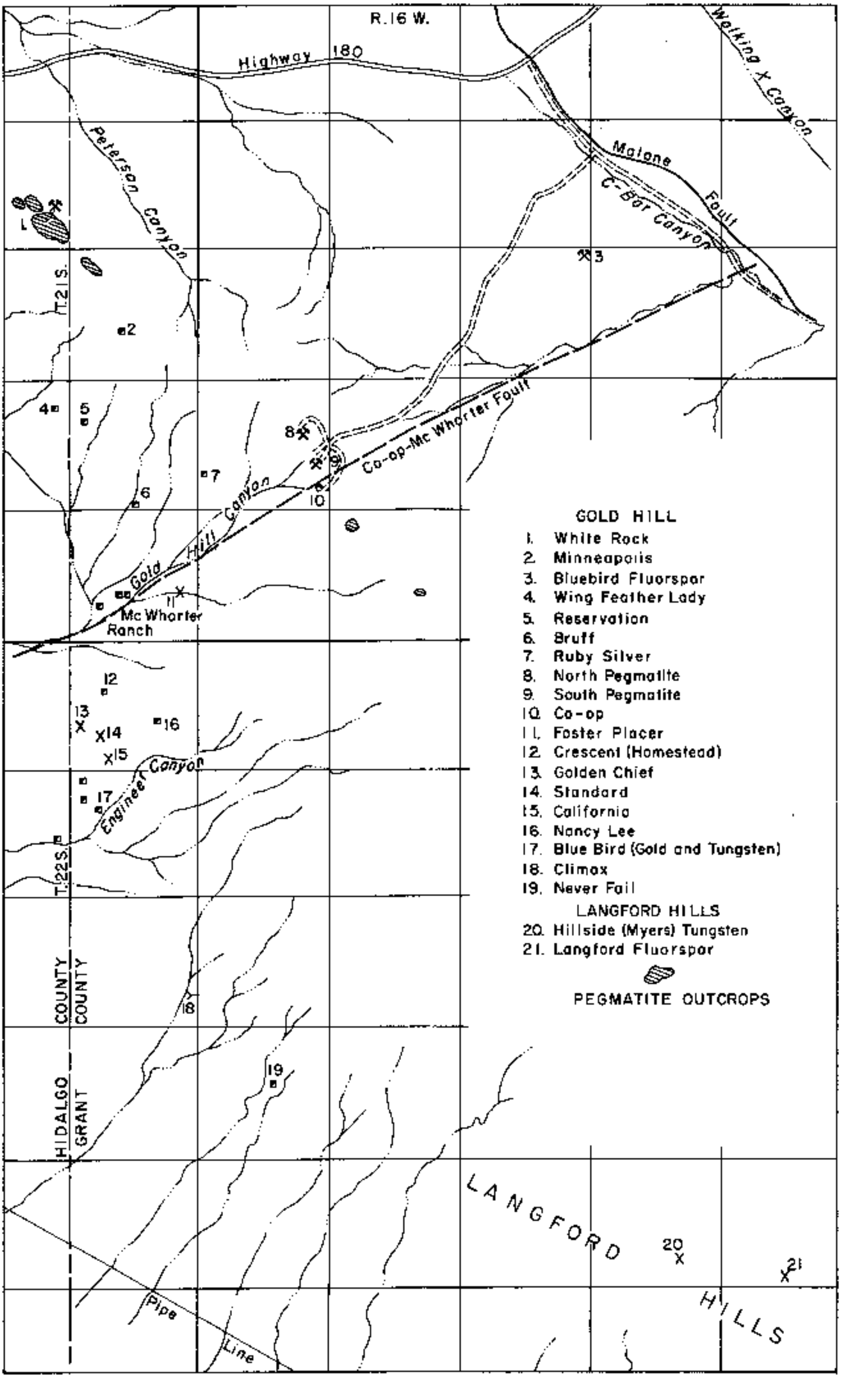


Figure 15

LOCATION OF MINERAL DEPOSITS IN GOLD HILL AND LANGFORD HILLS

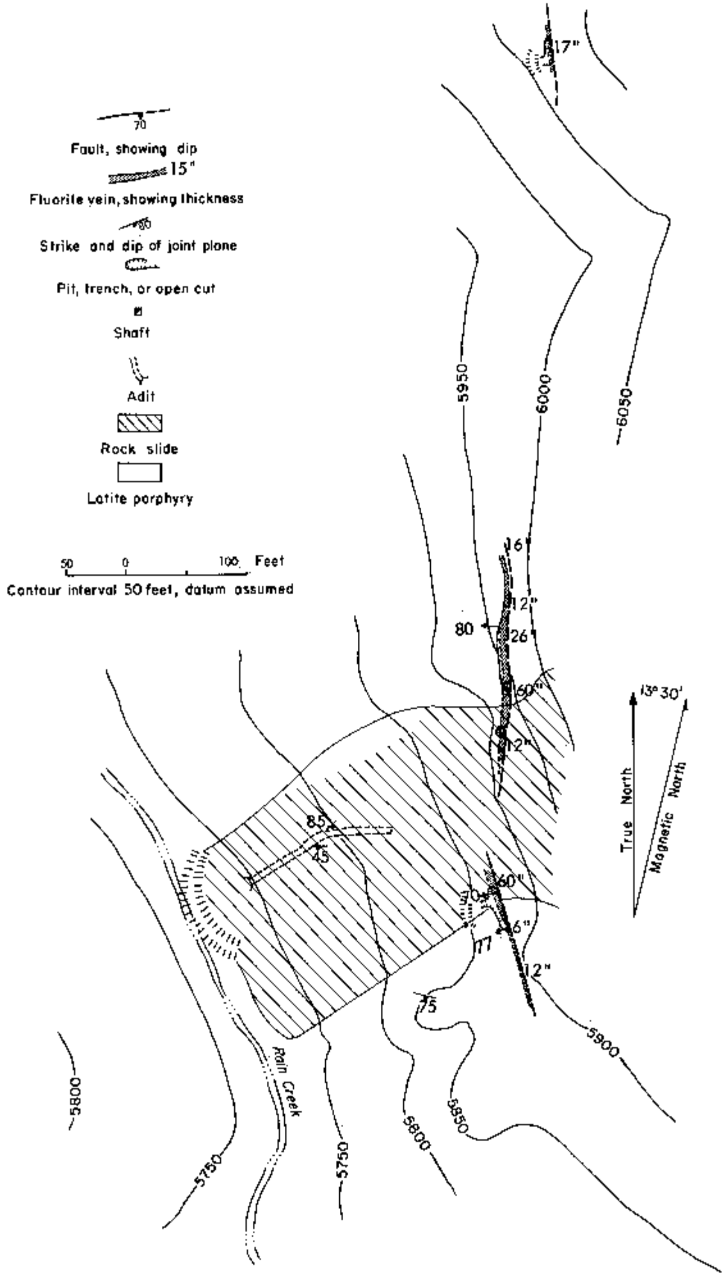


Figure 30

GEOLOGIC MAP OF THE RAIN CREEK (GOOD HOPE) FLUORSPAR DEPOSIT, SACATON MESA AREA

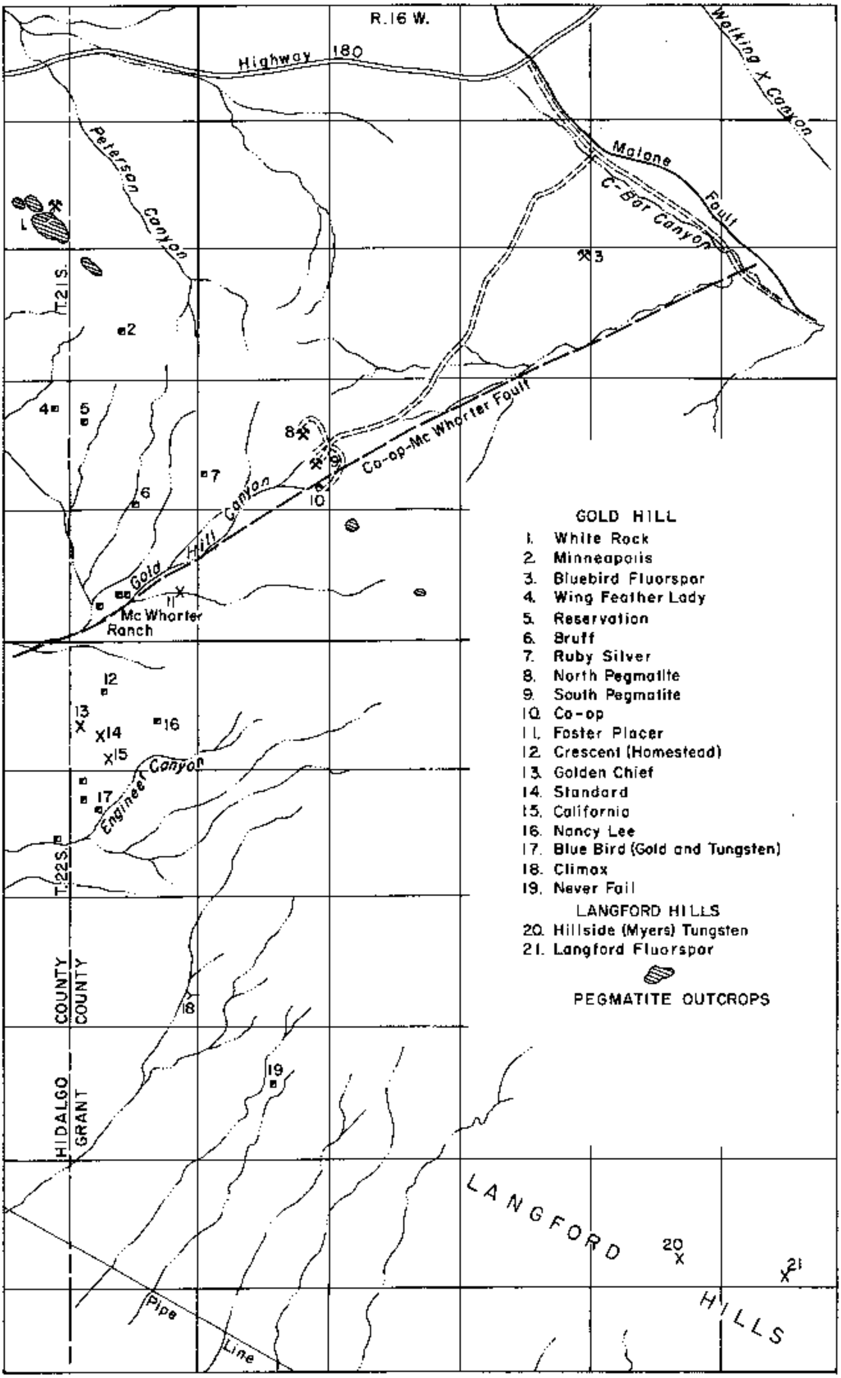


Figure 15

LOCATION OF MINERAL DEPOSITS IN GOLD HILL AND LANGFORD HILLS

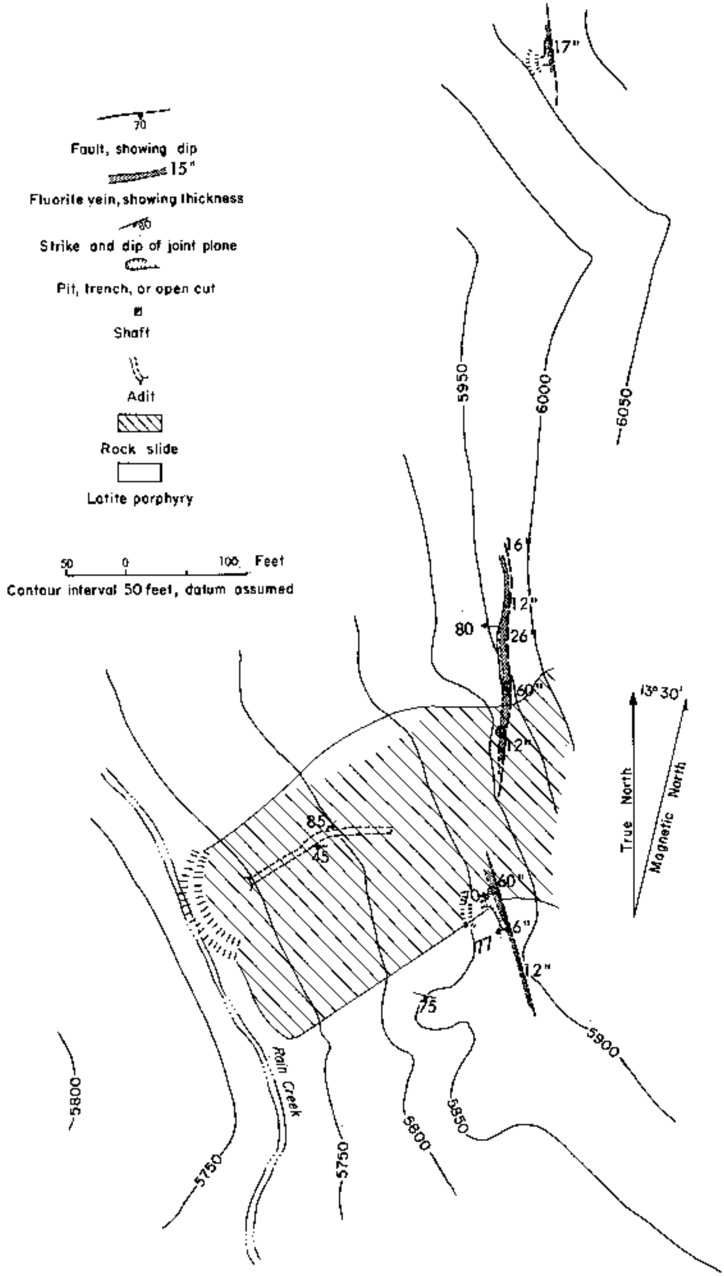


Figure 30

GEOLOGIC MAP OF THE RAIN CREEK (GOOD HOPE) FLUORSPAR DEPOSIT, SACATON MESA AREA

unobtainable. Native silver was the important mineral at all deposits, and nickel, cobalt, and uranium minerals were recorded at many of the mines. These minerals still can be observed on some of the dumps.

Osmer silver. In 1958 and 1959, Dave Osmer sank a shaft a few feet west of Black Hawk Canyon in the SE¼ sec. 29, T. 18 S., R. 16 W. about one mile south of the Alhambra mine. The shaft, along a vein striking N. 60° E. and dipping 80° S., was about 40 feet deep in 1960. According to Osmer (oral communication), native silver, argentite, and pitchblende are present, and assay values show good silver and uranium content. The vein is similar to those elsewhere in the Black Hawk district. This is the southernmost deposit known to contain the Black Hawk type of mineralization, with the possible exception of the old Eccles mine, described below, the character of the ore of which is doubtful.

Eccles mine. The old Eccles mine is in the SE¼ sec. 7, T. 19 S., R. 16 W., a few hundred yards northwest of the Giant scheelite prospect. It is southwest of Bullard Peak and not in the Black Hawk district, but the mineralogy is apparently similar. An old shaft in excess of 100 feet deep and a smaller, shallower pit a few feet south of the shaft are along a vien which strikes N. 10° W. and dips 55° SW. The workings are inaccessible. The country rock is amphibolite and granite gneiss. Gangue minerals found on the dump include quartz and calcite. No metallic minerals were found. The mine is reported to have been sunk in the 1880's for silver (Charles Russell, oral communication, 1961).

DEPOSITS SOUTH OF CLIFF

Cora Miller. The Cora Miller mine is near the center of sec. 6, T. 12 S., R. 16 W. on the south side of Mangas Creek about one and three-quarter miles below Mangas Springs (fig. 26). It is owned by Harvey Foster, Cliff. The workings are on a hillside 600 feet from the edge of the creek.

The mine was worked for silver in the 1880's and has been virtually abandoned since. Graton mentions it (Lindgren, Graton, and Gordon). The mine is developed by a 175-foot-deep shaft inclined 85 degrees, an upper adit at the level of the collar of the shaft, a lower adit at a depth of 75 feet, and a 175-foot level at the bottom of the shaft. Drifts are cut in both directions from the shaft, and there has been much stoping. Numerous cuts, shallow shafts, and underhand stopes exist along the vein for 800 feet. In 1959, the mine was accessible via the lower adit level for almost 400 feet; the adit is caved beyond this point. It was mapped and sampled at this time (pl. 11).

No record of shipments is available. Considerable high-grade silver is reported to have been removed, however. The extent of the workings lends credence to this report. The remains of an old mill are at the mine site.

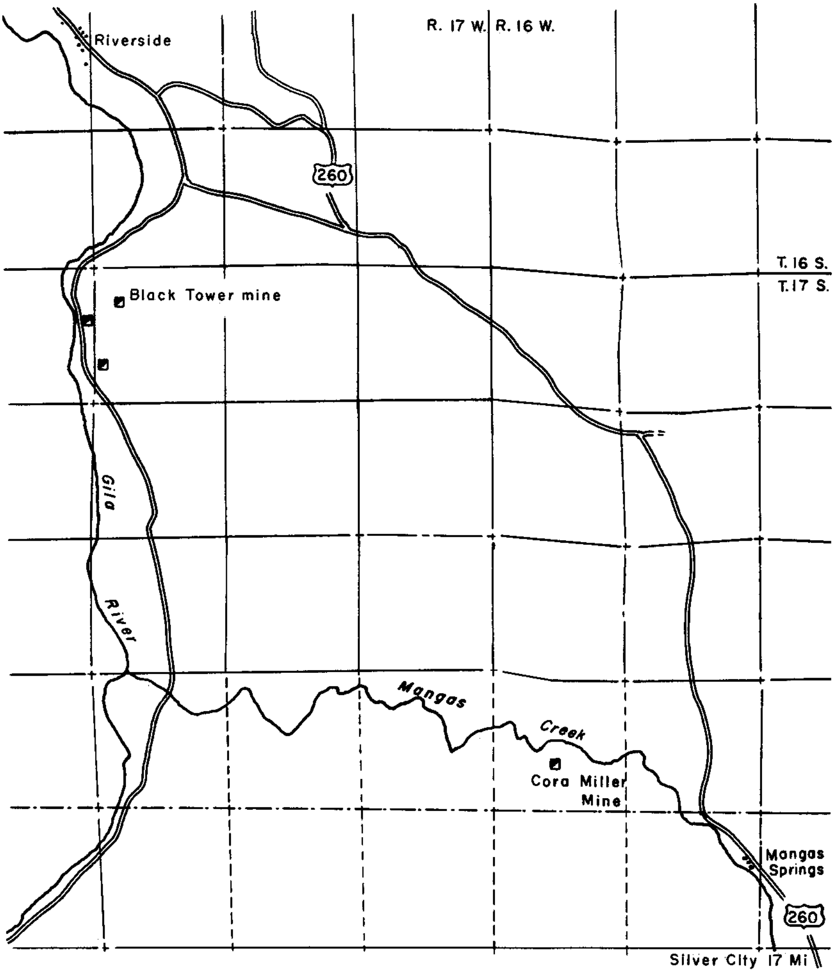


Figure 26

LOCATION OF THE CORA MILLER AND BLACK TOWER MINES

The rock in the vicinity of the mine is rhyolite. The vein fills a fissure which strikes N. 70°-75° E. and east of the mine dips beneath the floodplain alluvium of Mangas Creek. It cannot be identified in rhyolite east of the creek, half a mile east of the lower adit portal.

The vein is 3 to 4 feet wide at the surface from the portal of the lower adit to about 250 feet west of the shaft. At the shaft, it is 5 feet wide. At the westernmost pit excavated, the vein is only 1 foot wide. Comparable widths were noted on the adit level.

A small cross fault cuts the vein on the surface about 180 feet west of the shaft, and a small offset, possibly of an en echelon nature, is present in the adit about 70 feet east of the shaft.

No ore minerals were noted in the vein material at the time of examination, but some copper stain was seen in the adit. Samples were cut on the adit level just west of the shaft and on the bottom (170-foot) level and analyzed for silver with negligible results. The gangue is all quartz.

Black Tower mine. A small manganese deposit known as the Black Tower mine is in the NW¼ sec. 22, T. 16 S., R. 17 W. a quarter of a mile east of the Gila River and just north of Dam Canyon, four miles south of Cliff (fig. 26). The property was under lease to Marshal Kuykendahl and Lyle Poe of Lordsburg in 1956 and 1957, and according to Kuykendahl (oral communication), about 75 tons of ore averaging 42 per cent manganese were shipped during this period. Previously, the deposit had been worked by a Mr. Girard from Pennsylvania. It has not been operated since 1957, and the present ownership is unknown.

An inclined shaft, dipping steeply eastward, is sunk 60 to 75 feet. The vein has been stoped out adjacent to and southwest of the shaft to a depth of 40 feet, forming a large glory hole 30 feet long and 10 to 12 feet across. About 100 feet southwest and 60 to 70 feet below what was once the collar of the shaft, an adit is driven northeastward into the hillside and connects with the shaft 150 feet from the portal. Both the adit and the shaft were excavated along the vein, which strikes N. 20° E. and dips 75° SE. The deposit occupies an indistinct fracture zone in tuff and rhyolite.

WILD HORSE MESA

Fluorite fills fissures in granite in the vicinity of Wild Horse Mesa, about three miles east of the Gila River and five miles northwest of Bullard Peak (fig. 1, pl. 1). The principal deposits are on the north and west sides of the Mesa in secs. 2 and 3, T. 18 S., R. 17 W. A base-metal deposit is in Little Bear Canyon just south of the Mesa (fig. 27).

Beartooth Quartzite and Colorado Shale occupy most of the Mesa and adjacent areas. Burro Mountain granite and included schist and gneiss crop out around the sedimentary blocks. Faults cut and offset the sedimentary rocks and can be traced into the granite.

Fluorspar was first found in the area in 1947 at the Purple Heart deposit and was mined intermittently until 1958 when all operations ceased. The silver-bearing, lead-zinc deposit in Little Bear Canyon was mined about 1900.

Purple Heart. The Purple Heart deposit is on a tributary of Buzzard Canyon on the west side of Wild Horse Mesa in SE¼ sec. 3. It was originally owned by the Frost brothers, White Signal, but when visited by the writer in 1949, it was owned and operated by John Harrison (Gillerman,

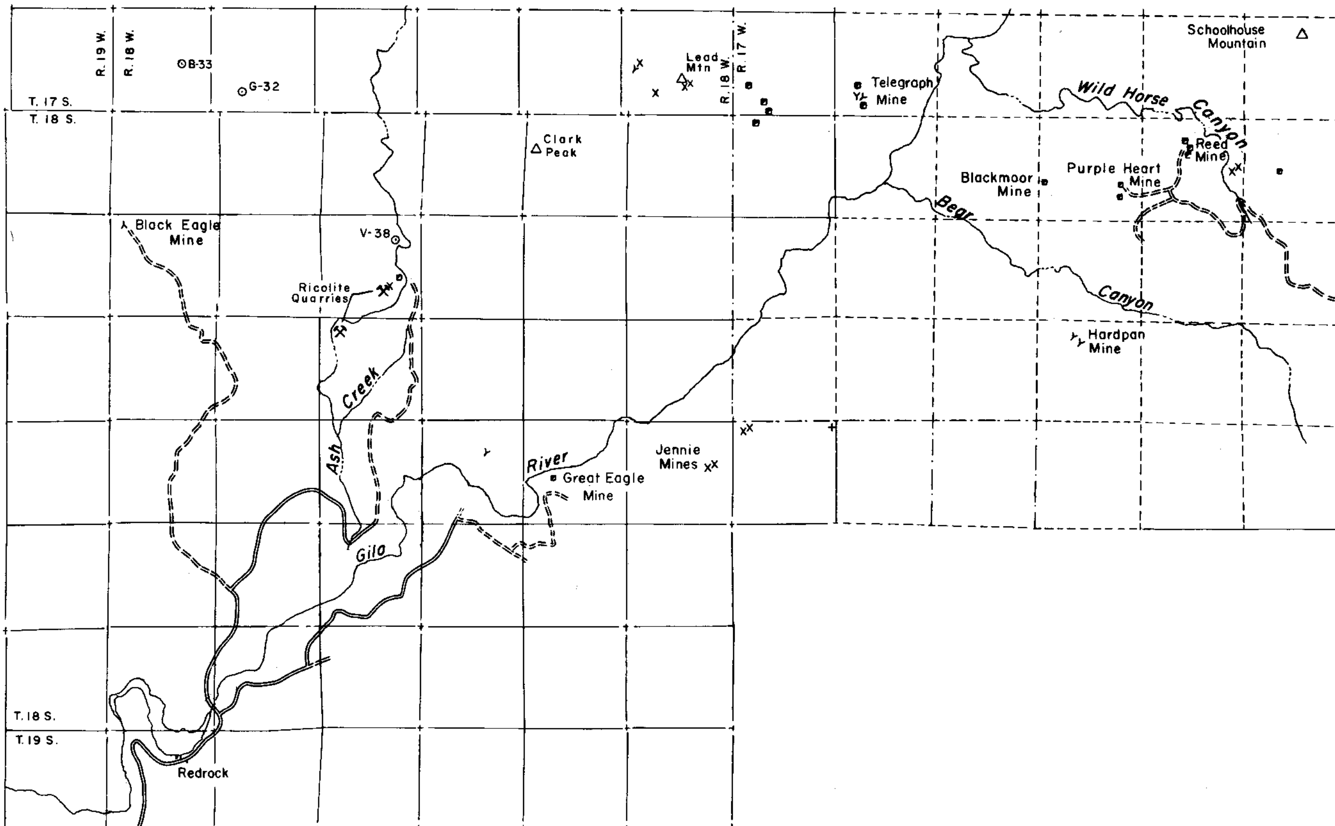


Figure 27

LOCATION OF MINERAL DEPOSITS IN THE REDROCK, SLATE CANYON, TELEGRAPH, AND WILD HORSE MESA AREAS

1952). In 1955, it was owned by J. B. Tucker and C. C. Hazed, El Paso, Mr. Tucker operating the property. In 1957 and 1958, the property was under lease to J. A. King, Casa Grande, Arizona, who shipped a few truckloads of ore.

Between 1947 and 1949, about 400 tons of fluorspar averaging 80 to 85 per cent fluorite were shipped from the prospect. During 1954 and 1955, several carloads of similar grade fluorspar were shipped.

Two shafts on subparallel veins explore the property. Shaft No. 1 is sunk 65 feet along the vein and inclined 65 degrees. An inclined stope trends northwest from the shaft to the surface. Mining in 1955 was from this inclined shaft. Shaft No. 2, now abandoned and on which a windmill has been erected to pump water for cattle, is 108 feet deep and nearly vertical. A short drift to the southeast is on the 25-foot level, and drifts 50 to 75 feet long in both directions are on the 100-foot level. The stopes are caved.

In shaft No. 2, the vein strikes N. 40° W. and is almost vertical. It can be traced on the surface 200 feet southeast and 500 feet northwest of the shaft. On the 100-foot level, the vein was 8 to 10 feet wide and consisted of a breccia zone in which fluorite occurred as seams, fillings, and crustiform masses surrounding breccia fragments. Much of the fluorite is crushed and mixed with clay gouge manganese oxide. This sequence of mineralization, movement, brecciation, and repeated mineralization is characteristic of many of the fluorspar deposits in the Burro Mountains and elsewhere in northwestern Grant County. The wall rock and granite boulders within the breccia zone are intensely argillized, and fragments of kaolinized granite with crusts of clear and purple fluorite can be seen on the dump. Lenses of schist are included within the granite in the vicinity of the mine; one such lens is exposed within the mine. Where the vein transects the schist, it narrows perceptibly. The vein contains considerable calcite, jasper, and quartz.

At shaft No. 1, the vein strikes N. 47° W. and dips 65° NE (Hewitt states that the vein at this shaft strikes N. 34° W. and dips 68° NE; it is probably irregular in strike). Fluorspar crops out at intervals along the vein for 500 feet northwest and 2000 feet southeast of the shaft. At the bottom of the shaft, according to Hewitt (p. 121), "6 inches of calcite separate a one-foot-thick layer of colorless, yellow, or light green fluorite from the granite hanging wall. A zone of fault gouge, about 2 feet thick, lies between the fluorite layer and the granite hanging wall." Elsewhere, I observed a vein width of 5 feet. The fluorite is purple and green and is associated with quartz and calcite. Silica is especially abundant along the hanging wall. The fluorspar is massive to granular and shows some well-developed crystal faces. Hewitt reports no breccia within the vein.

Clover Leaf. The Clover Leaf deposit (Blackmoor mine) is three quarters of a mile west of the Purple Heart in the SW¼ sec. 3. This deposit was not visited by me in 1960, nor did Hewitt see it in 1955.

When I saw it in 1949, a vein 6 feet wide of green and purple fluorite with considerable quartz was exposed in a pit 10 feet deep. The vein strikes north and is almost vertical. It can be traced about 500 feet on the surface. The outcrop is siliceous, but the silica content seems to be less where the vein is exposed in the pit. No further work has been done on the deposit to the best of my knowledge.

Small, subparallel veins which strike N. 35°-45° W. crop out between the Purple Heart and Clover Leaf deposits.

Reed fluorspar. The Reed fluorspar deposit is on the north edge of Wild Horse Mesa in the N½ sec. 2. Three shafts and some shallow trenches explore a fluorspar vein in granite (fig. 28). The deposit was

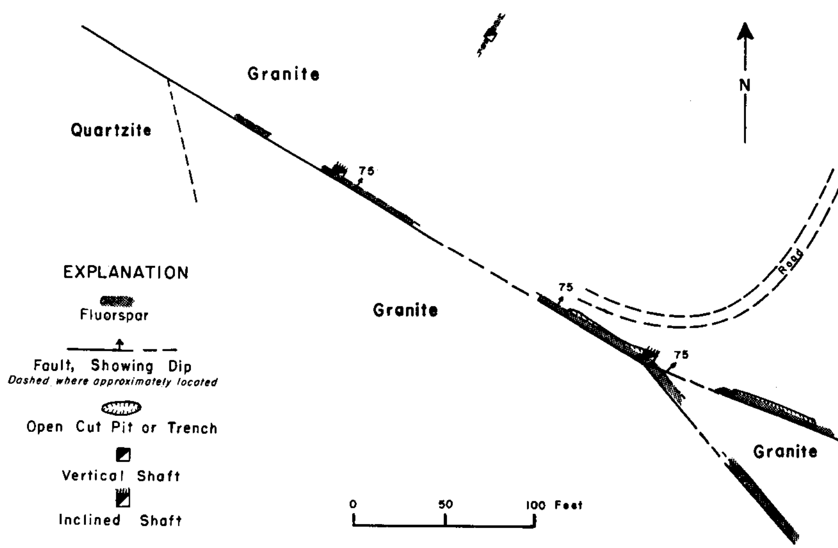


Figure 28

GEOLOGIC SKETCH MAP OF THE REED FLUORSPAR DEPOSIT, WILD HORSE MESA AREA

located in 1953 by James L. Reed, Hurley, who still controlled the property in 1961. Three claims cover the vein. About 150 to 200 tons of fluorspar averaging 60 to 75 per cent fluorite were shipped by Reed to the mill at Deming in 1953 and 1954. No shipments have been made since.

An inclined shaft 40 feet deep follows a vein which strikes N. 60° W. and dips 75° SW. There is no drifting off the shaft, but an open cut 6 to 8 feet deep runs southeastward from the shaft for 50 feet along the vein.

The bulk of the ore shipped was mined from this open cut. Another shaft is sunk on the vein about 250 feet southeast. The vein is narrow, and not more than a foot of vein material was observed anywhere; Reed (oral communication), however, reports that the vein is 3 feet wide at the bottom of the shaft. It can be traced intermittently for 300 feet southeast and 1000 feet northwest of the shaft.

A vertical shaft 35 or 40 feet deep explores a second vein 100 feet southwest of the major vein.

The ore is granular green and purple fluorite and quartz filling a fissure in granite. The granite-Beartooth Quartzite contact is within a hundred feet of the vein on the northeast, but the vein is confined to granite.

Rambling Ruby. A small fluorspar vein, the Rambling Ruby, is in granite north of Wild Horse Creek about one and a half miles east of the Purple Heart. It strikes N. 15° W. and consists of purple incrustations, purple and green granular fluorite, and quartz. A shallow pit explores the vein, which could be traced for only short distances.

Hard Pan (German) mine. The Hard Pan or German mine is in the NE¼ sec. 15, T. 18 S., R. 16 W. in Little Bear Canyon, about three quarters of a mile southeast of the junction of Bear and Little Bear canyons. It is four miles northeast of Bullard Peak. The mine is covered by the Hard Pan patented claim, owned by Dr. Arthur J. Kiser, Colorado Springs. Three adits and a shaft explore the property. It can be reached by a jeep road from the Wild Horse Mesa road to Bear Canyon and then across the ridge to Little Bear Canyon.

The deposit was probably originally worked prior to 1900, but it was relocated in 1937 by Dr. Kiser and was operated in the late 1930's and early 1940's. The tonnage or grade of ore shipped is not known. Between 1955 and 1957, the claim was leased to a Mr. Beasely. No shipments were made during this period.

The deposit is developed by an old caved adit and shaft and by two other adits lower on the hillside. One of these latter proceeds 8 feet S. 75° W., then 25 feet S. 35° W., and then is inaccessible. The other goes 119 feet S. 58° W., then 36 feet west, and then 21 feet N. 48° W. to a two-compartment winze that is inaccessible. At the winze, a crosscut is driven 30 feet N. 4° E., and at a point 66 feet from the portal there is another crosscut driven 30 feet S. 15° E.

The deposit was visited by the writer in 1948 but was not studied in detail. It is described in detail by Hewitt (p. 114), however, and the following is quoted from his report:

> On the west wall of the canyon, three adits were driven into a single vein about 5 feet wide. The adits are inaccessible, but the size of the dumps indicates that the workings were extensive. Several shacks and an ore bin in the canyon bottom have been partly destroyed by

> floods. The vein is a mineralized fissure in Burro Mountain granite and in xenoliths of quartz-feldspar gneiss of the Bullard Peak series. Talus and mine dumps cover the outcrop of the vein; however, the position of adits along the vein shows that it strikes west and dips steeply south. The vein apparently parallels a thick dike of Tertiary andesite porphyry that crops out north of the mine. The wall rock along the vein and fragments in the vein are strongly sericitized. Specimens from the ore bin show narrow veins, nodules, and disseminations of galena and sphalerite, and lesser amounts of chalcopyrite and pyrite, in a gangue of columnar and massive quartz and white calcite. . . . Some of the sulfide veins are as much as 6 inches across.
>
> A polished section of the coarsely crystalline sulfides shows pyrite rimmed and embayed by sphalerite. Sphalerite encloses tiny blebs of chalcopyrite in parallel orientation. Galena occurs along sphalerite grain boundaries and as veins in sphalerite. The sequence of formation of ore minerals is (1) pyrite; (2) sphalerite and chalcopyrite (unmixed from solid solution ?); and (3) galena. This assemblage of primary sulfides in a quartz-carbonate gangue denotes deposition under mesothermal conditions. The proximity of thick Tertiary andesite dikes suggests that the mineralization may be also of Tertiary age.

Uranium deposits. Small fractures filled with a secondary uranium mineral, tentatively identified as torbernite, were discovered in the Wild Horse Mesa area in 1955 by a Mr. Walkum. In 1956, a Mr. Nichols and J. H. Winslow, Deming, located a number of claims. The deposits are in the NW¼ sec. 11, T. 18 S., R. 17 W. south of Wild Horse Mesa.

In 1957 and 1958 the claims were leased to a group of unidentified individuals from the East, who drilled one 80-foot-deep hole and several shorter ones to explore the property. Very little uranium was found. The operation was apparently a promotion scheme, and because of litigation resulting finally in a jail sentence for one of the principals, the court ordered an adit driven along the vein to intersect the bottom of the drill hole. This was done by A. Akers, Bayard, during 1958 and 1959. The adit is cut 180 feet into the hillside. The vein dips 80° W., and according to Akers (oral communication), granite is on the hanging wall and Beartooth Quartzite on the footwall side of the vein in the adit. Small one- to two-inch pods and clusters of weakly radioactive material were scattered along the vein. No commercial nor potentially commercial uranium was exposed in the adit or on the property.

REDROCK AREA

The Redrock area comprises the country on both sides of the Gila River within a radius of ten miles north, northeast, and northwest of the

Redrock post office (figs. 1 and 27). It includes the old Anderson district, the Clarks Peak district, and the Telegraph district as defined by Jones.

The geology of the Redrock area was studied in detail by Hewitt. Precambrian Burro Mountain granite, the dominant rock type in the district, is limited on the south by faults which place it in juxtaposition to the Gila Conglomerate. West of the Gila River, this bounding fault trends N. 45° W. and dips steeply southwestward. East of the Gila River, the bounding fault trends N. 60° E. and dips 65° SE.

West of the Gila River in the vicinity of Ash Creek, a series of Precambrian schists, quartzite, and serpentine rocks occur as xenoliths within the granite immediately north of the fault. These are described by Hewitt as the Ash Creek series. He distinguishes four major rock units: (1) sericite phyllite and andalusite sericite schist; (2) cordierite hornfels; (3) andalusite hornfels, biotite hornfels, and diopside quartzite; and (4) serpentine carbonate rocks. In addition, isolated masses of sillimanite gneiss, quartz-feldspar gneiss, biotite gneiss, and mica schist, which are part of the Precambrian Bullard Peak series, occur in the eastern part of the area. Other Precambrian rocks included as xenoliths within the granite are metadiabase southeast of the Gila River and anorthosite west of Ash Creek.

The Beartooth Quartzite and Colorado Shale of Cretaceous age overlie the Precambrian rocks and crop out in the northern part of the area. These in turn are overlain by undifferentiated Tertiary volcanic rocks. Tertiary rhyolite and rhyolite porphyry dikes and Early Tertiary or Late Cretaceous dikes and pluglike masses of andesite porphyry intrude the Precambrian and Cretaceous rocks. Hewitt describes the various rock types, particularly the metamorphic rocks, in great detail.

Pre-Gila basalt and andesite, Gila conglomerate, and Quaternary terrace gravels are the country rock in the vicinity of the manganese deposits southwest of Redrock. The Gila consists of a lower member of consolidated coarse conglomerate and an upper member of semiconsolidated thin-bedded sandstone and clay and interbedded basalt and andesite flows. The thickness of the formation is in excess of 500 feet.

Besides the major faults which bound the district on the south, numerous other faults transect the area. Most of these trend northwest and dip steeply southwest, parallel to the bounding fault west of the Gila River. A few cross faults in the northern part of the area trend northeast.

Ore deposits in the area can be divided into two groups, those of hydrothermal origin and those resulting from processes of metamorphism. The hydrothermal deposits are associated with faults and are along or in proximity to the major faults. The metamorphic deposits are confined to the Ash Creek series of metamorphic rocks. Included in the first group are fluorspar, manganese, magnesite, lead, silver, and copper deposits. The second group includes ricolite (serpentine), asbestos, and magnetite. Of these, the silver, fluorspar, manganese, and ricolite have been of commercial importance.

Telegraph. The Telegraph mine is in the SW¼ sec. 32, T. 17 S., R. 17 W., about three quarters of a mile northwest of the Gila River and nearly ten miles northwest of Redrock. The area is extremely inaccessible, even for a jeep.

Silver ore was discovered in 1881 by J. Kirby, who located the Tecumseh lode (Jones). Soon others entered the area and the Telegraph Mining Company was organized in 1884. A year later, a 15-stamp mill was erected about one and a half miles up the Gila at the head of the box canyon. The ore, however, was soon exhausted. The concern collapsed and the mill was dismantled. In 1903, Dr. H. W. Brown, Silver City, and associates erected a small leaching plant with a five-ton-a-day capacity on the site of the mill, but this venture was not very successful either.

In the vicinity of the Telegraph mine, blocks of Beartooth Quartzite are in fault contact with Burro Mountain granite. The major faults trend northwest, but cross faults trend northeast. The Telegraph mine is along one of these cross faults which strikes N. 28° E. and dips about 65° SE, in proximity to a northwest-trending major fault. At the mine, the fault transects granite, but to the southwest it cuts through Beartooth Quartzite.

The deposit is explored by an adit excavated about 50 feet into the hillside along the vein. An old shaft 40 to 50 feet deep is nearby. To the north across the gulch and north of the block of Beartooth Quartzite, numerous pits and an underhand stope are present along a north-trending vein. South of the main workings, a 200-foot-long adit goes westward beneath the quartzite.

At the main adit, the vein was apparently 2 to 3 feet wide near the portal, but narrowed rapidly upward as the adit advanced (Lindgren, Graton, and Gordon). When Graton visited the mine in 1905, the only visible material was "fractured, much silicified granite, with drusy, iron stained quartz and in places black specks, which probably carried silver." In the vicinity of the vein, the granite is silicified and stained by hematite, limonite, and manganese oxide.

At the pits north of the gulch, the vein exposed is about 3 feet wide. Purple fluorite and manganese oxide are conspicuous. Graton stated that except for the fluorite, the ore from this vein was similar to that at the main workings.

Slate Canyon and Lead Mountain. The deposits in Slate Canyon and on the sides of Lead Mountain are described in detail by Hewitt (p. 113). The following information is taken from his report.

Lead Mountain lies east of Slate Creek in sec. 36, T. 17 S., R. 18 W. eight and a half miles northeast of Redrock and two miles west of the Telegraph mine. Two caved adits halfway up the southwest slope of the mountain explored a vein that strikes N. 30°-35° E. and dips 58° to 65° SE. The vein occupies a shear zone and ranges from 5 to 10 feet wide. The country rock is Burro Mountain granite which is intensely kaolinized for about 25 feet on both sides of the vein, with abundant quartz veinlets and millimeter-long pyrite cubes. Columnar quartz, galena, and crusts of purple fluorite on the kaolinized granite, chrysocolla, and iron and manganese oxides are present on the dumps.

The Slate Creek deposit is on the west side of Lead Mountain in Slate Creek Canyon. This deposit was formerly owned by Sherman Harper, Arena Valley, who did much of the work; Mr. Harper may still control the property. An adit is driven northeastward into the hillside on the east side of Slate Creek and a 15-foot-deep shaft connects the end of the adit to the surface. The vein is a mineralized breccia zone in the Beartooth Quartzite along a fault which trends N. 62° E. and dips 68° NW. Veins of milky to pale amethyst quartz transect the breccia, and drusy quartz coats the breccia fragments and lines the cavities between the fragments. Coarsely crystalline galena fills narrow fractures and cavities. Minor amounts of sphalerite, chalcopyrite, bornite, and pyrite are present.

In 1960, a few truckloads of ore, consisting mostly of quartz and galena but with some sphalerite and chalcopyrite, were mined, but the inaccessibility of the area is a drawback to commercial exploitation. Small prospects, not visited by the writer, are between Lead Mountain and the Telegraph mine along Foxtail Creek in the SW¼ sec. 31, T. 17 S., R. 17 W. and the NW¼ sec. 6, T. 18 S., R. 17 W.

The Slate Creek Canyon and Lead Mountain area was probably the district referred to by Jones as the Clarks Peak district. Clarks Peak is about one and a half miles southwest of Lead Mountain.

Great Eagle fluorspar. The Great Eagle fluorspar deposit is four and a half miles northeast of Redrock on the south bank of the Gila River in the S½ sec. 23, T. 18 S., R. 18 W. The property has been described by Johnston, by Rothrock (Rothrock, Johnson, and Hahn), and by Hewitt. According to Johnston, the property was first located in 1911 by A. B. Conner of Redrock, who operated it in 1914. It was idle until 1917 when it was reopened by the Great Eagle Mining Company. A mill was built in 1919, but milling operations were unsuccessful because of the siliceous character of the ore, and the mill was soon dismantled. Operations ceased in 1921. About 3000 tons of metallurgical spar had been produced.

In 1939, the Fluorspar Milling Company reopened the mine, and mining was continued until 1941 by the Southwestern Mining Company. In 1943, D. F. McCabe, Lordsburg, leased the property from Mrs. Ruth Spamm, Lampasas, Texas, and work continued into 1945. Several thousand tons of ore were shipped from the old dumps to the mill at Lordsburg, and more ore was also produced from the mine.

Fluorspar has been mined along the vein for about 750 feet. An adit 90 feet below the highest point on the outcrop gives access to the largest stope. An incline along the vein from the southeast end of the outcrop slopes 60 feet below the adit level, and this extends northwest for a total of 300 feet from the collar of the incline. A vertical shaft, 110 feet deep and dropping 90 feet below the 60-foot level, is sunk in the granite country rock northeast of the vein. A crosscut reaches to the vein from the bottom of this shaft. The vein is stoped extensively above the adit level and some stoping has been done above the 60-foot level. Stopes open to the surface on the northwest end of the vein are not connected with the underground workings.

The mine is on a vertical shear zone that strikes N. 30°-40° W. in Burro Mountain granite. The zone is 30 to 40 feet wide and can be traced for about three quarters of a mile. The deposit occupies the southeastern end of the shear zone and is covered to the southeast by alluvium. The vein continues northwestward across the Gila River, but only minor amounts of fluorspar are found north of the river.

The mineralized part of the zone is 2 to 10 feet wide. In the central and widest part of the deposit, horses of partly replaced granite separate discrete fluorspar veins. Toward the ends, the veins join and fluorspar occurs in a single low-grade vein, the average width of which is 7 feet, the average fluorite content being 66 per cent (Rothrock, Johnson, and Hahn). The extent of the ore at depth has never been determined because the lowermost part of the workings is below the level of the Gila River and is continuously flooded unless pumped.

The ore body contains coarsely crystalline and microcrystalline fluorite, chalcedony, fine-grained quartz, and fragments of altered granite. The coarse-grained fluorspar is high grade and green to blue-green in color. The microcrystalline fluorspar is dull reddish brown to white and has a conchoidal fracture. It is generally banded and has a nodular structure. Parts of the veins are zoned, with light green fluorspar at the margins and violet and purple fluorite in the center. Well-developed crystal faces inward toward the center of the vein indicate open-space filling.

According to Hewitt, thinsection studies revealed at least two periods of brecciations of the fluorspar. Light green fluorite occurs as fragments in gray chert and chalcedony, and this older breccia, with fragments of violet fluorite, is enclosed in brown jasper. The paragenetic sequence of (1) early green fluorite, (2) brecciation, (3) white and gray chert and minor fluorite, (4) violet fluorite, (5) brecciation, and (6) brown jasper is similar to the sequence described for other deposits in the area.

Incomplete records of shipment from the mine (Rothrock, Johnson, and Hahn) are as follows:

	TONS OF ORE
Metallurgical spar shipped between 1917 and 1921	3,800
Metallurgical spar shipped between 1931 and 1941	1,900
Milling ore shipped between 1943 and 1944	6,000
Incomplete total	11,700

Some assay values and analyses (Rothrock, Johnson, and Hahn) are as follows:

	PER CENT FLUORITE	PER CENT SILICA	PER CENT CALCITE
Average content of 1983 tons shipped July 1, 1918	91.5		
Average assay of 784 tons shipped from dump in 1943	65.0	30.0	5.0
Average content of 1206 tons shipped from dump in 1944	53.5		
High-grade vein in upper part of workings	93.0	2.9	
White microcrystalline ore	88.1	2.5	

Rothrock (Rothrock, Johnson, and Hahn) estimated that a low-grade ore body 200 feet long is near the surface in the northwest part of the deposit. Considerable high-grade ore may be at depth, but mining would be costly because of the water problem.

Hope prospect. This deposit was not visited by the writer. Hewitt describes it as an old prospect that was restaked by J. A. Moreland and Ernest Sisco in 1955. It is on the west side of Joe Harris Canyon, about three eighths of a mile southeast of the Great Eagle. A 20-foot pit exposes a two-foot-thick vein of green fluorite and chert in Burro Mountain granite that strikse N. 15° W. and dips 40° SW.

Other subparallel, narrow fluorspar veinlets and stringers between here and the Gila River consist of a breccia of chalcedony fragments cemented by light green fluorite.

Jackpot. The Jackpot fluorspar deposit, owned by Sherman Harper, Arena Valley, is near the center of sec. 7, T. 18 S., R. 18 W. about five miles north of the Redrock post office.

Three shallow pits, the deepest 15 feet, expose a vein along a fault that strikes north and dips 70° E. Burro Mountain granite forms the footwall. The vein is 3 feet wide and can be traced several hundred feet. It consists of a breccia containing fragments of green, coarsely granular fluorite cemented by manganese oxide, mostly psilomelane. One or possibly two coalescing and imbricating subparallel veins crop out less than 100 feet east of the major vein. These appear to be in Gila Conglomerate, which also appears to constitute the hanging wall side of the major vein. Exposures are poor, however, and what seems to be Gila may be merely surficial debris from the weathering of granite. Manganese oxide is more prevalent in the easternmost of the veins.

Deposits in section 22. Narrow fluorspar veins in Burro Mountain granite and Tertiary rhyolite are exposed in prospect pits and adits on the north side of the Gila River in the NE¼ sec. 22, T. 18 S., R. 18 W. about one mile west of the Great Eagle mine. The veins parallel two rhyolite dikes that strike N. 40°-50° W.; a few strike northeast. Fluorspar is most abundant and the veins are wider near the south end of the dikes where the dikes are closest together. Individual veins are less than 2 feet wide, and the mineralized zone has a maximum width of 125 feet.

Two shafts, now inaccessible, have been sunk along the veins that parallel the western dike. The veins are less than 6 inches wide and the fluorspar is mixed with light gray chert.

Near the south end of the eastern dike, two short adits and a 4-foot-deep pit expose a number of veins of dark purple fluorite and chert containing pyrite. The veins have a maximum width of 3 feet but cannot be traced along the strike for more than 100 feet. The vein in one adit is slightly radioactive, the count being about twice background. The fluorite occurs as granular masses and as crystals one millimeter long in the chert. Hewitt, who describes the property in detail, suggests that the dark purple color of the fluorite is a result of emanations from radioactive minerals precipitated from the ore solution contemporaneously with the fluorite.

At the north end of this same rhyolite dike, several pits expose a breccia of silicified rhyolite fragments cemented by brown cryptocrystalline quartz. The breccia is slightly radioactive, with the radioactive minerals deposited along fractures in the rhyolite fragments. The owner of the claim, Gerald Hunt, Clifton, Arizona, stated that the radioactive minerals had been identified as uranophane. Hewitt suggests that the radioactive mineralization is related to the deposition of the cryptocrystalline quartz cement and that both these and the fluorite at the southeast end of the dike are all genetically related. He further suggests that deposition was probably under low temperature and near surface hydrothermal conditions.

Copper deposits. Small copper deposits are along the northeasterly trending fault that forms the boundary between Precambrian rocks and Gila Conglomerate east of the Gila River (Jones; Hewitt).

In the NE¼ sec. 24, T. 18 S., R. 18 W., an adit has been driven northward through the fault into granite and metadiabase. The fault strikes N. 60° E. and dips 65° SE at this locality. Malachite and chrysocolla coat granite and fill narrow fractures. Near the east end of the fault in the NW¼ sec. 20 or SW¼ sec. 17, T. 18 S., R. 17 W., chrysocolla and tenorite occur as veinlets and narrow fracture fillings in fault gouge and in the granite footwall. No primary sulphides were observed.

In 1960, the Freeport Sulphur Company put down four diamond drill holes north and northeast of Redrock exploring the area for copper. The holes are in the SW¼NW¼ sec. 23, T. 17 S., R. 19 W.; the NW¼-SE¼, sec. 31, T. 17 S., R. 18 W.; the SE¼SW¼ sec. 32, T. 17 S., R. 18 W.; and the SW¼NE¼ sec. 9, T. 18 S., R. 18 W. The holes were drilled to depths of 1034, 1302, 749, and 405 feet, respectively. The first was in volcanic rocks. The second was collared in Cretaceous sedimentary rocks and, except for a few rhyolite dikes, was in shale, sandstone, or arkose throughout its length. The third was drilled in granite but passed through a few rhyolite dikes. The last hole was drilled near a fault between granite and Tertiary volcanic rocks and was largely in granite. No sulphides were observed in any of the cores, except for small amounts of pyrite in some of the rhyolite dikes in the third hole and oxidized pyrite along fractures near the bottom of the fourth hole. Nor was there any excessive alteration or other evidence of hypogene mineralization. The drilling program was abandoned in August 1960 after the completion of the four holes.

Black Eagle. The Black Eagle manganese mine is in the extreme southwest corner of sec. 6, T. 18 S., R. 18 W., five and a half miles north of Redrock on an unpatented claim controlled by Sherman Harper, Arena Valley. Workings consist of a 75-foot-long inclined adit at the southwest end of the vein, connected with a shaft and stopes open to the surface. Open cuts and shallow pits explore the vein for 200 feet northwest of the portal. The deposit was worked during World Wars I and II; in 1950, H. E. McCray, who leased the property, shipped several truckloads of ore to Deming. It has been idle since the early 1950's. No record of the total production or of the grade of ore shipped is available.

The deposit is along a major fault which strikes N. 15° W. and dips 70° SW at the mine. The general trend of this fault, however, is about N. 45° W. Precambrian Burro Mountain granite is on the footwall side and Tertiary volcanic rocks are on the hanging wall side of the fault at the mine, but to the southeast, Gila Conglomerate forms the hanging wall. To the northwest, Tertiary volcanic rocks are on both sides of the fault.

The manganese vein lies along the fault for 375 feet northwestward from the portal and then swings westward into the Tertiary volcanic rocks of the hanging wall. The vein is 6 to 8 feet wide in the adit and consists mostly of coarse black calcite, with lesser amounts of manganese oxides, white and pink calcite, and fluorite. A 6-inch gouge zone of orange clay separates the vein from the granite in the adit; microcline crystals in fragments of granite within the vein and in the granite footwall are intensely kaolinized.

Managanese minerals are abundant in the vicinity of the adit and near the surface. At the shaft, 50 feet northwest of the portal, about half the vein consists of manganese oxide. Pyrolusite and psilomelane both are present as nodules, veins, and lenses within the black calcite. Psilomelane is predominant. The pink calcite is in lenses within the black calcite, but the white calcite occurs as veins which transect the black and pink.

Microscopic studies of the ore minerals by Hewitt showed that the color of the black calcite is due to feathery inclusions of manganese oxide, and that the color of the pink calcite is due to tiny grains of anhedral fluorite. The sequence of mineral deposition was shown by fluorite successively rimmed by pink calcite, black calcite containing manganese oxide, and white calcite. A few veinlets of psilomelane that transect the white calcite are supergene, but the major amount of the manganese oxide is believed to be hypogene deposited from low-temperature hydrothermal solutions. The sequence of events in the formation of the deposit, as outlined by Hewitt, is as follows:

1. Faulting
2. Deposition from low-temperature hydrothermal solutions of fluorite and pink calcite, followed by brecciation (?) and deposition of abundant black calcite and manganese oxides, and this followed by the deposition of white calcite with small amounts of manganese oxide
3. Near-surface concentration of manganese oxides by supergene processes

In addition to the psilomelane deposits of the Redrock manganese district discussed in the next section, psilomelane and pyrolusite are found elsewhere in the Redrock area as nodules and in veins, in many places associated with fluorite. Among these are the Jackpot fluorite prospect; the Long Lost Brother fluorite deposit; the Telegraph mine; at the Simpson prospect in the SW¼, north of Jacks Canyon in the NW¼, and in a 2-foot-wide vein with chert along an andesite dike in the NE¼ sec. 14, T. 18 S., R. 18 W.; and in a number of places in the NW¼ sec. 24, T. 18 S., R. 18 W. and the NW¼ sec. 19, T. 18 S., R. 17 W., north of the large fault along which copper minerals have been found. None of these deposits has been worked commercially for manganese.

Redrock manganese district. A group of manganese deposits lies on both sides of the boundary between Grant and Hidalgo counties, 6 to 8 miles southwest of Redrock in secs. 20, 32, and 33, T. 19 S., R. 19 W., and sec. 19, T. 19 S., R. 20 W. (fig. 29). Although most of the mines are in Grant County, detailed descriptions of them will be included in the forthcoming study of the mineral deposits of Hidalgo County by Elston,

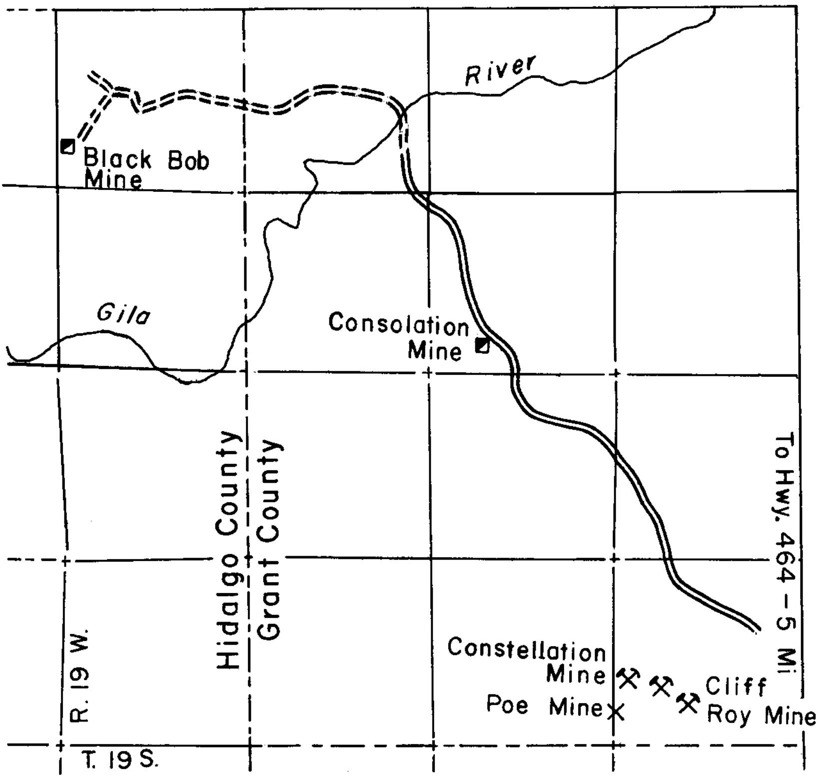


Figure 29

LOCATION OF MINERAL DEPOSITS IN THE REDROCK MANGANESE AREA

and they have also been the subject of a recent master's thesis (Pradhan and Singh).

The mines were operated in the late 1950's, and about 15,000 tons of manganese ore were produced. Most of the production was from the Consolation and Cliffroy mines, owned by the Duncan Mining Company, Duncan, Arizona, and Douglas Henry, Truth or Consequences, respectively. R. V. Mathis, Silver City, operated both mines under lease. Minor amounts of ore were produced from the Black Bob and Ward mines. The ore was psilomelane and occurred in small fissure veins. It was concentrated in two jig mills and a sink-float mill located nearby in the Gila Valley. The concentrates were shipped to the government stockpile in Deming and to manganese mills in Socorro County where they were in demand for blending because of low content of copper, lead, and zinc.

The manganese deposits are in Gila Conglomerate and belong to the class of epithermal hypogene manganese oxide veins described by Hewett and Fleischer (1960). At the Cliffroy mine, the manganese ore grades into banded travertine within a few feet of the surface, evidence of the association of manganese mineralization and hot-spring activity.

The veins at the Cliffroy and Ward deposits are in coarse consolidated conglomerate in the lower part of the Gila Conglomerate. At the Consolation mine, sandstone of the upper part of the Gila Conglomerate forms the hanging wall of the vein, and basalt or andesite flow rock, interbedded with the upper part of the Gila Conglomerate, forms the footwall. At the Black Bob, basalt is the host rock.

The veins fill faults which are aligned N. 45° W., parallel to major regional structures. Individual veins trend approximately N. 10° W., N. 35° W., or N. 63° W. Dips are steep and displacements along the faults are unknown. Psilomelane is the only commercial ore mineral, but some pyrolusite occurs. Calcite is scarce, but where present, it is locally black and manganiferous, similar to that at the Black Eagle mine northwest of Redrock. Travertine is present at the Cliffroy mine, the psilomelane grading up into it. Opal impregnates some of the ore and was precipitated from hot spring waters which soaked the surrounding rocks. The country rock also has been argillized and is locally stained by hematite.

There was little ore in sight when mining ceased in 1959, but the veins had been explored only above the water table. Experience at the Cliffroy mine shows that areas of travertine are worth investigating and that opalized areas are favorable.

Cliffroy mine. The Cliffroy mine is in the SW¼ sec. 33, T. 19 S., R. 19 W. It is on a well-defined psilomelane vein which strikes N. 90° W. and dips 75° W. It is 2 to 5 feet wide, but locally widens to 8 feet. The ore consists of calcite (banded travertine at the surface) and psilomelane, with intergrown opal. It averages 20 to 25 per cent manganese, but the opal effectively prevented the formation of a concentrate by jigging greater than 36 per cent manganese.

The mine consists of a single stope 300 feet long, 70 feet deep, and 5 to 9 feet wide. Access was through 35-degree incline at the south end. The vein pinched out at the bottom of the stope. About 5000 tons of ore were produced from the mine.

Ward mine. The Ward mine is half a mile northwest of the Cliffroy and was mined as an open pit. The pit is 500 feet long and 20 feet wide. The ore occurs as innumerable small stringers of psilomelane in two ill-defined diverging veins which strike N. 27° W. and N. 35° W. The ore is low grade.

Consolation mine. The Consolation mine is in the SW¼ sec. 20, T. 19 S., R. 19 W. The vein is in a well-defined fault which strikes N. 45° W. and dips steeply northwest. Ore occurs through a breccia zone up to 8 feet wide. It has been mined for a strike length of 120 feet and a depth of 100 feet. The ore mined consisted of psilomelane and wall rock containing only 8 to 10 per cent manganese. Concentration by jigging produced a product containing 43 per cent manganese. About 10,000 tons of ore were mined.

Black Bob prospect. The Black Bob is in the SW¼ sec. 13, T. 19 S., R. 20 W. Psilomelane is disseminated through a 12-foot-wide zone of soft argillized brecciated basalt and gouge. The strike of the zone is roughly east-west. A 75-foot-deep shaft inclined 78° SW explores the deposit.

Magnesite deposits. Magnesite crops out over an area about 60 feet wide and 75 feet long on a steep hillside on the west side of Smith Canyon near Smith Spring in the N½ sec. 17, T. 18 S., R. 18 W., where it has been eroded into a miniature badlands topography. Other small, scattered deposits are poorly exposed in pits on the west side of Smith Canyon for about three quarters of a mile southeast to its junction with Ash Creek. The magnesite is in fault contact with Burro Mountain granite on the northeast and is covered by debris from the Gila Conglomerate on the southwest. The deposit has been studied and described by Yale and Stone (1921, 1922) and by Hewitt.

At the deposit near Smith Spring, the magnesite occurs with dolomite and cryptocrystalline quartz in horizontal beds. The more siliceous beds are resistant and stand out upon weathering, accounting for the badlands type of topography. The magnesite is seen as veinlets that transect the dolomite and as diffuse masses replacing the dolomite. Veinlets of quartz also transect the dolomite. The carbonate host rock may be horsts of Paleozoic or Mesozoic rocks similar to those along this same fault in sec. 23, T. 18 S., R. 18 W., or they may be xenoliths of the Precambrian Ash Creek series. Hewitt believed there is evidence to support both possibilities. Regardless of the age of the host rock, however, he believed that the replacement of the dolomite by magnesite resulted from hydrothermal solutions circulating along the fault in Middle or Late Tertiary time.

The size of the deposit and its distance from a railroad make it of little commercial importance.

Ricolite (serpentine). Ricolite is banded light to dark green talc-serpentinite which crops out in Ash Creek Canyon in the S½ sec. 9, and N½ sec. 16, T. 18 S., R. 18 W., about five miles north-northwest of Redrock. The rock is included in the steeply dipping tabular xenoliths of serpentine-carbonate rocks of the Ash Creek series (Hewitt). Mottled and massive canary-yellow serpentine is associated with the ricolite.

The ricolite, and some of the mottled and massive serpentine, has been quarried intermittently since the 1880's for use as an ornamental stone and in building interiors. In 1888, a shipment was made to Chicago for interior wainscoting. Because of the lack of impurities, the ricolite can be easily carved and has a limited use in the making of lamp bases, ash trays, book ends, paperweights, and similar small ornamental objects. It would make ideal table tops and mantlepieces. Several attempts have been made to exploit and market the stone, the latest in the mid-1940's. None has been successful, the physical characteristics of the rock and the distance to market being equally to blame. Although the banded appearance of the ricolite is pleasing, the porous texture, extreme softness, and the difficulty of imparting a high luster in polishing are deterrent factors to its use.

The geology and origin of the ricolite and related serpentinite are fully discussed by Hewitt. According to him, the banding reflects the original stratification of the rock, which he suggests was a finely bedded, silty dolomite with lenses of argillaceous sediment. Serpentinization occurred by thermal metamorphism as a result of the intrusion into the Ash Creek series of diabase or granite. The formation of talc or serpentine was dependent upon the magnesium content of the original sedimentary rock and was caused by local reaction of quartz, dolomite, and thermal waters.

Asbestos. Veinlets of chrysotile serpentine less than one-quarter inch thick transect the ricolite and the yellow massive serpentinite in the vicinity of the ricolite quarry in Ash Creek Canyon. The material is fine quality, silky, white, cross-fiber asbestos, but the veins are too narrow and too widely spaced to constitute a deposit of commercial importance. The deposit, however, has been only slightly explored.

Magnetite. Magnetite-rich serpentinite, in which locally the magnetite constitutes as much as 90 per cent of the rock, crops out in Ash Creek Canyon about half a mile above the ricolite quarry in sec. 9, T. 18 S., R. 18 W. The magnetite-rich rock occurs in several bands 1 to 2 feet wide, through a zone about 8 feet wide; most are less than 10 feet long. The deposit is too small and too inaccessible to be of commercial importance. Hewitt and also Kelley (1949) discuss the deposit.

Clay. A deposit of white clay is exposed near Smith Spring in the N½ sec. 19, T. 18 S., R. 18 W. on the west side of Smith Canyon. The clay can be seen through a vertical distance in excess of 50 feet. It lies west of the large fault which goes down Smith Canyon and is in contact with gravel on the west side. No attempts to explore or develop the deposit have been made.

GILA FLUORSPAR DISTRICT

The Gila fluorspar district is in the southwest corner of T. 14 S., R. 16 W. in the canyon of the Gila River and the mountainous terrain southwest of the river (fig. 1 and pl. 1). It is five miles upriver from the town of Gila. The earliest recorded fluorspar mined in New Mexico was from the Foster mine in the Gila district, in the 1880's. Several mines were operated during World War I and in the 1920's. In 1943, a mill was constructed at Gila which stimulated mining in the district. Ore from the Clum, Foster, and Victoria mines was beneficiated. Average daily output of the mines in 1944 was 50 tons, most of which came from the Clum mine. Mining of fluorspar was discontinued in 1955, and except for a short period in 1959, the district has been dormant since.

Complete descriptions of all the fluorspar properties in the district were given in detail and a thorough study was made by H. E. Rothrock (Rothrock, Johnson, and Hahn) in 1943 and 1944 when the district was in its maximum period of activity. The reader is referred to this publication. Herein is only a brief summary with a few remarks about the general geology. The information is condensed from Rothrock, and additional information of pertinent value relative to activity since 1944 is included. The area and most of the deposits were revisited by the writer in 1960.

The fluorspar deposits are within the sequence of volcanic rocks described by Elston (1960a), Weber and Willard, and others as the Datil Formation, but are said by Rothrock (Rothrock, Johnson, and Hahn) to represent the lower part of a Cretaceous ? or Early Tertiary sequence. In the vicinity of the deposits, the rocks are trachytic latite, latite porphyry, andesite, and andesite porphyry flow breccia, agglomerate, and tuff. These have been hydrothermally altered in the vicinity of the fluorspar deposits. Near east-trending fracture zones, the bleaching and alteration of biotite has caused the dark gray trachytic latite and andesite to be bleached light gray or buff. Locally, small pyrite crystals are disseminated through the rock, and decomposition of the pyrite has resulted in the formation of small alum masses. Silicification is also noticeable.

A fault limits the volcanic rocks on the southwest. Gila Conglomerate is southwest of the fault and consists of cobbles and pebbles in a semiconsolidated sandy matrix and coarse sandstone, locally unstratified but elsewhere bedded, which has been tilted southwest. The fault is exposed in road cuts and near the Foster mine. It terminates the Foster vein and is postmineral.

Fluorspar deposits are confined to the volcanic rocks. They are in normal faults and fissures which strike northwest to north and slightly east of north. The major exception is the Foster vein which strikes N. 45° E. Dips are steeply inclined either to the east or west, or the veins are vertical. Changes of dip and strike along the course of the veins are common.

Brecciation is usual along many of the faults. The fluorspar occurs as open-space fillings in the fractures and in the interstices between the breccia fragments and also as replacement of the breccia fragments and, in a few spots, of the wall rock. At the Clum mine, a breccia zone is bordered by a sheeted zone formed by subparallel fractures. The breccia zone is so greatly altered that much of the finer material has been reduced to clay. Masses and veins of fluorspar are imbedded in the clay and fill fractures in the rock. Quartz is intimately associated with the fluorspar. It, too, replaces breccia fragments and wall rock. At the Clum East and others, replacement and cavity filling together contribute to the formation of the vein. The average width of the vein at the Clum is 5 to 6 feet. Elsewhere, widths are from 2 to 6 feet. At some of the deposits, movement reopened the veins and brecciated the fluorspar, and a second generation of fluorite then filled the reopened fissures and recemented the early fluorspar. In many places, more than one vein is within the brecciated zone.

The fluorspar is coarse, crystalline, clear translucent-to-transparent, massive green fluorite with minor amounts of quartz that fills fissures; or fine- to medium-grained fluorite with inclusions of brecciated rock and varying amounts of quartz; or white, red, gray, brown, or light blue translucent-to-opaque microcrystalline fluorite with tiny quartz grains distributed throughout, and locally banded. The latter two types are too siliceous for shipment as metallurgical spar, the silica content being as much as 30 per cent. The coarse-grained, massive fluorspar has been shipped for metallurgical spar.

The principal deposits in the district are the Clum and Clum East, the Foster, and the Victoria. Others include the Blue Spar, Green Spar, Brock Canyon (Blue Betty), Watson Mountain, Last Chance, Big Spar, Thanksgiving, Big Trail, and Cedar Hill (Howard) deposits. Most of the ore shipped was from the Clum and Clum East, Foster, Victoria, Watson Mountain, and Last Chance.

Foster. The Foster mine is reputedly the oldest fluorspar mine in New Mexico. Ore was produced by Apolinario Ogas and Pedro Carajl in the early 1880's and used as a flux in the silver-lead smelters in Silver City. The mine is six miles from Gila and is the first fluorspar mine along the access road from Gila to the fluorspar district. In 1960, it consisted of a lower adit level about 700 feet along the vein, with raises connecting to older workings, drifts, and stopes higher on the hillside. A 45-foot winze slopes from the adit level; a 70-foot-deep shaft inclined toward the north had been excavated from the surface at the portal of the adit. Considerable stoping had been done, largely above the lower adit level. On the hillside are old pits, short drifts, shallow shafts, and associated stopes. Only the lowermost of these is connected to the main lower adit workings. The workings extend 1000 feet along the vein.

During 1943 and 1944, the mine was under lease to D. F. McCabe, Lordsburg. Between 1951 and 1955, it was operated by Jack Wallace, Gila. In 1960, the claim was owned by Fayette Rice, Gila. The total amount of ore shipped from the mine is unknown, but between 1951 and

1955, Wallace shipped about 5000 tons. It was last worked for a short time in 1959.

The vein is along a normal fault which strikes N. 45° E. and dips 85° NW. It is abruptly terminated 150 feet southwest of the lower adit by the major fault that strikes N. 33° W. and brings Gila Conglomerate against the latite within which the vein lies. The southwestern end of the vein has been dragged southward along this fault. The vein can be traced for 1350 feet northeast from the fault to where it dies out in the trachyte agglomerate. It is exposed for a vertical distance of 435 feet. According to Rothrock (Rothrock, Johnson, and Hahn), displacement of the agglomerate along the vein indicates a throw of 20 feet and a strike-slip of 60 feet, the hanging wall moving southwest.

The vein occupies a breccia zone 3 to 8 feet wide, fluorspar occurring within fissures and between breccia fragments. Recurrent movement resulted in the reopening of fissures and a second generation of fluorite. Average width of the vein is 2.5 feet, but it swells and pinches. The bulk of the ore was shipped for metallurgical spar and was coarse-grained green fluorite with little quartz from the filled fissures. Ore from the breccia sections of the vein contains 50 to 70 per cent fluorite and is of good milling grade.

Clum mines. The Clum mines include the Clum and Clum East veins. The Clum is about one mile east of the Foster mine and on the crest of a ridge. The Clum East is in a small gulch 300 feet lower and 750 feet northeast.

The Clum was first operated in 1937, and several hundred tons of ore were shipped. It was reopened by Jack Wallace in 1942, and mining was continued in 1943 and 1944 by the Brown–Johnson Corporation under Wallace's management. By the end of 1944, a total of 20,300 tons of ore had been shipped. The Clum East was first opened in 1943 by Brown–Johnson, 4000 tons of ore having been shipped by the end of 1944. Twenty thousand tons of ore shipped to the mill at Gila during 1943 and 1944 from both deposits averaged 52.0 per cent fluorite. Three thousand tons shipped from the Clum alone between 1937 and 1942, apparently for metallurgical purposes, averaged 70 per cent fluorite.

The Clum deposit consists of two ore bodies. The north ore body has been developed by an inclined shaft 300 feet deep with levels at vertical depths of 55, 160, and 260 feet. On the 160-foot level, drifts were driven 200 feet south and 400 feet north. Ore has been stoped to the surface over much of this length, the stopes averaging six feet wide. Ore left in the face averages 2.5 feet wide. The 260-foot level reaches 30 feet north of the shaft and exposes only a narrow vein. According to Rothrock (Rothrock, Johnson, and Hahn), this "may be either a lean part of the main vein or a minor vein beneath the main ore shoot, whose northerly pitch may place it beyond the end of this short drift."

The south ore body is 325 feet south of the main shaft. It is exposed for 100 feet on the surface and in 1944 was stoped to a depth of 30 feet. Width of the ore body was 3 to 6 feet.

The Clum East vein is developed by a 160-foot-deep shaft with levels at 60 and 130 feet. Ore was mined to the surface from the 60-foot level for a total distance on both sides of the shaft of about 125 feet. On the 130-foot level, a drift leads 35 feet northwestward from the shaft and exposes only some narrow stringers of fluorspar.

The following description of the deposit is from Rothrock (Rothrock, Johnson, and Hahn):

> Trachytic latite occurs both as massive rock and as agglomerate in the vicinity of the Clum mine. The east wall rock of the Clum vein is generally lighter colored than that on the west, owing to bleaching of biotite. South of the mine the latite is darker and the groundmass is more glassy.
>
> The vein occupies a fault that strikes N. 5° W. and dips 70°-80° W. Movement on this fault was greatest along the footwall producing a coarsely brecciated zone in which large "horsts" of rock are common. This zone is bordered on the west by a sheeted zone formed by fractures that are roughly parallel with the fault. The brecciated zone has been so greatly altered that much of the finer material between the large masses of rock has been reduced to clay. Embedded in this clay and filling crevices in the rock are masses and veins of fluorspar. Some of the veins consist of coarse-grained transparent green fluorite that is coarsely brecciated or forms crusts on rock fragments. A larger proportion, however, is microcrystalline, translucent to opaque, brown, light blue, red, or white, and forms banded or homogeneous cavity fillings and nodules. The chief gangue mineral is quartz, which was deposited contemporaneously with the fluorite, partly replacing wall rock and breccia. No metallic minerals are present. Both replacement and cavity-filling processes contributed to the formation of the vein. . . .
>
> The deposit at the Clum East mine is much smaller than the main ore body of the Clum mine, but otherwise the two are quite similar. The wall rock is trachytic latite, the vein is the product of both replacement and cavity filling in fault breccia, and the ore is chiefly microcrystalline fluorite with minor proportions of coarsely crystalline fluorite in veins and pockets.
>
> The vein occupies a fault that strikes N. 33° W. Near the surface in the main shaft it dips 80° SW., but 75 feet southeast of the shaft the dip is 80° NE and the vein pinches out. This change or roll of the vein is reflected underground at a point about 80 feet down the shaft, below which the ore body becomes narrower. The roll, with a pitch of 45° NW., marks the bottom of the ore body in the southeast half of the mine and may do so northwest of the shaft. . . .
>
> The ore is composed predominantly of nodules and irregular masses of white, red, or brown fluorite, so finely crystalline that it has a velvety appearance. Tiny quartz grains are distributed through this ore. Assays show that the ore contains from 80 to 81 percent CaF_2 and 6 percent SiO_2. Minor amounts of green coarsely crystalline fluorite

are embedded in the granular nodules or form veinlets through the breccia. Fluorspar constitutes about one-half of the breccia zone and occurs irregularly through it.

Other deposits. The Victoria deposit was not visited by the writer in 1960. Rothrock (Rothrock, Johnson, and Hahn) gives an excellent description of the deposit to which the reader is referred. The owner was unknown in 1960.

The Blue Spar, Blue Spar West, Green Spar, Brock Canyon (Blue Betty), Watson Mountain, Last Chance, Big Spar, Thanksgiving, Big Trail, and Cedar Hill (Howard) deposits were revisited by the writer in 1960. Little additional work had been done on any of these since 1945, and many were caved and covered by debris. Excellent descriptions of all these deposits are given by Rothrock. Ownership of the deposits in 1960 was unknown, except that the Brock Canyon (Blue Betty) was controlled by Fayette Rice, Gila. Although no shipments had been made from any of these deposits, the flurry of excitement in 1958 and 1959, caused by the rumor that the mill at Deming would be reactivated, resulted in some of the mines being reopened then for a short period. A new deposit, a few hundred yards northeast of the Watson Mountain and just a few hundred feet from the bank of the Gila River, was also opened in 1959. There was no activity in the district in 1960 or 1961.

DEPOSITS WEST OF CLIFF

Wallace perlite. A deposit of perlite on the Wallace Ranch in secs. 19 and 30, T. 16 S., R. 18 W., nine miles southwest of Cliff, was opened in 1958 (fig. 1, pl. 1). The perlite was hauled by truck 45 miles to Silver City, where it was crushed and loaded on railroad cars for shipment to popping plants. Activity ceased in 1960. The property was located by George Stone, Lordsburg, and leased to Charles Day, Odessa, Texas, who operated it under the name of the Hellamae Mining Company. About 200 tons of perlite were hauled to Silver City between July 1959 and July 1960. Additional material was shipped prior to July 1959.

The perlite, quarried at three different localities, is part of the Late Tertiary upper rhyolite, as mapped by Elston (1960a). This unit consists largely of lenses and beds of perlite interbedded with rhyolite flows and tuffs and containing rhyolite plugs. It is interbedded in places with gravels of the Gila Conglomerate. The unit is more than 200 feet thick and crops out over an area one mile wide and eight miles long, trending northwest. The perlite deposits are in the southern part of the outcrop area. The rhyolite is faulted against basalt along its southwestern side.

At the most extensive workings, a quarter of a mile southwest of the Wallace ranch house in the SE¼ sec. 19, a large, open cut exposes perlite for more than 150 feet along the strike, more than 150 feet down dip, and through a vertical distance of 20 feet. Northeast of the cut, the perlite crops out on the hillside for nearly one fourth of a mile. At the cut it appears to strike N. 30° E. and dips 15° NW. The perlite is dark green to black, with closely spaced, steeply dipping joints perpendicular to the direction of strike. It is remarkably free of nodules, concretions, and masses of opal, chalcedony, and other forms of silica. Individual beds can be recognized only with difficulty. Brecciated material, consisting of angular fragments of black perlite in a tuffaceous matrix, was found as float near the basal part of the section. Overlying the perlite is a bed of impure glass containing small, spherical, vitric concretions.

At the locality near the center of sec. 19, a smaller cut exposes large boulders and lenses of perlite cemented by ash and pumaceous material. Massive perlite containing almost no joints or fractures is also present. The perlite is light gray to green and much more pumaceous-looking than that at the locality just described. The attitude of the perlite could not be determined here.

On a knoll west of the road in the center of the N½ sec. 30, a few hundred feet south of the line between secs. 19 and 30, black perlite similar to that in SE¼ sec. 19 crops out. Above the perlite and covering the top of the knoll is a layer of round spherulites of vitric material, which range from less than half an inch to one and a half inches in diameter. They are identical to the spherulite concretions lying above the black perlite in the SE¼ sec. 19. At this site, however, they make up almost all the rock. Many weather free and resemble marbles, walnuts, or small balls. The surfaces of these balls are smooth or covered with small tubercles. They have a radial structure, and nearly all have been cracked and recemented so that one or two (rarely more) raised ridges run concentrically around the ball. The appearance suggests that, upon cooling, the solidified skin cracked and viscous glass on the interior oozed out to form the raised ridge.

At the deposit in the extreme northwest corner of sec. 30, an open cut exposes black perlite similar to that in the SE¼ sec. 19.

The exposures in the SE¼ sec. 19, N½ sec. 30, and NW¼ sec. 30 are all approximately along strike and are part of the same lens, bed, or series of beds. The spherulite bed above the perlite at the first two of these deposits is confirmatory evidence. The deposit near the center of sec. 19 represents another zone or horizon, apparently higher in the volcanic sequence than the black perlite and spherulite bed.

The perlite at the Wallace Ranch deposits is of exceptional purity and high quality and produces a superior product. It is extensive, consists of thick beds free of foreign material, and is easy to quarry. It is, however, a long way from the railroad, and truck transportation for 15 of the 45 miles is over a rough road. The long truck haul is a great detriment, and the product cannot compete commercially with perlite that is more fortuitously situated with regard to transportation.

Diatomite. Diatomite occurs within a sequence of lacustrine deposits along U.S. Highway 260, 12 to 15 miles northwest of Cliff (fig. 1, pl. 1). At one locality, in the W½ sec. 3, T. 14 S., R. 19 W., seven and a half miles northwest of Buckhorn and 300 feet southwest of the highway, the U.S. Bureau of Mines explored and sampled the deposit. Eleven shallow bulldozed trenches on the hillsides expose diatomite over an area 350 feet by 500 feet and through a minimum thickness of 25 feet. The sampling and testing of the deposit was done in the early 1940's. The results of the testing are not public, never having been published. Informal reports by the U.S. Bureau of Mines engineers indicated that the quality of the diatomite was good. Transportation costs to market, however, would be too excessive for the deposit to be of commercial importance at present.

The diatomite at the locality sampled crops out in horizontal beds on the steep hillsides forming the valley walls. It is overlain on the tops of the ridges by a thin veneer of gravel and boulders. Above and to the west, the hills are rhyolite tuff. The diatomite sequence probably extends below the present surface of the valley floor, which is carved in alluvium. No excavations were made below the valley floor, and the true vertical extent of the diatomite is not known. Nor have the lateral limits of the deposit been determined, although exposures can be seen in the hillsides north of the area trenched.

Within the 25-foot sequence exposed, diatomite is in three distinct beds separated by clay and diatomaceous clay. The lower two beds are 3 to 4 feet thick but the uppermost bed is about 8 feet thick. The whiter color and finer grain of the upper bed suggest that it is purer than the lower beds.

The lacustrine deposits were laid down in a lake which occupied what is now the upper part of Duck Creek Valley. Erosion has produced a miniature badlands type of topography, and the eroded remnants of that part of the sequence above the valley floor are seen as isolated hills and buttes within and along the walls of the valley. The diatomite exposures by the highway are near the valley margins. Weber and Willard include these lacustrine deposits within the Gila Conglomerate.

SACATON MESA AREA

Numerous fluorspar deposits and the Lone Pine Mountain gold-tellurium mine are in the Sacaton Mesa area (known sometimes as the Wilcox district) astride the Grant–Catron county line on the southwest side of the Mogollon Mountains (fig. 1). The deposits lie between Little Dry Creek and Seventy-four Mountain, in or near the canyons of Pine Creek, Sacaton Creek, Rain Creek, and Mogollon Creek. The Mogollon fault, which forms the southwestern boundary of the high-standing Mogollon block of Tertiary volcanic rocks, extends northwestward through the area. The deposits are all within the Tertiary andesitic and latitic rocks and are a maximum of two miles northeast of the fault.

Fluorspar was first mined in the area during World War I and has been intermittently produced since that time. Gold was mined at the Lone Pine Mountain mine in the 1930's and probably in the early part of the twentieth century. Tellurium, although known since before 1904, has been of interest commercially only since 1960.

The major fluorspar deposit, the Rain Creek or Good Hope mine, is described in detail by Rothrock (Rothrock, Johnson, and Hahn, p. 96). Rothrock also describes the Sacaton mine and Blue Rock prospects (p. 47-48) and mentions the Lakeview, Seventy-four Mountain, and Fairview prospects (p. 97-98). These will be only briefly mentioned in this report. The Lone Pine Mountain mine, although it is in Catron rather than Grant County, will be described in more detail because of the recent interest in tellurium, as well as because of the uniqueness of mineralization. It has previously been described only briefly (Ballmer, 1932; Crawford, 1937).

Rain Creek fluorspar. The Rain Creek (Good Hope) fluorspar mine (fig. 30) is two miles west of Seventy-four Mountain, on the east side of Rain Creek Canyon in the SE1/4 sec. 11, T. 13 S., R. 18 W. In 1960, it was controlled by Fayette Rice, Gila. The property is explored by shafts, open cuts, and pits to a depth of about 55 feet, and by a 123-foot-long adit, 160 feet below the collar of the shaft, which has never been extended to reach the vein (Rothrock, Johnson, and Hahn, p. 96). The ore occurs within a breccia along a fault which strikes N. 5° E. and dips 80° W. The country rock is latite porphyry.

Fluorite occurs with calcite and quartz in the breccia, and locally the material is stained by manganese oxides. The breccia zone is 1 to 10 feet wide, and fluorite, calcite, and quartz occur mostly as fracture fillings within the zone. Locally, high-grade veins, as much as 5 feet in width, are present, but mostly the veins are less than 12 inches wide and are contained in a zone 2 to 2 1/2 feet wide. Fluorspar is exposed for about 200 feet along the vein (Rothrock, Johnson, and Hahn).

Although the grade and tonnage of ore at the Rain Creek mine is encouraging, the inaccessibility of the deposit makes it of little present interest.

Other fluorspar deposits. The Sacaton and Blue Rock deposits in Catron County and the Seventy-four, Lakeview, Fairview, and Rainbow deposits in Grant County contain narrow veins of high-grade fluorspar, but either they cannot be traced for any distance or the amount of waste rock between the veins which has to be mined is excessive. These factors, coupled with the inaccessibility of the deposits, make them of no current economic significance. They are described by Rothrock, Johnson, and Hahn (p. 47-48, 97-98), who calculated reserves only for the Sacaton deposit.

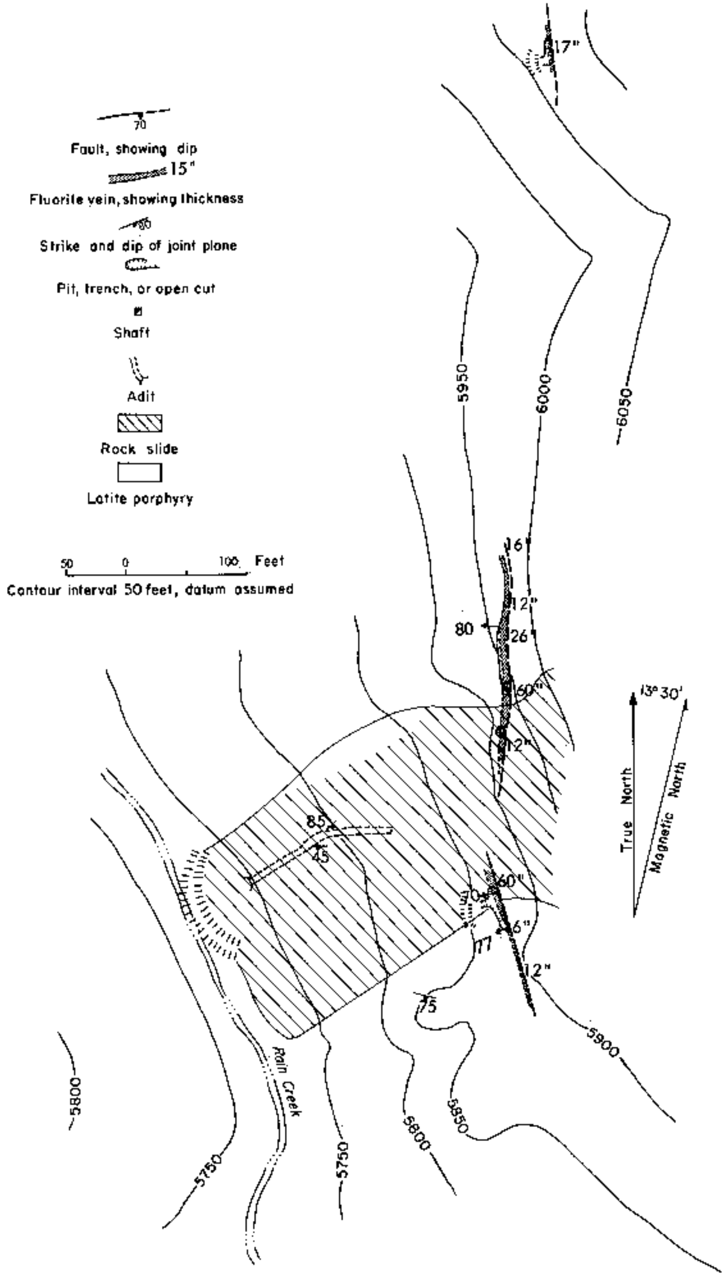


Figure 30

GEOLOGIC MAP OF THE RAIN CREEK (GOOD HOPE) FLUORSPAR DEPOSIT, SACATON MESA AREA

Lone Pine Mountain tellurium mine. The Lone Pine Mountain tellurium mine is about two miles north of the Grant–Catron county line, probably in S½ sec. 20 or N½ sec. 29, T. 12 S., R. 18 W. It is on one of a group of six claims owned by Fayette Rice, Gila, and in 1960 and 1961 was under lease to the Minnesota Mining and Manufacturing Company, St. Paul. The property is locally known as the Schwartz property, from a former owner.

Workings consist of an old adit with drifts from which a winze extends downward 180 feet. A caved shaft extends downward from the surface to the adit level, bottoming a few feet south of the collar of the winze. In 1961, part of the adit level had been made accessible, the winze had been rehabilitated, and short drifts, mostly for underground drilling stations, had been driven from the winze at 40, 80, 140, and 160 feet. In addition, six diamond drill holes, the deepest 250 feet, had been sunk from the surface to explore the vein. Numerous less extensive adits, shafts, and pits are present in the vicinity of the major workings.

The ore is native tellurium and native gold in a gangue of pyrite, quartz, and fluorite. Tellurite and tellurobismite are recorded from dumps and old workings (Crawford; Ballmer). No gold tellurides have been identified. Microscopic studies of the ore indicate that the tellurium is associated with pyrite but apparently not with gold. Fluorite is present in small quantities and, in one area on the adit level, occurs as a discrete vein. Gold occurs with the quartz and possibly with the fluorite. It was present, at least in parts of the deposit, in appreciable quantities.

The ore occurs along a shear zone in latite and andesite, and the individual ore shoots are apparently localized by fracture intersections. A large shear zone, which crops out prominently as a wide silicified zone in Little Dry Creek about half a mile west of the mine, can be traced eastward through the old workings toward the mine. It strikes N. 75°-80° E. and dips steeply. It cannot be recognized on the surface at the mine, but apparently the old shaft and the winze were sunk on the structure. The winze appears to be sunk along an intersection of the shear zone and a cross structure, resulting in a pipelike ore shoot. The major shear can be traced at least a mile eastward from the mine.

In 1961, the Minnesota Mining and Manufacturing Company was actively exploring the property for tellurium.

STEEPLE ROCK DISTRICT

The Steeple Rock district is in extreme western Grant County adjacent to Arizona, in T. 15 and 16 S., R. 21 W., and T. 16 S., R. 20 W. (figs. 1 and 31). It extends generally north and northwest for about ten miles from Steeple Rock, which is a prominent landmark six miles east of the state line. The Carlisle mine in the center of the district is 16 miles by road from Duncan, Arizona. Access to the district is via Duncan.

Mr. Livingstone Utter, Long Beach, California, has many old maps, reports, assay data sheets, and other information pertaining to mining in the Steeple Rock district, which he inherited from George H. Utter who owned and operated many of the mines prior to 1920.

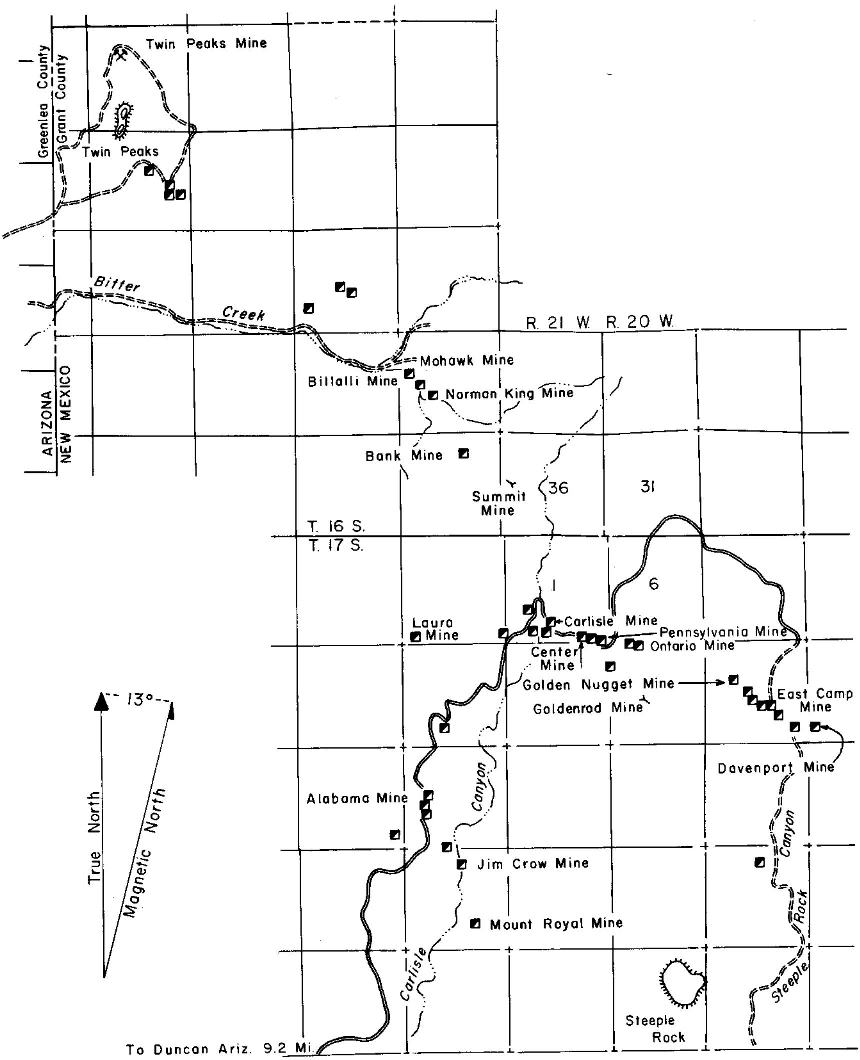


Figure 31

LOCATION OF MINERAL DEPOSITS IN THE STEEPLE ROCK, EAST CAMP, AND BITTER CREEK AREAS

History, Ownership, and Production

Numerous patented and unpatented claims cover the various mines and prospects in the Steeple Rock district; ownership of many of these is now unknown. In 1960, the Carlisle group of four patented and fifteen unpatented claims belonged to the Carlisle Development Company, Mrs. Roy B. Wilson, Phoenix. The East Camp group is owned by Parks Brothers, Mr. Lavar Parks, Riverton, Utah. The Bilali, Bank (unpatented), and Jim Crow–Imperial–Consolidated quartz group belong to Livingstone Utter. The Ontario and Alabama are owned by Billingsley Brothers, Ben Billingsley, Duncan, Arizona. The Norman King is owned by Mrs. Harris Craddock, Lake Charles, Louisiana; the Mohawk by Donald P. Jones, Safford, Arizona; the Carnation by Chris B. Quanto, Santos, Texas; and the Golden Rod by Paul Wrinkler and Ted Faulkner, Safford, Arizona. Ownership of the Summit group was unknown. The locations of many of the mines is shown in Figure 31.

The earliest available record of mining in the district is a military report of the dispatch of troops from Fort Thomas to the district in 1860 to protect the miners from the Apaches. L. Utter (written communication) states that the Carlisle was a producing mine prior to 1880. In 1883, the Carlisle was sold to a group which included Marshall Field, N. K. Fairbanks, and other prominent merchants and capitalists from Chicago. Between 1883 and 1887, the Carlisle group of claims was patented, a 20-stamp mill built, and the Carlisle mine operated to the 300- or 400-foot level. During this period the company was organized as the Carlisle Mining Company (photo 11).

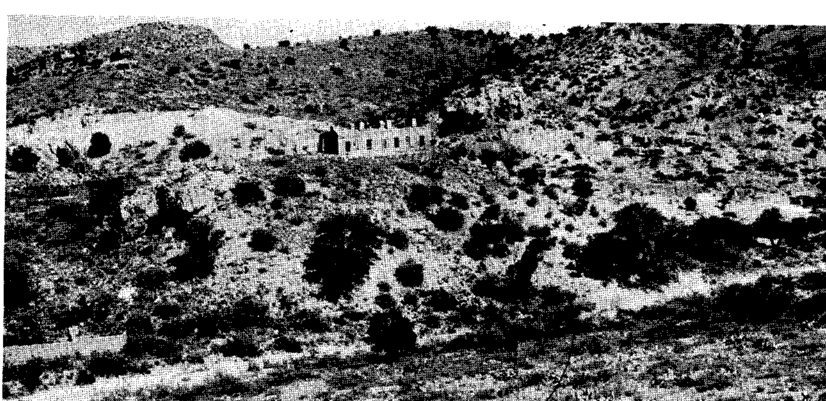


Photo 11

Carlisle mine, Steeple Rock district

Old hotel (center) is the only building standing. Ruins of the old mill are below and to the right of the hotel. Main shaft is near the left margin of dump to right and beyond hotel.

In January 1887, the Carlisle Mining Company was sold, reputedly for $1,000,000, to English interests, the Golden Leaf Mining Company, Limited, and Henry Cameron Richardson. The Rothschild interests in England were involved in the purchase. The affairs of the Carlisle Gold Mining Company were conducted by a series of trustees until 1896 when the Steeple Rock Development Company was organized. At about this time, other companies were interested in the district, including the Laura Consolidated Company, also controlled by English interests.

The Steeple Rock Development Company and its predecessor company spent large sums of money developing the Carlisle and other properties in the district. The Carlisle was developed to 600 feet; the mill was enlarged to a 60-stamp mill; thirty-three claims were purchased, patented, and organized into groups, including the Jim Crow, Imperial, and others; many others were optioned but later dropped; roads were built; ten or twelve mines were systematically developed, and shallow prospecting was conducted at numerous other sites; and a smelter was built at the Carlisle mine. The smelter was supposedly unsuited for the complex Carlisle ores. Although about $4,000,000 worth of ore, principally gold and silver but including small tonnages of copper, lead, and zinc, were shipped from the Carlisle during this period, the great expenses incurred resulted in 1897 in the mine being closed. The smelter was dismantled and moved away, supposedly to be replaced by one more adapted to the Carlisle ores. This was never done, and the mine remained shut down. In 1914, the estate was sold to George H. Utter.

Between 1914 and 1917, Utter operated the Jim Crow mine, sinking the shaft to 300 feet. Some mining was done at the Carlisle and other properties by Utter and by other individuals, but only small lots of ore were mined and shipped. In 1920, operations virtually ceased, and between 1920 and 1932 essentially no ore was mined. In 1927, the United Metals Corporation dewatered, examined, and sampled the Carlisle mine (Russel, 1947). It sank the winze from the 600- to the 700-foot level, drifted on this level, and drilled some diamond-drill holes below it, but mined no ore. In 1930, the mine was again allowed to fill with water. In 1932, activities were resumed in the district. The East Camp Exploration Syndicate (the name was later changed to the Exploration Syndicate, Inc.) began producing ore from the East Camp group of claims in 1934, and gold and silver containing some lead and copper were mined at East Camp until 1942. A 50- to 75-ton cyanide mill was erected in 1940 to treat the ores. Between 1943 and 1946, the Syndicate operated the Carlisle mine under lease from the Carlisle Development Company which owned the property. The complex gold-silver-copper-lead-zinc ore was first treated at the mill of the Southwest Minerals Company in Duncan, but in 1944, the mill at East Camp was converted to flotation to handle the ore. Mining by the Syndicate ceased in 1946.

Between 1936 and 1941, the Veta Mines Inc. and other lessees operated the Carlisle mine, and in 1941 and 1942, it was operated by Southwest Minerals Company. The ore and also old mill tailings were treated at the mill in Duncan.

Between 1942 and 1944, the district was examined by the U.S. Geological Survey and the U.S. Bureau of Mines and the deposits studied in connection with the government's interest in strategic war minerals. In 1946 and 1947, the Empire Zinc Company made a detailed analysis of the district.

Since 1946, only sporadic prospecting and small lease operations have been conducted. The equipment at East Camp was sold and dismantled in the 1950's. In 1960, small exploration operations were in progress at the Ontario mine by the Norart Mining Company of Toronto, Canada, under a lease agreement, but the remainder of the district was abandoned.

Geology

Rocks exposed in the Steeple Rock district consist mostly of dacite and andesite tuffs, flows, and flow breccias, and some rhyolite flows, tuffs, and intrusive masses. These rocks are mapped by Elston (1960a) as belonging to four different units, which he describes as *dacite, rhyolite, andesite,* and *Datil Formation undifferentiated.* The first three he dates as Upper Cretaceous, the Datil as Tertiary. In addition, Late Cretaceous Virden Formation crops out south of the district west of Steeple Rock, and a Tertiary or Cretaceous rhyolite dike or plug constitutes Twin Peaks in the northern part of the district. Griggs and Wagner (1943) distinguish other rhyolite intrusive masses in the vicinity of the Carlisle mine.

The dacite is the oldest unit of the volcanic sequence. It crops out between the East Camp and Steeple Rock faults, comprising almost all the surficial rock within this block; various members of the unit are the host rock for mineralization. It also crops out southeast of the mineralized area west of Steeple Rock. The unit consists of dark green, gray and reddish brown dacite flows, tuffs, and tuff breccias containing phenocrysts of hornblende, biotite, and plagioclase feldspar (andesine). Locally, the rock is coarsely porphyritic and the phenocrysts are large, abundant, and conspicuous. Elsewhere, they are small but constitute almost 50 per cent of the rock. Quartz is locally absent or scarce, and the rocks grade to andesite.

Rhyolite flows and welded tuffs crop out south and east of the mineralized area and east of Steeple Rock. These rocks overlie the dacite. They are gray, fine-grained, with a few small quartz and feldspar phenocrysts.

Andesite constitutes most of the surface rock northeast of the East Camp fault, and also occurs west of the Steeple Rock fault. Flows, tuffs, and flow breccias are included in a sequence which reaches a thickness of 3000 feet. The andesite is purple, brownish purple, gray, or greenish gray. The flows are commonly vesicular, the vesicles being filled or lined with minute crystals of quartz and an unknown mineral. Much of the andesite is porphyritic with abundant chalky-white plagioclase phenocrysts and a few hornblende and biotite phenocrysts. Flow structures are commonly visible. Rhyolite and latite flows and tuffs are interbedded with the andesites. The andesite unit is apparently younger than the rhyolite and dacite described above.

The Datil Formation, which consists mostly of gray rhyolite tuffs and flows, makes up Steeple Rock and crops out to the south. This is the youngest of the volcanic rock units in the area.

The volcanic rocks strike northwest and dip 10° to 30° NE. They are cut by numerous faults, the more prominent ones being the northwest-trending East Camp and Steeple Rock faults, which parallel the strike of the rocks and delimit an upthrown block occupied by dacite and rhyolite. The Steeple Rock fault dips 60° SW, but the East Camp fault dips more steeply, in places southwestward and elsewhere northeastward. Shorter and less continuous faults parallel these major faults; others trend more northwesterly or nearly due west.

Mineral Deposits

Veins fill numerous faults and fissures in a northwesterly trending zone eight to ten miles long. Most deposits lie between the East Camp and Steeple Rock faults. The Carlisle mine is about in the center of the zone. Brecciated and crushed wall rock cemented by quartz and ore minerals fill the fissures. Open-space filling is the dominant method of emplacement of minerals, but replacement of wall rock is reported at the Carlisle mine. At many of the deposits, fissures branch from the main veins into the hanging or footwall and are filled with vein material.

Ore minerals identified in the district include gold, silver, galena, sphalerite, chalcopyrite, argentite, tetrahedrite, and cerargyrite. Pyrite is common, and quartz, some of it amethystine, is the dominant gangue mineral; calcite, barite, and fluorite also are present. Oxidized minerals at East Camp, in addition to cerargyrite, include limonite, copper carbonates, and a greenish mineral identified as vanadinite or pyromorphite. At the Carlisle, manganese oxide and films of chalcocite on chalcopyrite occur. Quartz occurs as crustiform masses of amythestine or milky quartz crystals around breccia fragments or lining cavities or vugs; as medium-grained milky quartz which fills spaces between the breccia fragments; and as dull horny quartz which is presumed to be due to replacement of wall rock. Alteration of the wall rock adjacent to the veins has produced sericite, epidote, chlorite, and kaolinite.

The veins are marked by prominent siliceous outcrops, and at several places on the surface, brecciated and silicified vein fillings widen, forming conspicuous dikelike masses known locally as "blowouts." Many of these overlie ore bodies. At the Carlisle, and apparently at East Camp, ore shoots are localized by changes in strike and dip of veins, and possibly by changes in wall rock.

Two or three stages of mineralization have been identified (Griggs and Wagner; C. W. Botsford, written communication, 1918; J. E. Clayton, written communication, 1889) at the Carlisle and East Camp mines. Early quartz, essentially barren, cements fragments of brecciated wall rock. This in turn is brecciated and the fragments are coated with radiating masses of milky and amethystine quartz which also lines vugs and cavities and replaced some of the wall rock. Pyrite, galena, sphalerite, and chalcopyrite are associated with this quartz and belong to the second stage of mineralization. The gold and silver, and probably the fluorite, were deposited during a third stage of mineralization along with the quartz veinlets which cut the sulphides. Elston (1960b) believes that the base-metal mineralization, at least, is Cretaceous. The writer thinks that the precious metal mineralization is middle to late Tertiary and probably correlative with gold-silver and fluorite mineralization elsewhere in western Grant County during the Tertiary.

The mineral deposits are primary hypogene concentrations. Little oxidation of the ore has occurred at the Carlisle mine, but at East Camp, oxidized minerals are common in the upper workings and have been identified as deep as 600 feet. There is no evidence of supergene enrichment.

At the Carlisle, the base-metal tenor of the ore increases with depth, but the tenor of the precious metals was too low below 400 feet to be considered ore. At East Camp, the character of the ore and the vein changed at 600 feet. Graton (Lindgren, Graton, and Gordon) reports that to the northwest of the Carlisle mine, the deposits contain more copper.

Carlisle mine. The Carlisle mine is the principal mine of the district and has accounted for most of the production of both precious and base metals. The mine was inaccessible in 1960 and was last operated in 1948, although about eight carloads of ore were shipped in 1959 and 1960 from the open pit north of the shaft. Workings go to a depth of 700 feet. A vertical, 518-foot-deep shaft is sunk on the hanging wall side of the vein, passing through the vein and into the footwall at about 200 feet. Levels are at 160, 300, 400, and 500 feet. A winze was sunk from the 500-foot level to a depth of more than 200 feet, with drifts and crosscuts on the 600- and 700-foot levels. Drifts extend a maximum of 1400 feet northwest and 500 feet southeast of the shaft on the 500-foot level (fig. 32).

In the vicinity of the shaft, the Carlisle fault strikes N. 45° W. and dips 65° to 70° SW. One hundred feet southeast of the shaft, the fault turns due east, and 800 feet northwest of the shaft, it turns due west. The Carlisle ore body is within the segment which trends northwest. The country rock is andesite and dacite porphyry, but Griggs and Wagner mapped intrusive rhyolite on the southwest side of the fault, west of the shaft.

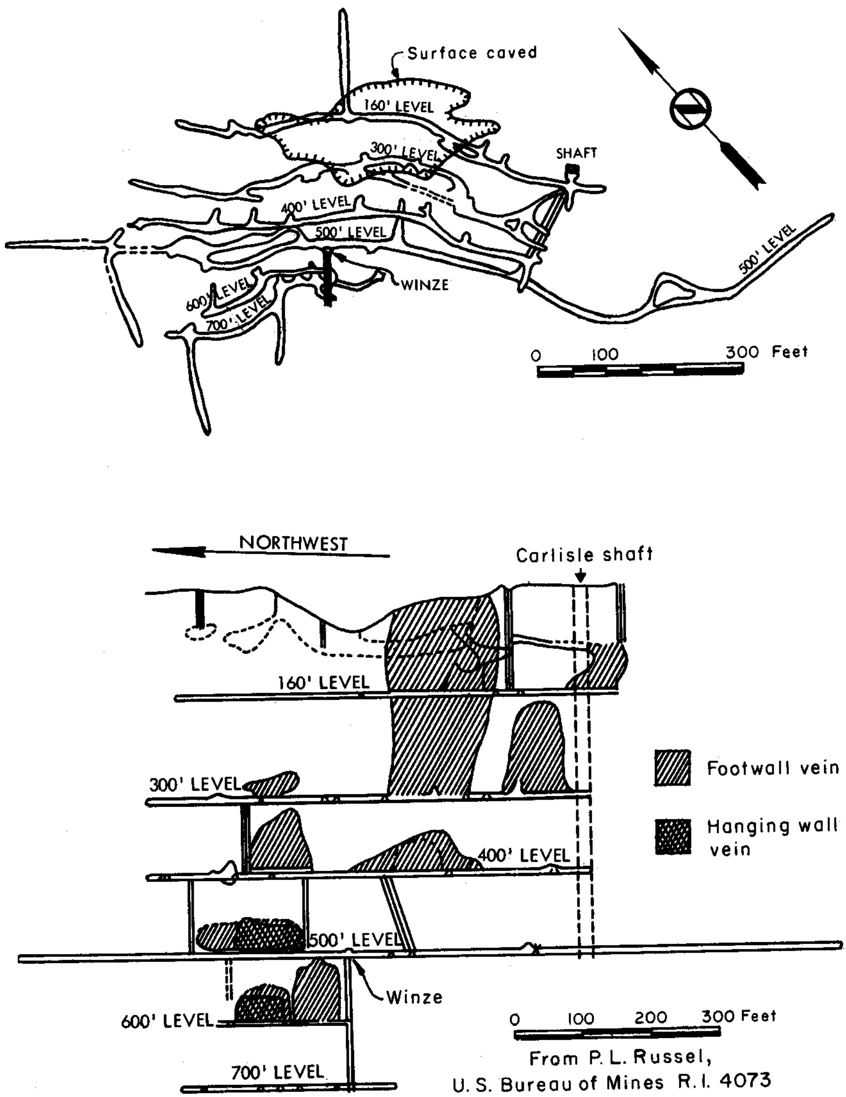


Figure 32

PLAN AND VERTICAL SECTION, CARLISLE MINE, STEEPLE ROCK DISTRICT

A breccia zone 5 to 8 feet wide occupies the fault, the widest part at the surface being just northwest of the shaft. The breccia fragments consist of wall rock and of barren quartz belonging to the early period of mineralization. Shear planes, parallel to the walls of the fault, are in both hanging and footwalls, and numerous fissures branch from the main fault into the footwall. According to Clayton (written communication), a well-defined fissure splits the breccia zone in the northwest-trending segment of the fault, but lies on the hanging wall west of where the fault turns westward and is on the footwall east of where the fault turns eastward. Only where this fissure is on the hanging or footwall of the zone is there a well-defined clay gouge zone between breccia and wall rock.

Both precious and base metals occur in pods, bunches, and as irregular masses in the interstices between the breccia fragments and as thin crusts with quartz in concentric layers around angular breccia fragments. The higher-grade segments of the vein are where brecciation has been most intense.

On the 160-foot level, two sulphide-bearing ore shoots, 7 to 8 feet wide and 200 and 50 feet long, respectively, lie on or near the footwall. A shoot, mined in the early days for gold, paralleled these base-metal shoots on the hanging wall. The best gold and silver ore lay above the 300-foot level within 400 feet northwest of the shaft. The gold was free-milling. Lower-grade ore lay southeast of the shaft on the upper levels, beyond 400 feet northwest of the shaft and below 300 feet. Beyond 500 feet northwest of the shaft, the vein was essentially barren of precious metals, and this condition also exists below the 500-foot level. Base metals, particularly zinc and copper, are present in increasing amounts in the lower levels. The ore body pitches steeply northwest (fig. 32).

Griggs and Wagner report that approximately 100,000 tons of ore containing 1 per cent copper, 45 per cent lead, 5.7 per cent zinc, and a little gold were blocked out below water level (200 feet) and that geologic evidence indicates that it may be possible to develop 175,000 tons of ore. This does not take into consideration any extension of the deposit below the present workings.

Center and Pennsylvania mines. The Center and Pennsylvania shafts are along the Carlisle fault, 1550 and 2150 feet, respectively, east of the Carlisle shaft. The fault strikes N. 75° W. at the shafts but turns west toward the Carlisle shaft 400 feet northwest of the Center shaft, bending sharply to S. 45° E. at the Pennsylvania shaft. It dips about 65° SW.

Workings at the Center mine are 300 feet deep; those at the Pennsylvania, 150 feet deep. The shafts are connected by a drift on the 150-foot level, which was accessible in 1943.

At both mines, the character of the vein and of the ore is similar to the Carlisle, except that the ore is finer grained. Ore shoots were lenslike, 1 to 8 feet wide. At the Pennsylvania, ore is concentrated at bends in the fault zone. Silicification is less intense than at the Carlisle, and ore minerals are less abundant; the intensity of mineralization decreases eastward along the vein. Sericite, chlorite, and epidote were deposited beyond the zone of silicification.

Production at the Pennsylvania is estimated at 1500 to 2000 tons of gold-silver ore. No figures are available for the Center. Total base metals are calculated at 2 to 3 per cent at the Pennsylvania and 4 to 5 per cent at the Center, but tonnages are believed to be small.

Ontario. The Ontario claim adjoins the Pennsylvania on the east and is one of a group of nine claims leased in 1960 from Ben Billingsley, Duncan, Arizona, by Norart Minerals, Limited. In the early 1940's, Billingsley sank an inclined shaft 160 feet deep, with levels at 40, 100, and 140 feet. The 40-foot level is open to the surface via an adit. Maximum drifting is on the 100-foot level, the drifts going 200 feet east and 75 feet west of the shaft (Billingsley, oral communication).

The mine is along the eastward extension of the Carlisle fault. At the shaft, the vein strikes due east and dips 70° S. In the face of the adit level, the vein is 1 foot wide, but Billingsley reports a width of 4 to 6 feet in the west drift of the 100-foot level, and ore carrying gold and silver values of $188 a ton. In the bottom of the shaft, 4 per cent of combined lead and zinc are reported.

East Camp. The East Camp group of claims includes the Gold Bug, Davenport, MacDonald, Great Eastern, Nugget, Sunset, Gold Note, and Gold Pick (fig. 33). They stretch for about 9600 feet along the East Camp fault, about two and a half miles east of the Carlisle. The principal workings are on the MacDonald claim, and the MacDonald mine is sometimes spoken of as the East Camp mine. Other extensive workings are on the Nugget, Davenport, and Gold Bug claims. Elsewhere, only shallow shafts and pits explore the vein. The workings of the MacDonald, Nugget, Davenport, and Gold Bug develop what are apparently separate ore bodies. Ore was thus mined over a distance of about 4500 feet from the Nugget to the Gold Bug.

On the MacDonald claim, an old adit, the MacDonald tunnel, extends 460 feet northwest along the vein, and an old shaft goes vertically downward at the portal of the tunnel (fig. 34). Levels are at 100, 200, and 300 feet. All drifting is to the northwest. In 1939 and 1940, a new shaft, the MacDonald No. 2, was sunk almost on the site of the old MacDonald No. 7 shaft, 700 feet northwest and 150 feet above the portal of the tunnel. This shaft intersected the 100-, 200-, and 300-foot levels at 250, 350, and 450 feet, respectively, and was sunk to a total depth of 635 feet. A new level, the 600, was driven from near the bottom. Maximum drifting is on the 200- and 300-foot levels, which extend 1700 and more than 1800 feet, respectively, along the vein.

The Davenport shaft is 1100 feet southeast of the portal of the Mac-

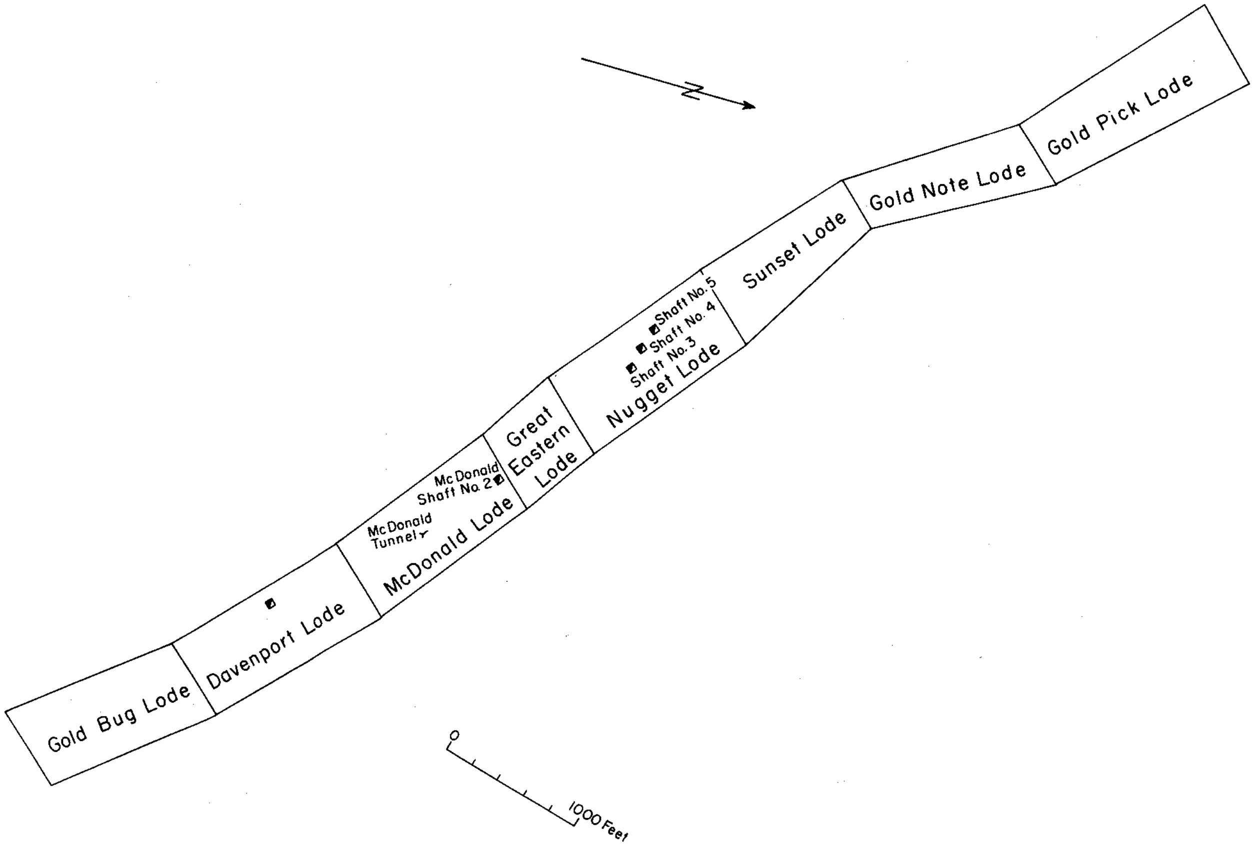


Figure 33
CLAIM MAP, EAST CAMP, STEEPLE ROCK DISTRICT

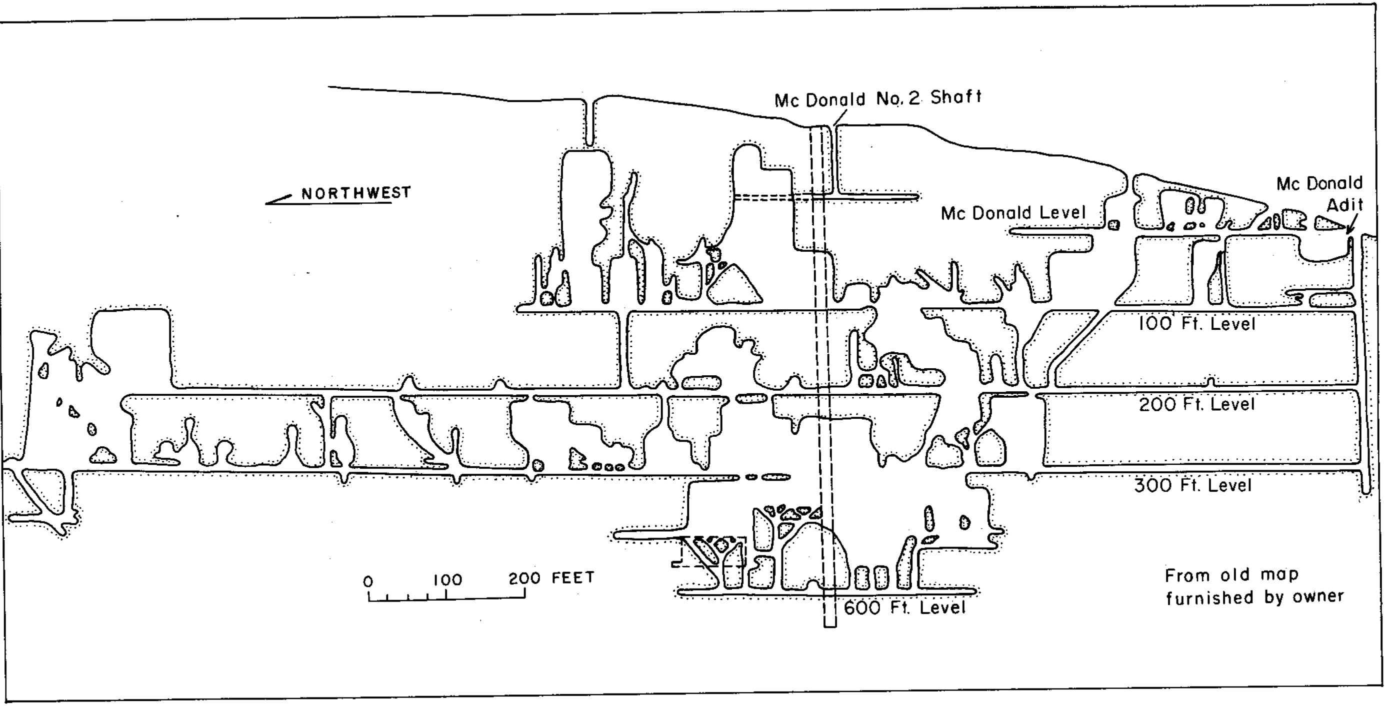


Figure 34

LONGITUDINAL SECTION THROUGH McDONALD (EAST CAMP) MINE, EAST CAMP, STEEPLE ROCK DISTRICT

Donald tunnel. It is 320 feet deep, inclined 85° SW, and has levels at 55, 200, and 300 feet. On the lower levels, the drifts go 375 feet southeast and at least 60 feet northwest of the shaft.

On the Gold Bug claim, which adjoins the Davenport to the southeast, two shafts 150 and 175 feet deep are joined by a 75-foot-long drift going from the bottom of one shaft to the 75-foot level of the other shaft and continuing southeastward 150 feet.

On the Nugget claim, three shafts, 1150 to 1450 feet northwest of the MacDonald No. 2 shaft, are 200, 116, and 150 feet deep, respectively, from southeast to northwest. About 800 feet of drifts develop the ore body.

The East Camp fault strikes N. 70° W. and dips steeply southwest, but locally the direction of dip is to the northeast. The vein along the fault is 1 to 10 feet wide but averages 5 feet in the stopes. It consists largely of brecciated wall rock with quartz, calcite, minor fluorite and limonite, and ore minerals. It is crustified, banded, and vuggy. The wall rock is andesite on both sides of the fault. Within the mine, andesite porphyry is on one side and andesite tuff on the other. The brecciation and the discrepancy of rock types on the two sides of the fault are evidence of movement, but the amount of displacement is unknown. Post-mineral faulting consists of a major strike fault within the vein, a zone of cross faulting northwest of the MacDonald tunnel portal, and many minor faults at acute angles to the strike of the vein.

Gold occurs as finely disseminated particles intimately associated with quartz. It is free milling, at least on the upper levels. Argentite is the primary silver mineral and is on the 200-foot level. The precious metals occur in pods and streaks, which are more widely scattered on the 600-foot level than in the upper levels. Oxidation of the ores in the upper part of the mine was prevalent, and the vein is oxidized locally, as deep as the 600-foot level. Cerargyrite, native silver, and copper carbonates are the oxidized minerals identified, and a greenish mineral associated with the precious metals is reported as pyromorphite or vanadite. Both cerargyrite and, to a lesser degree, native silver were important ore minerals. With depth, the amount of base metals and calcite increases.

Thanksgiving. This deposit lay just to the southeast of the Gold Bug claim, along the East Camp fault. It is the farthest southeast that the vein can be followed on the surface. High-grade native silver, argentite, and a little cerargyrite are reported to have been produced from shallow workings.

Bluebird. The old Bluebird shaft is about 4000 feet northeast of the MacDonald shaft, on a vein trending N. 60° W. and subparallel to the East Camp vein. The shaft is vertical for 60 feet and then dips northeast 65 to 70 degrees. A well, marked by a windmill a short distance northeast of the old shaft, intersects the old shaft at 120 feet. The shaft is 300 feet deep. A rhyolite dike cuts andesite at the Bluebird, and the shaft is sunk along the andesite-rhyolite contact on the northeast side of the dike.

Azurite is present on the dump, but according to Croom (personal communication), ore was present only near the surface.

Carnation. The Carnation, in the NE¼ sec. 6, T. 17 S., R. 20 W., is on a vein striking N. 55° W. No dip could be measured. An old shaft, old pits, a newer open cut, and a 30-foot-deep diamond drill hole put down in 1959 or 1960 explore the property. The mine is along or near the East Camp fault, between East Camp and the Summit group.

Summit group. The Summit group of ten claims are about one and a half miles north of the Carlisle mine. The Summit and Apex tunnels and associated workings are along the East Camp fault about three and a half miles northwest of the MacDonald shaft. Drifting at the Summit extends northwest along the vein from the adit for about 500 feet. At the Apex, drifts go about 150 feet both southeast and northwest of the adit.

At the Summit, the vein strikes N. 40° W. and dips 75° NE; at the Apex, the dip is 80 degrees. The vein is a wide, silicified breccia zone that crops out prominently on the surface above the workings and underground is 30 feet wide. No information as to mineralogy or possible production is available, but information from old sampling records indicates that the gold and silver values were low.

The Bank, Hoover tunnel, and Bilali mines. The Bank mine is the largest in the Bitter Creek area, except for the Norman King. It is northwest of the Summit mine, about halfway between it and the Norman King, and is a few hundred feet southwest of the East Camp fault on a parallel vein.

The Hoover tunnel, named after former president Herbert Hoover who worked in the Steeple Rock district as a young mining engineer in the late 1890's, is about 1500 feet southeast of the Norman King. The tunnel extends from the canyon of Bitter Creek southwest for 500 to 600 feet to the vein. The portal is on the Bilali claim.

The Bilali mine is near the portal of the tunnel. (It is incorrectly shown on the Steeple Rock quandrangle map as being north of the Norman King.) It is a small mine, with no extensive workings. Little information is available pertaining to it.

Norman King. The Norman King is on Bitter Creek in the center of sec. 26, T. 16 S., R. 21 W., about two and a half miles northwest of the Carlisle mine. The vertical shaft is 500 feet deep and most of the drifting is to the southeast. The 85-foot level extends at least 400 feet in this direction.

The mine is along the East Camp fault. The shaft is sunk on the southwest side of a wide, silicified and brecciated zone that trends N. 35°-40° W. and can be traced northwest to the Mohawk mine. The vein is essentially vertical. Numerous subparallel brecciated and silicified zones cut the country rock for a distance of 500 feet northeast of the main fault. A few are present to the southwest.

The Norman King is the largest mine in the Bitter Creek area. It was last worked by Louis Jacobson in 1940. Between 1936 and 1940, an incomplete record of shipments by Jacobson shows 3,278,565 tons of ore shipped with a total value of $45,703. The gold averaged 0.1773 ounce and silver 10.690 ounces a ton. The ore averaged $13.94 a ton. In 1919 to 1921, 342,927 tons of ore, averaging 0.629 ounce of gold and 43.23 ounces of silver and valued at $17,908.76, were shipped.

Mohawk. The Mohawk is a fluorspar mine along the East Camp fault about 2000 feet northwest of the Norman King, in the NW¼ sec. 26. It is incorrectly labeled as the Bilali mine on the Steeple Rock quadrangle topographic map. The Mohawk was last operated in 1945. About 3000 tons of milling grade fluorspar were shipped from the mine, most of which averaged 65 to 70 per cent fluorite.

Four shafts have been sunk along the vein. A caved stope, 150 feet long and 7 feet wide with an 80-foot-deep shaft in the center of it, was the original workings. From the 75-foot level, a drift extended north about 50 feet and south 250 feet. A new shaft, 200 feet south of the old shaft, was sunk to connect with this drift. Both these shafts are on the west side of the vein. Another shaft, 50 feet southeast of the new main shaft, is on the east side of the vein. The fourth shaft is northwest of the caved workings.

The vein strikes N. 15° W. and dips 85° to 90° E, with local reversals of dip direction. About 75 feet north of the caved shaft, it turns N. 60° W. toward the fourth shaft. The vein consists of a breccia and silicified zone, which widens to 15 feet near the new main shaft; it can be traced south to the Norman King mine. Fluorspar occurs in shoots and pods along the silicified zone, mostly on the east side. Ore widths of more than 7 feet occurred in the stopes, but in most places, the width of the ore was less. The fluorspar consists of pale green, fine-grained fluorite associated with fine-grained white quartz. Fine-grained pyrite occurs along the fault. Fluorite also occurs along the vein at the Norman King and near the Hoover tunnel.

Black Willow. The Black Willow mine is north of Bitter Creek, about 4500 feet northwest of the Mohawk mine along the East Camp fault. At the mine, the vein strikes N. 60° W. and is vertical; it consists of a wide, silicified breccia zone containing mostly silver but with some gold and pyrite. A few hundred feet southeast of the shaft, fluorspar crops out along the vein. The shaft is 50 to 60 feet deep. The mine was operated in the 1920's.

Fraser Brothers mine. Three or four deep shafts sunk along the East Camp fault south of Twin Peaks comprise the Fraser Brothers mine. The northernmost shaft was last worked in 1958 by Ben Billingsley, who did the work for the Southwestern Mining Industry, Tucson. The shaft is 600 to 700 feet deep. The recent work was in the upper levels of the mine, above the water table. Values at the mine were reportedly mostly in silver, but some gold was present.

These workings are about two and a half miles northwest of the Black Willow mine and are the farthest northwest along the East Camp fault.

Twin Peaks. The Twin Peaks mine in the N½ sec. 8 is the northernmost mine in the Steeple Rock district. It lies about one mile northeast of the East Camp fault. The shaft, reportedly 500 to 600 feet deep, is sunk along a breccia zone in andesite, about 500 feet north of the surface outcrop of the rhyolite dike which makes up Twin Peaks and along the strike of the dike. The vein, however, strikes N. 35° W. and is vertical. The breccia zone is not more than 5 feet wide at the surface. Gold and some silver are reported to have been mined. The mine was formerly owned by the Fraser Brothers.

Alabama. The Alabama mine, in the W½ sec. 14, T. 17 S., R. 21 W., is two miles southwest of the Carlisle mine along the main road leading from Duncan to the Carlisle. A 300-foot-deep shaft inclined 80° W is sunk along the east or footwall side of a large silicified zone that marks a fault. The vein strikes north. No information is available as to extent of workings, production, and grade or character of ore. The vein is west of and subparallel to the Steeple Rock fault.

Jim Crow–Imperial. The Jim Crow–Imperial group consists of eight patented claims owned by Livingstone Utter and others in the south part of the district about three miles southwest of the Carlisle mine. The claims are the Jim Crow, Imperial, Gold King, Tunnel, Gold Bug, Red Prince, Three Brothers, and Contention. Major workings were the Imperial and Jim Crow shafts, sunk to depths of 300 and 307 feet, respectively. Four other shafts on the property were sunk to 100 feet, and a 178-foot-long adit explored the vein on the Imperial claim. The mines were last worked in 1917 and in 1960 were inaccessible.

The Imperial mine is along a breccia and silicified zone which strikes N. 15°-20° W. and dips 60° SW. This is the Steeple Rock fault. The country rock is andesite, but rocks of the Datil Formation are east of the fault. The quartz which cements the andesite breccia fragments is itself brecciated and recemented, as at the Carlisle and East Camp mines, indicating at least two periods of movement, brecciation, and mineralization along the fault. The silicified zone is 80 feet wide on the surface; widths of 20 feet have been measured underground. The shaft is sunk about in the center of the zone. Precious-metal mineralization is confined to widths of 5 to 25 feet.

The Imperial shaft is 300 feet deep and inclined 50 degrees. It has levels at 100, 150, and 300 feet. The 300-foot level is reported to extend 300 feet south. An average of 0.08 ounce of gold and 8.00 ounces of silver a ton is believed by Utter to be a reasonable estimate of the grade of ore.

The vein crops out for more than 300 feet both north and south of the shaft, showing ore at numerous places. The Imperial tunnel, 350 feet north of the shaft, crosscuts 22 feet of vein material.

The vein at the Jim Crow shaft strikes N. 45°-60° W. and dips 70° to 75° S. It branches from the Imperial vein about 400 feet southeast of the shaft. Ore crops out along it at shallower shafts near its junction with the Imperial vein.

The Jim Crow main, or No. 3, shaft is 307 feet deep, inclined 75 degrees, and has levels at 44, 200, and 300 feet. Drifts at the 200-foot level were driven 396 feet southeast and 136 feet northwest of the shaft, and on the 300-foot level, 300 feet southeast. Ore widths of 8 to 10 feet were found in the northwest drift on the 200-foot level, but elsewhere in stopes and drifts of the mine, widths were 3 to 4 feet. The ore and the vein at the Jim Crow are similar to that at the Imperial.

Ore shipped from the Jim Crow, Imperial, and Gold King mines prior to 1914 is estimated by Livingstone Utter to total approximately 1000 tons valued at $50,000 to $75,000. From 1914 to 1936, production was 366,791 tons valued at $22,587. These values are based on the price of gold at $35 an ounce and silver at 77 cents an ounce. The ratio of gold to silver in 286 tons of ore shipped from the Jim Crow between 1914 and 1936 was 1:58 by weight and $1.00:$1.27 by value. Most of the production was from the Jim Crow.

Mount Royal. The Mount Royal mine is south of the Imperial and Jim Crow, along the Steeple Rock fault or a subparallel shear east of the main fault. The shaft, now inaccessible, is inclined 85° W and is reported to be 350 feet deep. The deposit was last worked in 1939; the ore extracted then averaged $8 to $12 a ton.

Laura. The Laura mine, northwest of the Alabama and Jim Crow, is in the SW¼ sec. 2, T. 17 S., R. 21 W. at the head of Laura Canyon on the east side of Vanderbilt Peak (Laura Mountain). In 1914, the shaft was 300 feet deep with levels at 200 and 250 feet. The ore was 18 inches wide at the bottom of the shaft. Billingsley (oral communication) reported that the mine was 700 feet deep, the shaft inclined 80° to 85° W, and it was last worked in 1940 or 1942. The mine is along the Steeple Rock fault.

New Year's Gift. The New Year's Gift mine is on the west side of Vanderbilt Peak. The shaft is reported to be 250 feet deep. It is probably along an extension of the Jim Crow vein.

References

Anderson, E. C. (1957) *The metal resources of New Mexico and their economic features through 1954*, N. Mex. Inst. Min. and Tech., State Bur. Mines and Mineral Res., Bull. 39.

Ballmann, D. L. (1960) *Geology of the Knight Peak area, Grant County, New Mexico*, N. Mex. Inst. Min. and Tech., State Bur. Mines and Mineral Res., Bull. 70.

Ballmer, G. J. (1932) *Native tellurium from northwest of Silver City, New Mexico*, Am. Mineralogist, v. 17, n. 10, p. 491-492.

Boyd, F. S., Jr., and Wolfe, H. D. (1953) *Recent investigations of radioactive occurrences in Sierra, Dona Ana, and Hidalgo counties, New Mexico, in* N. Mex. Geol. Soc., Guidebook, Fourth field conference, Southwestern New Mexico, p. 141-142.

Bush, F. V. (1914) *Phelps Dodge in the Burro Mountains*, Eng. Min. Jour., v. 98, p. 375-377.

——— (1915) *Burro Mountain porphyry copper developments*, Min. and Sci. Press, v. 110, p. 222-224.

Callaghan, Eugene (1953) *Volcanic rocks of southwestern New Mexico, in* N. Mex. Geol. Soc., Guidebook, Fourth field conference, Southwestern New Mexico, p. 143-144.

Corle, Edwin (1951) *The Gila river of the Southwest*, New York: Rinehart and Company.

Crawford, W. P. (1937) *Tellurium minerals in New Mexico*, Am. Mineralogist, v. 22, p. 1065.

Dale, V. B., and McKinney, W. H. (1959) *Tungsten deposits of New Mexico*, U.S. Bur. Mines, Rpt. Inv. 5517.

Edwards, G. H. (1961) *Geology of the central Little Burro Mountains, Grant County, New Mexico*, unpub. M.S. thesis, Univ. Kansas.

Elston, W. E. (1956) *Reconnaissance geology of the Virden quadrangle, Grant and Hidalgo counties, New Mexico* (abs.), Geol. Soc. Am., program 1956 annual meeting, p. 45.

——— (1960a) *Reconnaissance geologic map of the Virden thirty-minute quadrangle*, N. Mex. Inst. Min. and Tech., State Bur. Mines and Mineral Res., Geol. Map 15.

——— (1960b) *Upper Cretaceous vulcanism and mineralization in Steeple Rock mining district, Grant County, N. Mex.* (abs.), N. Mex. Geol. Soc., Fourteenth annual meeting program, April 1960.

Ferguson, H. G. (1927) *Geology and ore deposits of the Mogollon mining district, New Mexico*, U.S. Geol. Surv., Bull. 787.

Gilbert, G. K. (1875) *Report on the geology of portions of New Mexico and Arizona*, U.S. Geol. Surv. west of the 100th meridian (Wheeler), v. 3, p. 503-566.

Gillerman, Elliott (1952) *Fluorspar deposits of the Burro Mountains and vicinity, New Mexico*, U.S. Geol. Surv., Bull. 973-F.

——— (1953) *Fluorite deposits of Burro Mountains and vicinity, in* N. Mex. Geol. Soc., Guidebook, Fourth Field Conference, Southwestern New Mexico, p. 137-138.

———, and Whitebread, D. H. (1956) *Uranium-bearing nickel-cobalt-native silver deposits, Black Hawk district, Grant County, New Mexico*, U.S. Geol. Surv., Bull. 1009-K.

Granger, H. C., and Bauer, H. L., Jr. (1950) *Results of diamond drilling Merry Widow claim, White Signal, Grant County, New Mexico,* U.S. Atomic Energy Commission, TEM 146-A, Tech. Inf. Serv.

———, and ——— (1952) *Uranium occurrences on the Merry Widow claim, White Signal district, Grant County, New Mexico,* U.S. Geol. Surv., Circ. 189.

Griggs, R. E., and Wagner, H. C. (1943) *Carlisle area of the Steeple Rock mining area, New Mexico,* U.S. Geol. Surv., press release.

Heindl, L. A. (1952) *Gila conglomerate,* Arizona Geol. Soc. Guidebook, p. 113-116.

——— (1954) *Cenozoic alluvial deposits in the upper Gila River drainage basin, Arizona and New Mexico* (abs.), Geol. Soc. Am. Bull., v. 65, p. 1262.

Hewett, D. F., and Fleischer, M. (1960) *Deposits of the manganese oxides,* Econ. Geol., v. 55, p. 1-55.

Hewitt, C. H. (1959) *Geology and mineral deposits of the northern Big Burro Mountains–Redrock area, Grant County, New Mexico,* N. Mex. Inst. Min. and Tech., State Bur. Mines and Mineral Res., Bull. 60.

Johnston, G. D., Jr. (1928) *Fluorspar in New Mexico,* N. Mex. Inst. Min. and Tech., State Bur. Mines and Mineral Res., Bull. 4.

Jones, F. A. (1904) *New Mexico mines and minerals,* Santa Fe.

Kelley, V. C. (1949) *Geology and economics of New Mexico iron ore deposits,* Univ. N. Mex., geol. ser., n. 2.

Knechtel, M. M. (1936) *Geologic relations of the Gila conglomerate in southeastern Arizona,* Am. Jour. Sci., 5th ser., v. 31, p. 81-92.

Lang, S. S. (1906) *The Burro Mountains copper district,* Eng. Min. Jour., v. 82, p. 395-396.

Lasky, S. G. (1947) *Geology and ore deposits of the Little Hatchet Mountains, Hidalgo and Grant counties, New Mexico,* U.S. Geol. Surv., Prof. Paper 208.

———, and Wootton, T. P. (1933) *The metal resources of New Mexico and their economic features,* N. Mex. Inst. Min. and Tech., State Bur. Mines and Mineral Res., Bull. 7.

Leach, A. A. (1916) *Black Hawk silver-cobalt ores,* Eng. Jour., v. 102, p. 456.

——— (1927) *The mining of radium ores in New Mexico,* Arizona Min. Jour., v. 10, p. 3-4.

——— (1928) *The geology and history of the Malone mines,* Arizona Min. Jour., v. 12, p. 5-6, 34.

Leach, F. I. (1920) *Radium ore discovered in New Mexico,* Eng. Min. Jour., v. 109, p. 989.

Lindgren, Waldemar, Graton, L. C., and Gordon, C. H. (1910) *The ore deposits of New Mexico,* U.S. Geol. Surv., Prof. Paper 68.

Lovering, T. G. (1956) *Radioactive deposits in New Mexico,* U.S. Geol. Surv., Bull. 1009-L, p. 327-355.

Paige, Sidney (1911) *Metalliferous ore deposits near the Burro Mountains, Grant County, New Mexico,* U.S. Geol. Surv., Bull. 470-C, p. 131-150.

——— (1912) *The origin of turquoise in the Burro Mountains, New Mexico,* Econ. Geol., v. 7, p. 382-392.

——— (1916) *Silver City folio, New Mexico,* U.S. Geol. Surv., Geol. Atlas, Folio 199.

——— (1922) *Copper deposits of the Tyrone district, New Mexico,* U.S. Geol. Surv., Prof. Paper 122.

——— (1935) *Santa Rita and Tyrone, New Mexico, copper resources of the world,* Sixteenth Internat. Geol. Cong., Washington, D.C., p. 327-335.

Pradhan, B. W., and Singh, Y. L. (1960) *Virden formation and flora, Hidalgo County, New Mexico* (abs.), N. Mex. Geol. Soc., Fourteenth annual meeting program, p. 11.

Raup, R. B. (1953) *Reconnaissance for uranium in the United States, southwest district, in* Geologic investigations of radioactive deposits, semi-annual progress report June 1 to November 30, 1953, U.S. Geol. Surv., TEI-390, p. 209-212.

Reid, G. D. (1902) *The Burro Mountain copper district, New Mexico,* Eng. Min. Jour., v. 74, p. 778-779.

Rothrock, H. E., Johnson, C. H., and Hahn, A. D. (1946) *Fluorspar resources of New Mexico,* N. Mex. Inst. Min. and Tech., State Bur. Mines and Mineral Res., Bull. 21.

Russel, P. L. (1947) *Steeple Rock zinc-lead district, Grant County, New Mexico,* U.S. Bur. Mines, Rpt. Inv. 4073.

Somers, R. E. (1916) *Geology of the Burro Mountains copper district, New Mexico,* Am. Inst. Min. Eng. Trans., v. 52, p. 604-656.

Stauber, I. S. (1910) *Burro Mountain mining district,* Mines and Minerals, v. 30, p. 380-382.

Sterrett, D. B. (1908) *Turquoise [in] New Mexico,* U.S. Geol. Surv., Mineral Res. 1907, pt. 2, p. 828-832.

——— (1909) *Turquoise [in] New Mexico,* U.S. Geol. Surv., Mineral Res. 1908, pt. 2, p. 846.

——— (1911) *Turquoise in New Mexico,* U.S. Geol. Surv., Mineral Res. 1909, pt. 2, p. 788-795.

——— (1912) *Turquoise in New Mexico,* U.S. Geol. Surv., Mineral Res. 1911, pt. 2, p. 1066-1971.

Wade, W. R. (1907) *Burro Mountain copper district, New Mexico,* Eng. Min. Jour., v. 84, p. 355-356.

Waller, E., and Moses, A. J. (1892) *A probable new nickel arsenide (from Grant County, New Mexico),* N. Mex. School Mines Quart., v. 14, p. 49-51.

Wargo, J. G. (1958) *Structure and volcanic stratigraphy in the Schoolhouse Mountain area, Grant County, New Mexico* (abs.), Geol. Soc. Am. Bull., v. 69, p. 1748.

——— (1959a) *Sequence of volcanic rocks in southwestern New Mexico* (abs.), Geol. Soc. Am. Bull., v. 70, p. 1754.

——— (1959b) *The geology of the Schoolhouse Mountain quadrangle, Grant County, N. Mex.,* unpub. Ph.D. thesis, Univ. Arizona.

Weber, R. H., and Willard, M. E. (1959) *Reconnaissance geologic map of Mogollon thirty-minute quadrangle,* N. Mex. Inst. Min. and Tech., State Bur. Mines and Mineral Res., Geol. Map 10.

Yale, G. G., and Stone, R. W. (1921) *Magnesite,* U.S. Geol. Surv., Mineral Res. 1918, pt. 2, p. 149-150.

———, and ——— (1922) *Magnesite,* U.S. Geol. Surv., Mineral Res. 1919, pt. 2, p. 234.

Zalinski, E. R. (1907) *Turquoise in the Burro Mountains, New Mexico,* Econ. Geol., v. 2, p. 464-492.

——— (1908) *Turquoise mining, Burro Mountains, New Mexico,* Eng. Min. Jour., v. 86, p. 843-846.

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Composition: Linotype—Text 10 on 11 Baskerville
Display 18 pt. Baskerville

Presswork: Text—38" Miehle Offset
Cover—20" Harris Offset

Binding: Sewn with softbound cover

Stock: Text—60 lb. White Offset
Cover—10 pt. Kivar
Plate 1—Map Bond
Plates 2-11—50 lb. White Offset

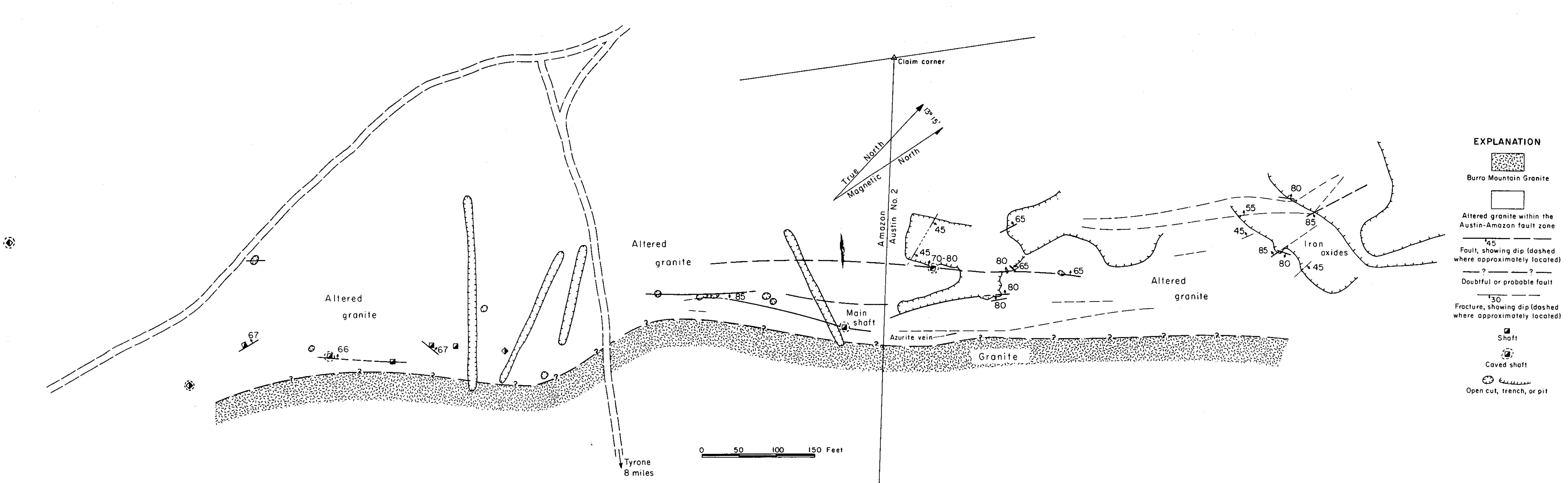


Figure 5. Geologic sketch map of the Austin-Amazon mine, Big Burro Mountains

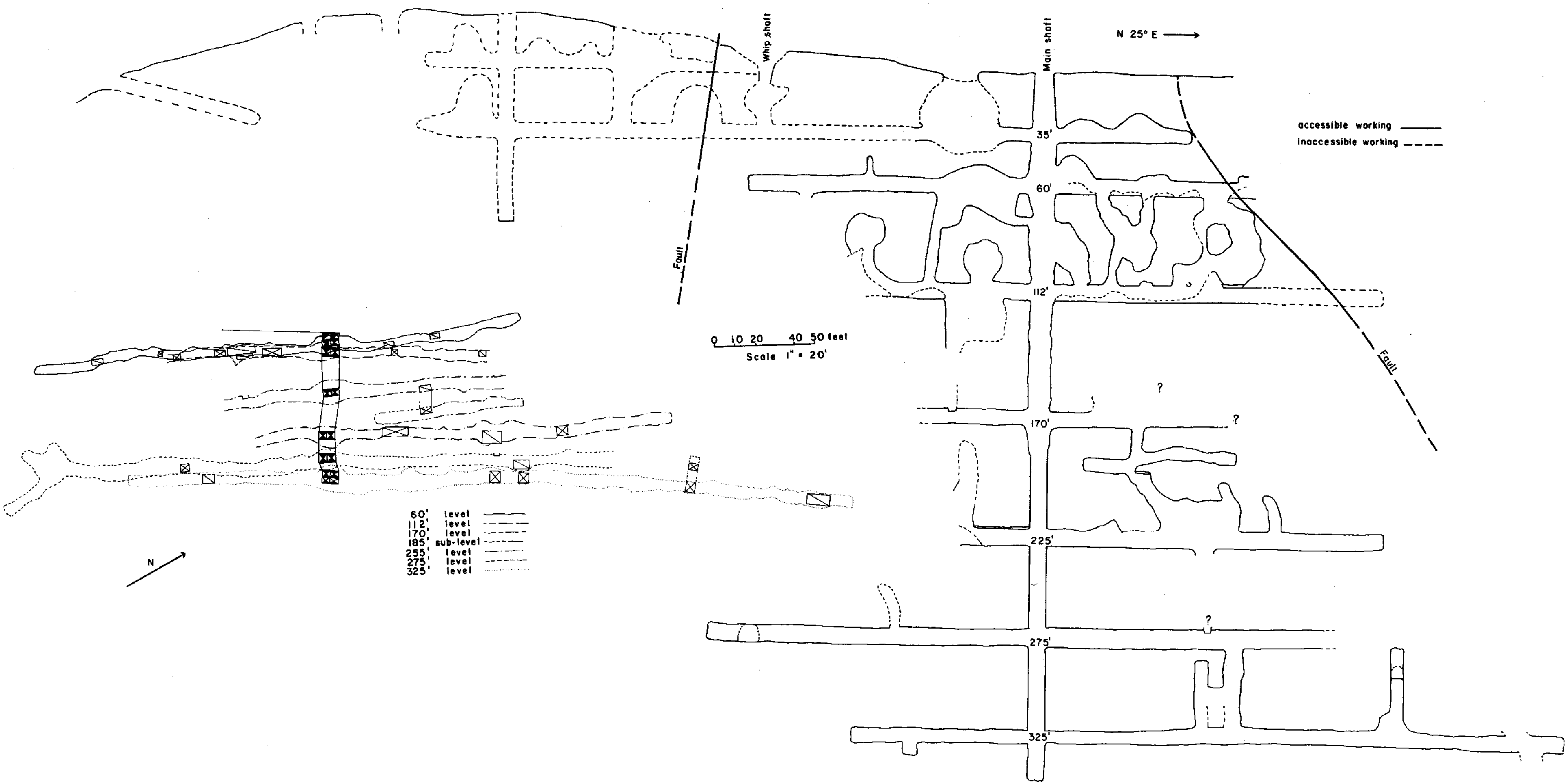


Figure 23. Composite level map and vertical section through the Alhambra mine, Bullard Peak district

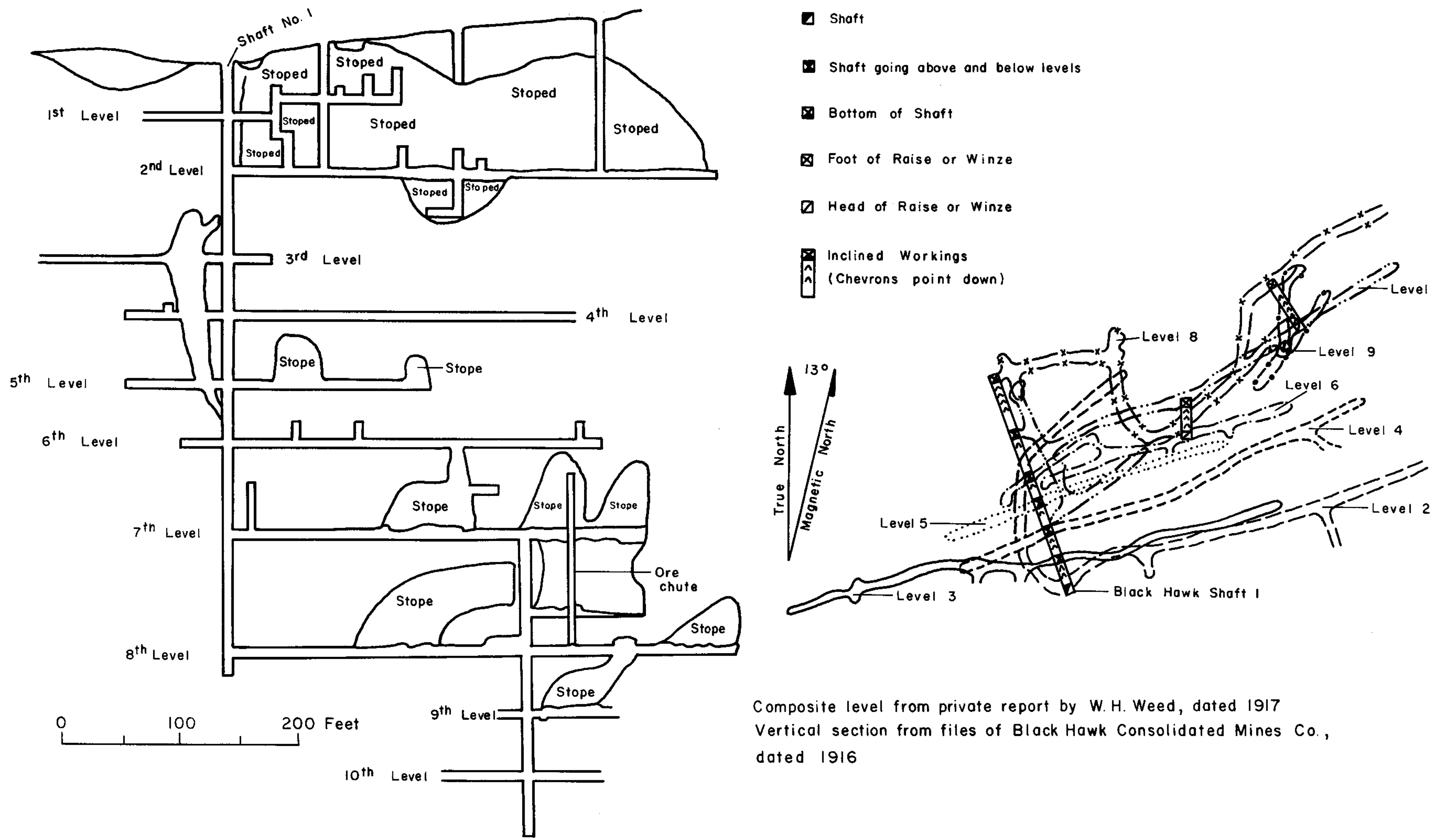


Figure 24. Composite level map and vertical section through the Black Hawk mine, Bullard Peak district

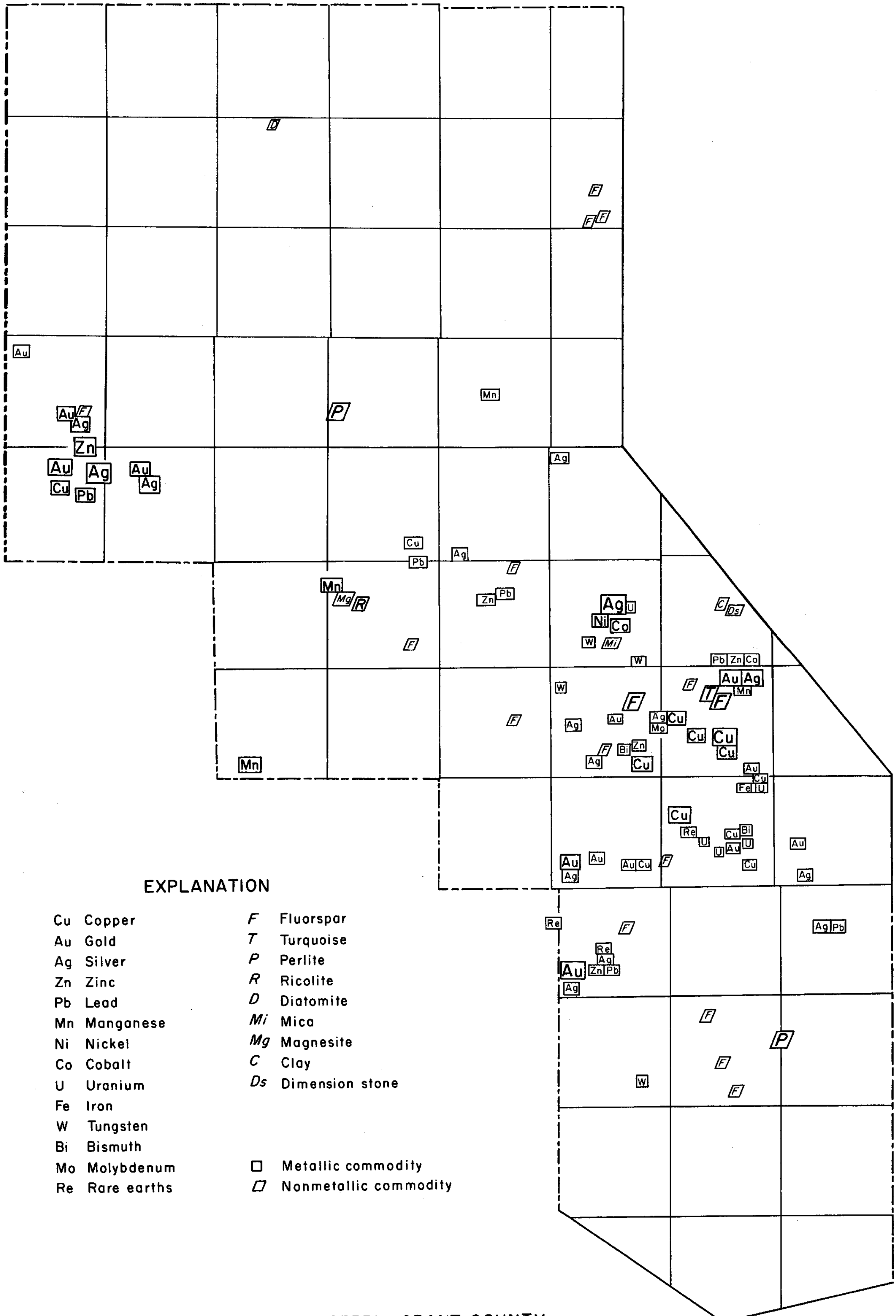
GEOLOGIC MAP OF WESTERN GRANT COUNTY, NEW MEXICO

Scale 1:126,720

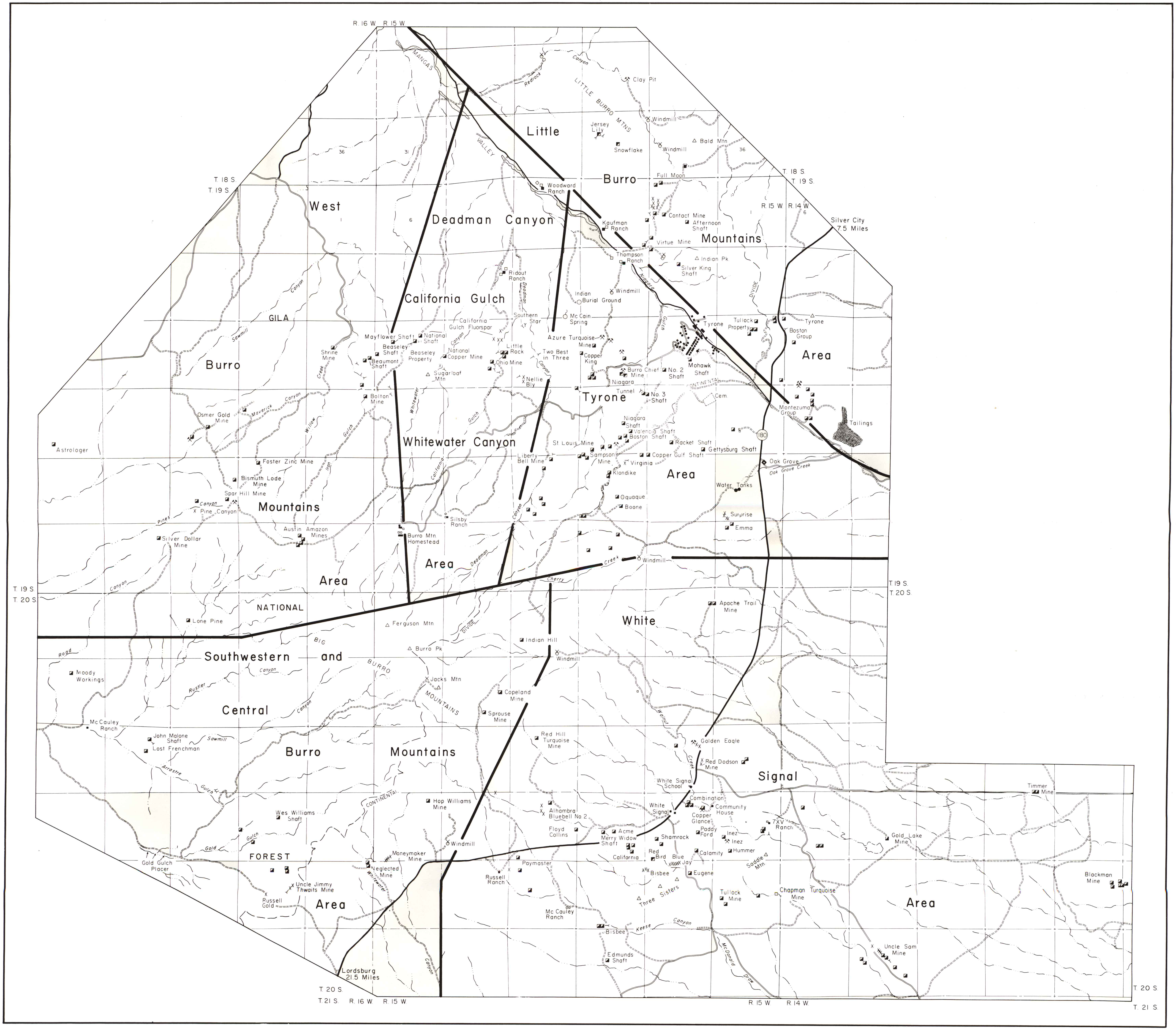
0 1 2 3 4 5 6 7 8 9 10 Miles

1964

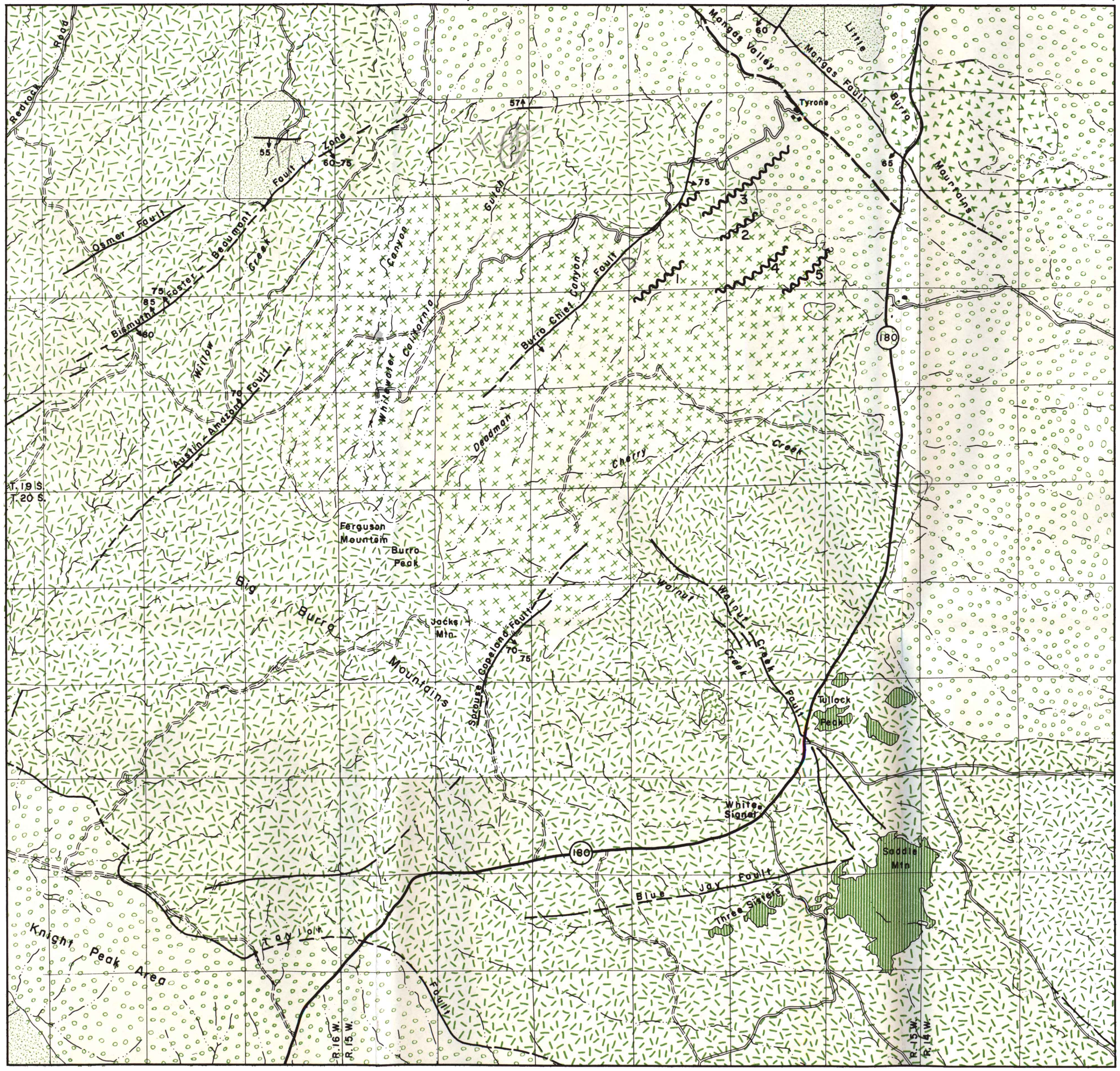
Compiled by Elliot Gillerman



MINERAL RESOURCE MAP OF WESTERN GRANT COUNTY



MINE MAP OF BIG BURRO MOUNTAINS SHOWING SUBDIVISIONS



GEOLOGIC MAP OF THE BIG BURRO MOUNTAINS

EXPLANATION

Gila Conglomerate, terrace gravels and alluvium

Tertiary volcanic rocks
Rhyolite, latite, andesite, and basalt

Tyrone stock
Quartz monzonite and monzonite

Quartz monzonite and monzonite
Exposed in Little Burro Mountains

Granite porphyry plug

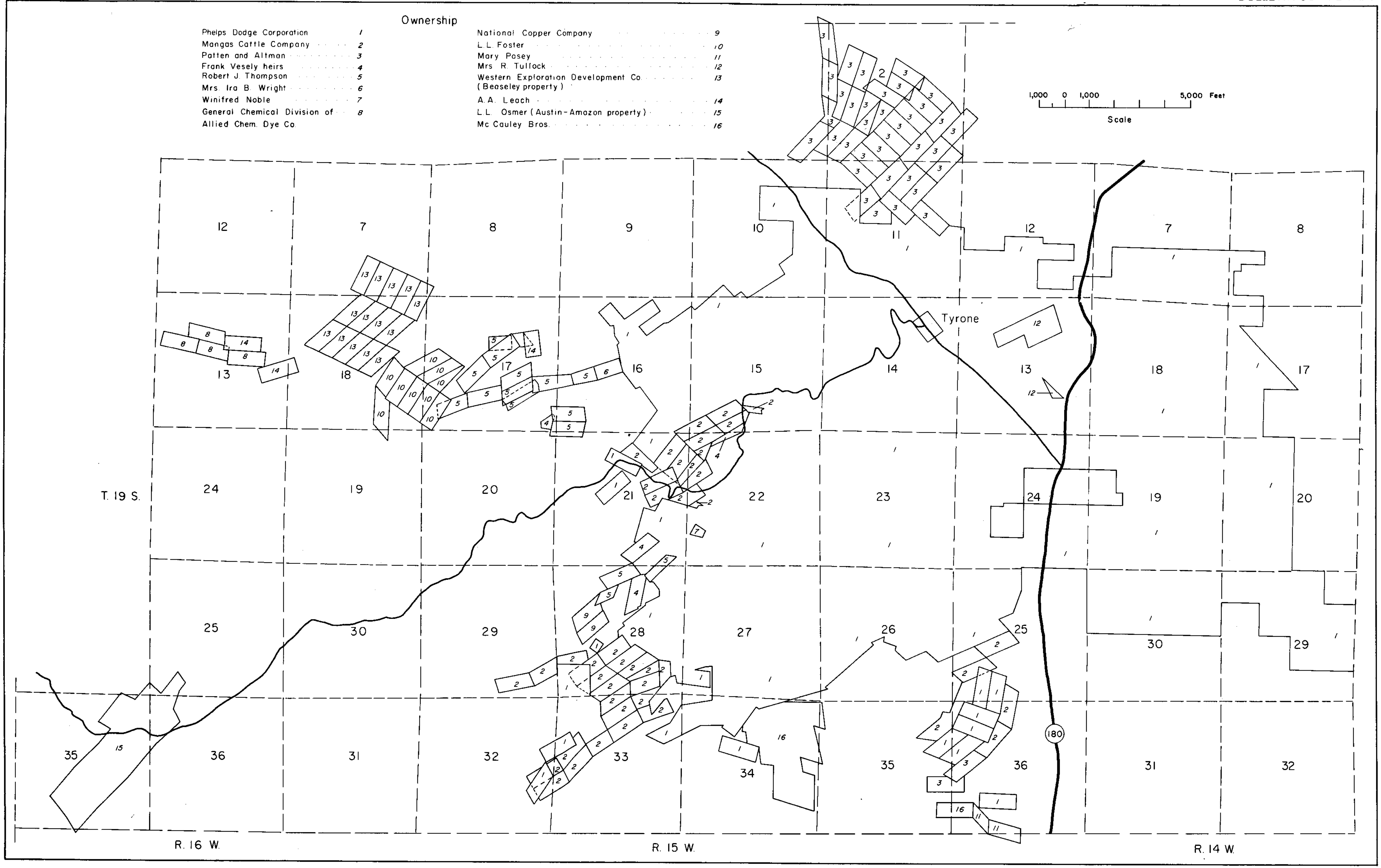
Rhyolite plugs

Burro Mountain Granite and associated igneous and metamorphic rocks

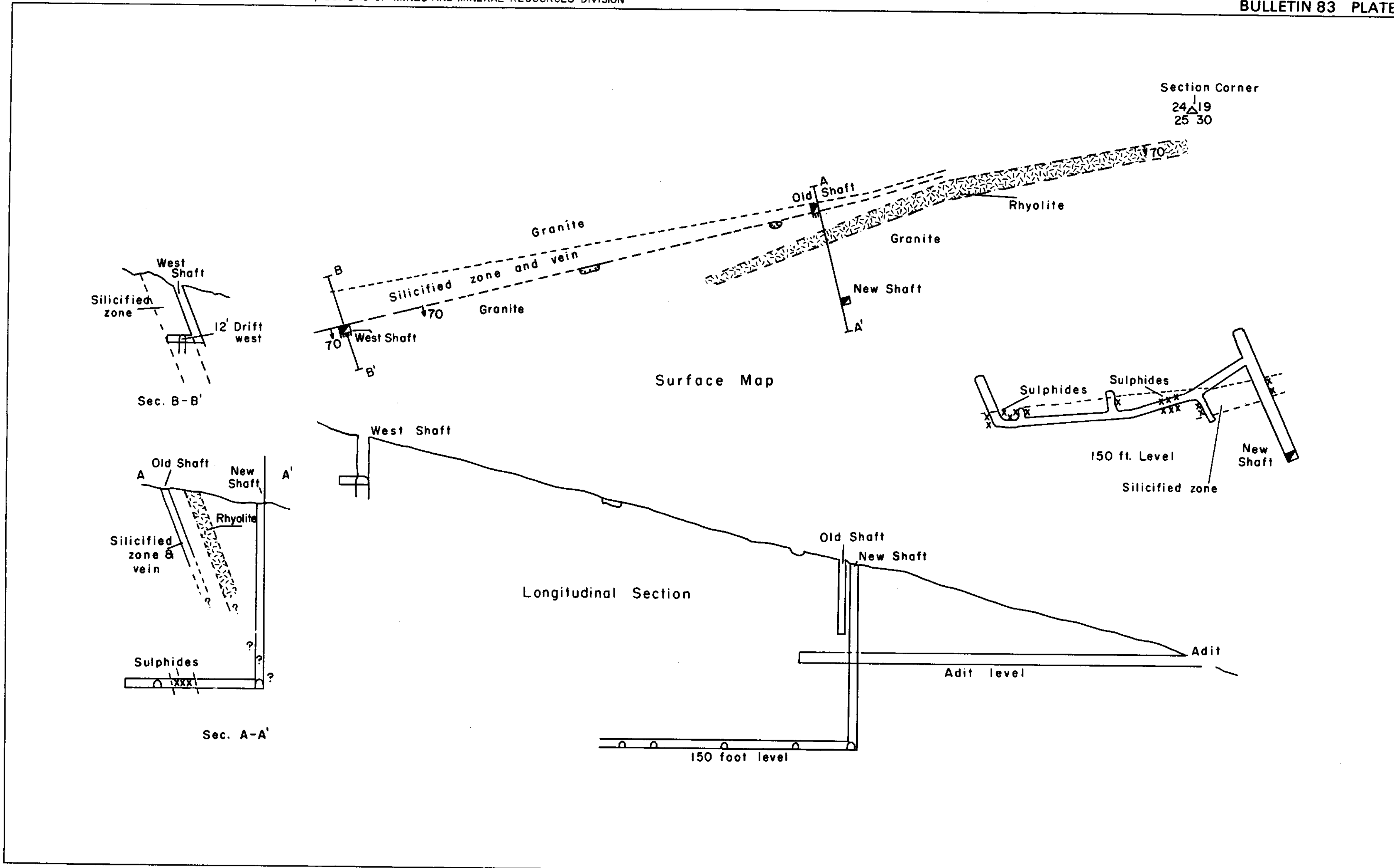
Fault

Axis of zones of more intense and close-spaced fracturing. Higher copper content than elsewhere in Tyrone copper body

1. Sampson
2. Bison-Thistle
3. Niagara-Mohawk
4. Copper Gulf-Racket-Virginia-Klondike
5. Gettysburg-Oquaque-Boone

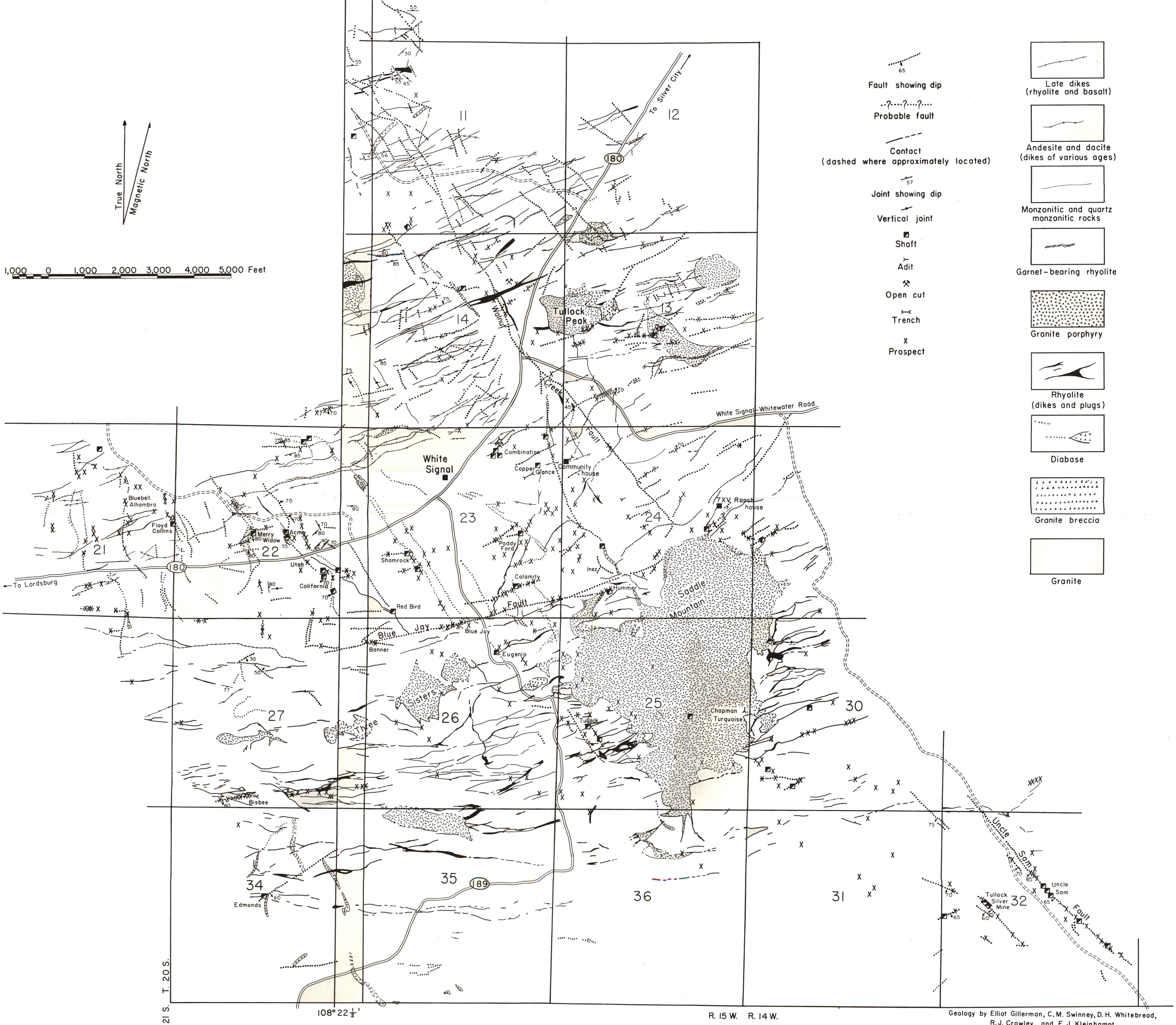


CLAIM MAP, TYRONE DISTRICT



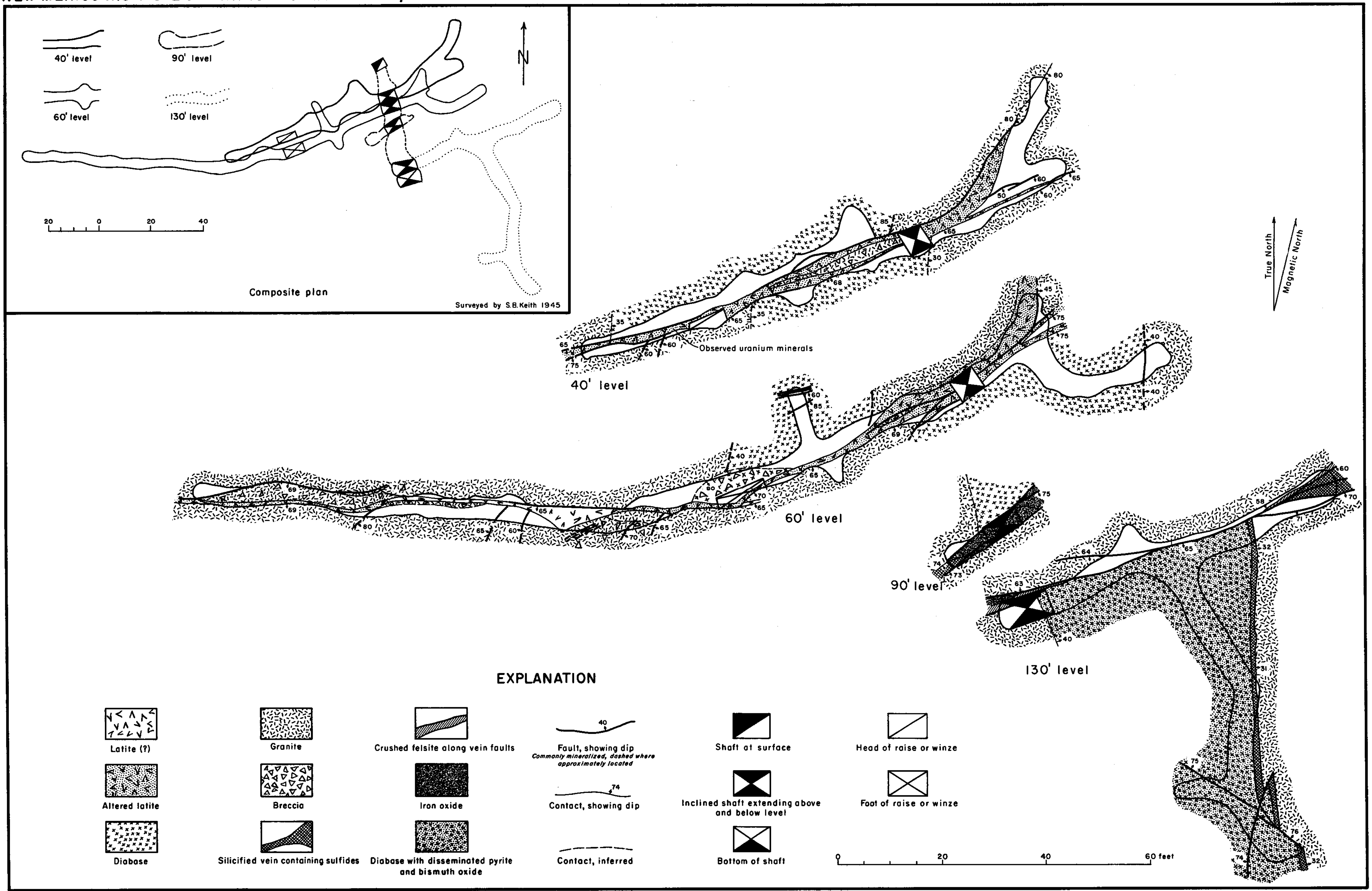
GEOLOGIC SKETCH MAP AND SECTIONS, NEGLECTED MINE

CLAIM MAP, WHITE SIGNAL DISTRICT



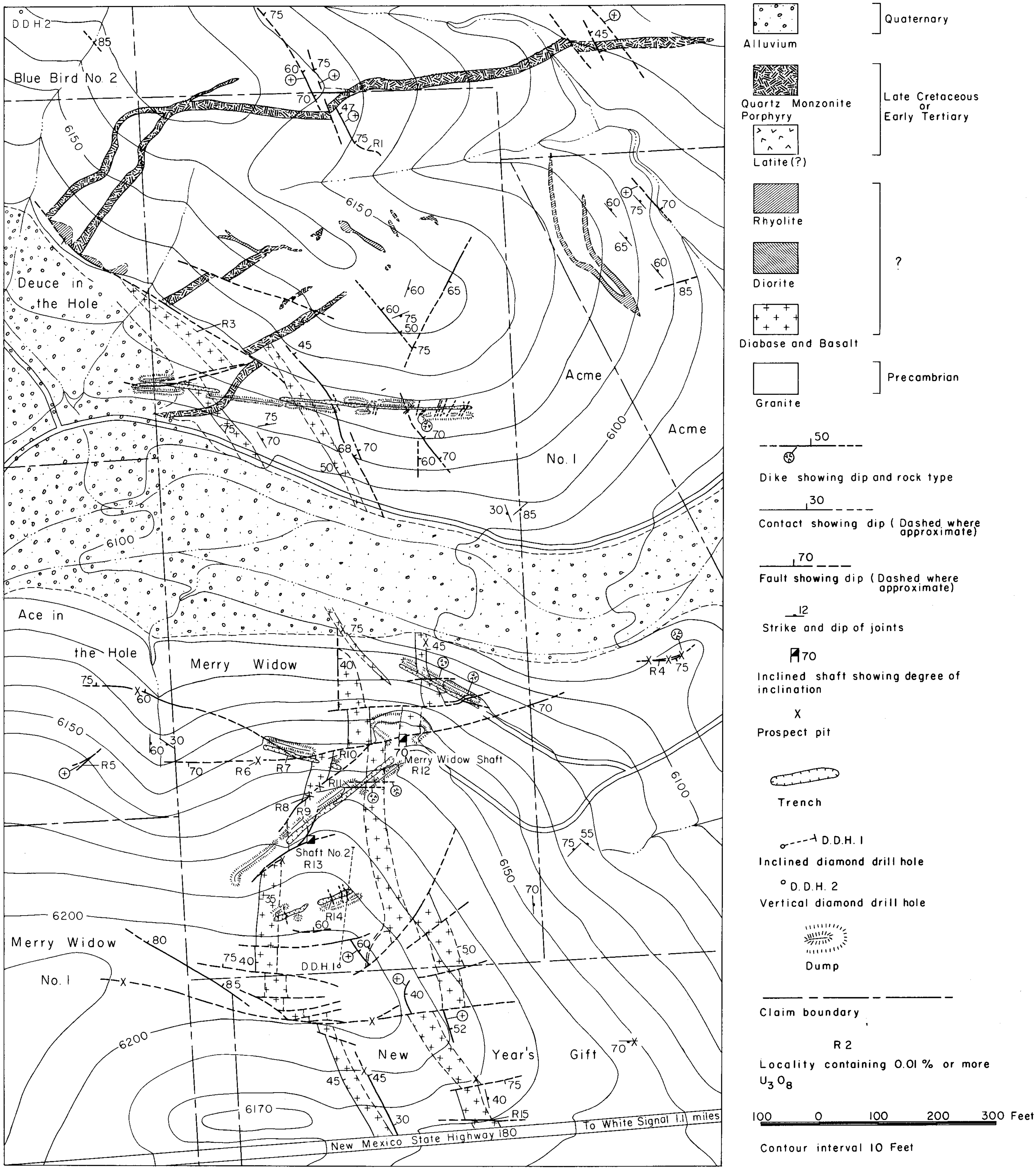
Geology by Elliot Gillerman, C. M. Swinney, D. H. Whitebread, R. J. Crowley, and F. J. Kleinhampt
1953

GEOLOGIC MAP OF THE WHITE SIGNAL DISTRICT

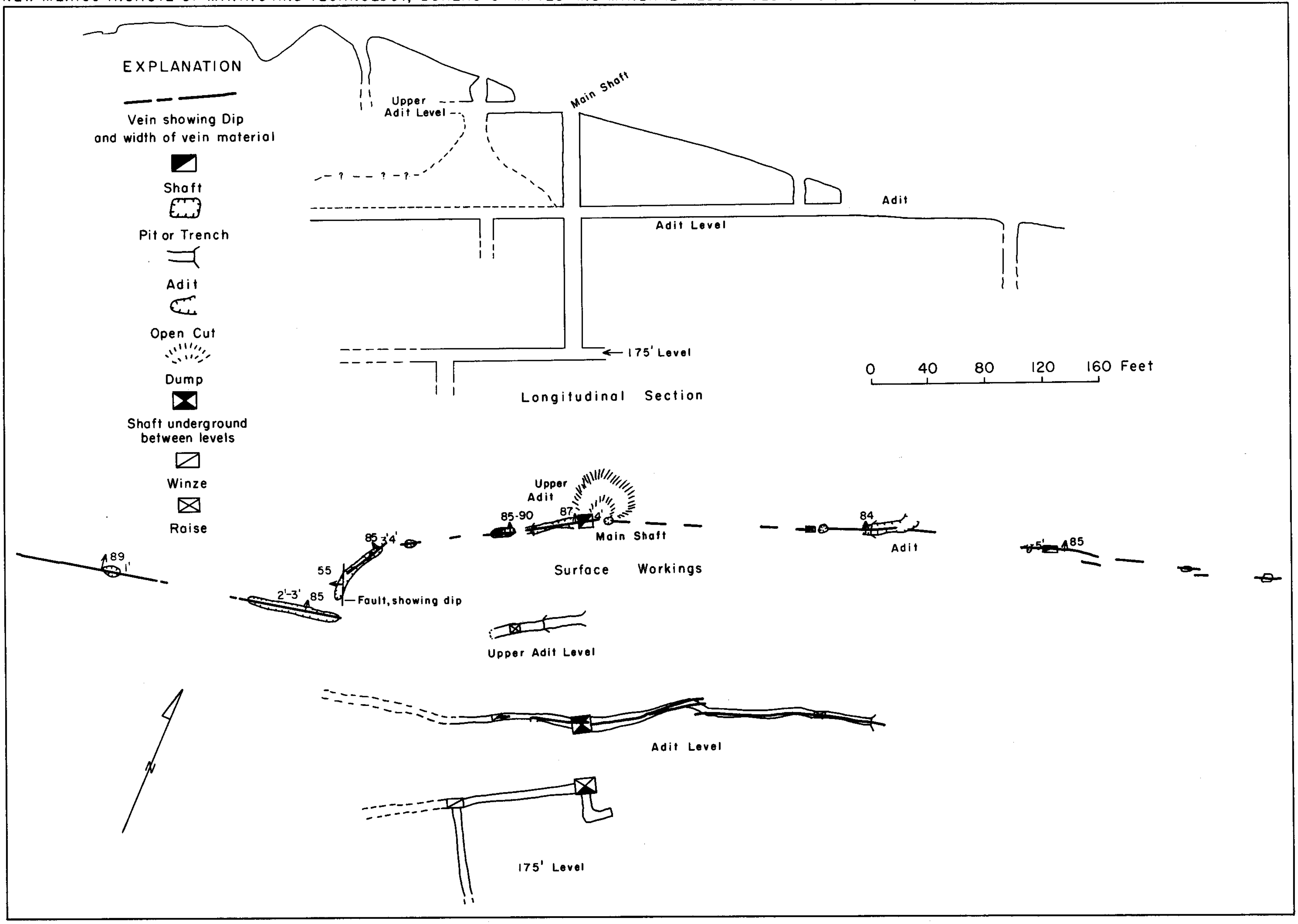


Geology of 40' and 60' levels by H. C. Granger and H. L. Bauer, Jr. 1951
Geology of 90' and 130' levels by S. B. Kieth 1945

GEOLOGIC PLANS OF LEVELS IN MERRY WIDOW MINE, WHITE SIGNAL DISTRICT, GRANT COUNTY, NEW MEXICO



GEOLOGIC MAP OF MERRY WIDOW CLAIM AND VICINITY, WHITE SIGNAL DISTRICT, GRANT COUNTY, NEW MEXICO



PLAN AND VERTICAL SECTIONS, CORA MILLER MINE