Fluorspar Deposits of Burro Mountains and Vicinity New Mexico

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A brief description of the regional geology and the fluorspar deposits

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FLUORSPAR DEPOSITS OF BURRO MOUNTAINS AND VICINITY, NEW MEXICO

By Elliot Gillerman

ABSTRACT

The fluorspar deposits in the Burro Mountains and adjoining areas to the west and south are in southwestern Grant County, N. Mex. Silver City, population 7,000, on a branch line of the Atchison, Topeka & Santa Fe Railway, is 10 miles northeast of the central part of the Burro Mountains, and Lordsburg, a town of 3,000 people on the main line of the Southern Pacific Railroad, is about 25 miles southwest.

Pre-Cambrian granite and included schists and quartzites constituting the main mass of the Burro Mountains are intruded by many pre-late Cretaceous dikes of diverse composition and age, and also by the late Cretaceous or early Tertiary quartz monzonite of the Tyrone stock and associated dikes. The Tyrone stock is exposed as an elliptical area, 4 miles wide and 6 miles long, on the northeast side of the Big Burro Mountains. Middle Tertiary volcanic rocks and associated dikes overlie and intrude the older rocks. Aside from small isolated areas of Cambrian quartzite southeast of the Burro Mountains, and Cretaceous shale and quartzite in the Little Burro Mountains, the sedimentary rocks are confined to the Gila conglomerate of late Tertiary and early Quaternary age, and unconsolidated Quarternary gravels. East- and northeast-trending faults, possibly of pre-late Cretaceous age, are common in the area, and many of the faults are mineralized. The major faults of the area trend northwest, and the latest movement on these faults displaced the Quaternary gravels. The fluorspar deposits are arranged around the Tyrone stock and along the Malone fault, south and west of the Burro Mountains.

The Burro Mountains area is known primarily for its copper and turquoise mining, but fluorspar was mined as early as the 1880's for use as flux in the smelting of copper. Sporadic mining of fluorspar continued until 1942, when continuous operations were begun at the Shrine mine, and a year later at the Burro Chief mine. From 1943 through 1949 slightly over 100,000 tons of fluorspar was shipped from the Burro Chief and Shrine mines, the major producers of the area.

The fluorspar deposits were localized along favorable faults, and the best deposits occur where the wall rock is granite. Small linkage faults and somewhat larger but similar faults that split off the major faults into the footwall, and are called footwall splits, were the sites best suited for fluorspar deposition. The grosser factors of ore control, which affected the regional distribution of the fluorspar deposits, were the major structural features of the area, and possibly the preparation of the ground by the intrusion of the Tyrone stock.

The Burro Chief fluorspar deposit, which is the major deposit in the area, occurs in a wide breccia zone in granite. Quartz monzonite porphyry dikes intrude the granite and at places form the wall rock on the hanging-wall side

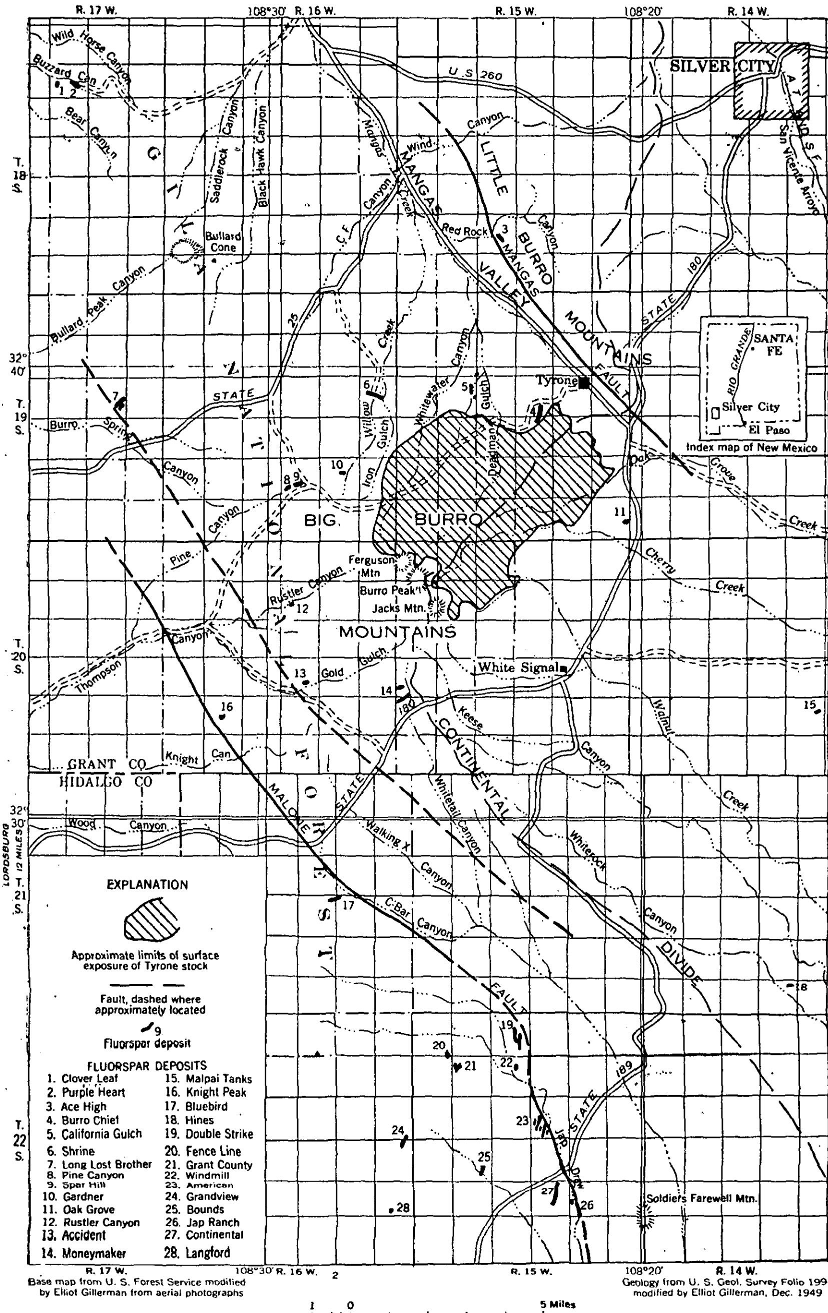

FIGURE 30.—Index map showing location of fluorspar deposits and major geologic features of the Burro Mountains and vicinity, Grant County, N. Mex.

of the breccia zone. Most of the fluorspar within the zone has been intensely brecciated by late movement, and the individual ore shoots are controlled by linkage faults and by footwall splits. At another important deposit in the area, the Shrine mine, fluorspar occurs along a simple fault in granite and rhyolite, and the ore shoots were localized by the wall rock and by irregularities along the fault. Of the 25 or more other small mines and prospects, many have not been sufficiently explored to determine their economic worth.

INTRODUCTION

The fluorspar deposits described in this report are in the Burro Mountains and adjoining areas to the south and west, in the southwestern part of Grant County, N. Mex. (See fig. 30.) Silver City, population 7,000, is in the northeast corner of the area, and Lordsburg, a town of 3,000, is 8 miles west of the southwest corner of the mapped area. The small town of Tyrone and the village of White Signal are within the area. State Highway 180 and U. S. Highway 260 traverse the region. Silver City is the terminus of a branch line of the Atchison, Topeka & Santa Fe Railway, and Lordsburg is on the main line of the Southern Pacific Railroad.

Topographically the area can be divided into two parts, the Burro Mountains in the north and the gently sloping gravel-covered plain in the south. The Burro Mountains consist of two distinct masses: the Big Burro Mountains and the Little Burro Mountains, separated by the Mangas Valley. (See fig. 30.) The Big Burro Mountains are subconical and rise to a height of 8,035 feet above sea level. From the three central peaks, which stand up abruptly 1,000 feet above the surrounding country, the land slopes away, at first steeply and then more gently, and finally merges into the desert basin to the south and east. South of the Burro Mountains rolling hills and broad valleys slope gently southeast toward the Mimbres and Hachita desert basins. Isolated hills stand 200 to 500 feet above the surrounding plain.

In June 1947 the author began a study of the geology and fluorspar deposits of the Burro Mountains and vicinity as a component part of a larger program of geologic studies in adjoining areas to the north and east. The work is still in progress [1950] and, accordingly, the present report is limited in scope and makes no attempt to discuss more than the broad outlines of the regional geology. Nor does the author delve deeply into the problems of paragenesis and the origin of the fluorine-bearing solutions. His purpose is merely to present the maps and brief discussions of the individual deposits. A complete study of the geologic problems of the area, including a geologic map of the Burro Mountains quadrangle, will be covered by another report.

The cooperation of the staffs at the Burro Chief and Shrine mines and of the officials of the Phelps Dodge Corporation and the General

Chemical Division of the Allied Chemical & Dye Corporation facilitated the studies. The information supplied by them and by many of the individual mine owners, particularly Charles Russell, owner of the Moneymaker deposit, greatly aided the work.

PREVIOUS WORK

Studies of the geology and ore deposits of the Burro Mountains and vicinity have been made by Graton (1910), Paige (1911, 1916, and 1922), and Somers (1916), and the Burro Chief and California Gulch fluorospar deposits were mentioned by the first two authors. Johnston (1928) in his study of the fluorspar deposits of New Mexico mentioned the Burro Chief deposit and numerous small veins "found on the Young Bounds ranch" south of the Burro Mountains. Rothrock (1946) in his comprehensive study of New Mexico fluorspar deposits briefly described the Burro Chief, Shrine, Spar Hill, Pine Canyon, Long Lost Brother, Moneymaker, Valley Spar (Double Strike of this report) and Friday (Bluebird of this report) deposits, and mentioned the deposits on the Bounds ranch. Eight short papers by other authors discuss the copper, turquoise, and uranium deposits of the Burro Mountains. (See references.)

GEOLOGY

GENERAL FEATURES

The Burro Mountains and the adjacent region to the south and west are subdivided into five geologic provinces by two, and probably three, major northwest-trending faults: the Mangas, the Malone, and a fault 2 miles northeast of the Malone fault. (See fig. 30.) Northeast of the Mangas fault the Little Burro Mountains consist of a complex of pre-Cambrian granite, late Cretaceous or early Tertiary monzonitic intrusions, Tertiary volcanic rocks, and Cretaceous sedimentary rocks (Paige, 1916). Southwest of the Mangas fault is the Mangas Valley, which consists of Gila conglomerate of Pliocene and Pleistocene age and more recent sands and gravels. Southwest of the Mangas Valley pre-Cambrian granite constitutes most of the Big Burro Mountains, but it is intruded by the quartz monzonite Tyrone stock and by dikes of diverse composition. On the southwest side of the Big Burro Mountains a graben valley occurs between the Malone fault and the fault 2 miles to the northeast. This graben contains Tertiary volcanic rocks overlain by Gila conglomerate, both units dipping steeply northeast. Southwest of the Malone fault pre-Cambrian granite and included schists and quartzites are present. Quaternary sands and gravels and possibly Gila conglomerate occupy the basins south and southeast of the Burro Mountains.

The fluorspar deposits are arranged around the Tyrone stock in the Big Burro Mountains and along the Malone fault south and west of the Burro Mountains. Isolated deposits occur in the Little Burro Mountains, northwest of the Burro Mountains, southeast of the Burro Mountains, and southwest of the Malone fault. The fluoritization is associated with post-middle Tertiary volcanic rocks, and fluorite is present in all rocks except the late Tertiary and early Quaternary Gila conglomerate and the Quaternary gravels. It is most prevalent in the pre-Cambrian granite.

IGNEOUS ROCKS

The predominant rock exposed in the Burro Mountains and vicinity is pre-Cambrian granite, which in places contains inclusions of older schists and quartzites. The granite is not homogeneous, and at least four different varieties have been distinguished. The decision as to whether these represent separate intrusions or are merely differentiates of the magma before or during intrusion must await additional mapping. At least one body—a coarse-grained light-gray and grayish-black hornblende-biotite granite, cropping out in the vicinity of the Shrine mine and to the north—definitely represents a distinct intrusion and is probably the oldest of the granites. The relationships of the others are not as definite. The most widespread variety is a predominantly grayish-orange medium-grained rock containing much quartz and potash feldspar, a little albite, and a moderate amount of small flaky biotite. The potash feldspar is orthoclase or microcline, or both. Large poikilitic orthoclase phenocrysts containing inclusions of quartz, albite, biotite, and the accessary minerals are locally present. Other varieties of granite are an alaskite and a porphyritic granite. Sphene, apatite, and magnetite are common, and some zircon, rutile, and tourmaline are present. A pale yellowish-orange fine-grained granite present on the south and west sides of the Burro Mountains contains no sphene or apatite, and the granite south of the Burro Mountains in the vicinity of the American fluorspar deposit also lacks these accessory minerals. Aplite and pegmatite dikes are common.

Lenses of pre-Cambrian schist, amphibolite, quartzite, and other metamorphic rocks included in the granite are common in the area south and west of the Malone fault (see fig. 30); they range in size from a few feet to more than a mile in length. In the Burro Mountains proper these metamorphic rocks have been found only in the northern parts.

Dikes of various composition and age intrude the pre-Cambrian granite throughout the area. Fine- to medium-grained diabase dikes are very common in the White Signal area, south of the Burro Mountains, but also occur elsewhere. These dikes, with few exceptions, strike north or west.

Fine-grained white rhyolite dikes that contain a few quartz phenocrysts are abundant in a belt about 10 miles long and 5 miles wide, trending N. 80° E. and centering around White Signal. These dikes are as much as 200 feet wide and strike east or slightly north of east. Individual dikes can be followed for 2 miles or more. Similar dikes are present on the north and west sides of the Burro Mountains. These dikes are older than the quartz monzonite of the Tyrone stock and are thus confined to the area where the granite is exposed. They are cut by quartz monzonite porphyry dikes.

Associated with the rhyolite dikes in the belt south of the Burro Mountains are numerous andesite, dacite, latite, and quartz latite dikes. Within this belt they strike east or slightly north of east, paralleling or nearly paralleling the strike of the rhyolite dikes. They are found elsewhere in the area but are not as abundant as within the main belt and, like the rhyolite dikes, are limited to the areas of granite exposure because they are earlier than the Tyrone stock.

All these dikes are epidotized, chloritized, and sericitized, and many contain copper minerals, gold, and fluorite. The exact age relationships have not been fully determined, but dikes of at least five ages have been recognized. Small andesitic and rhyolitic plugs are associated with the dikes.

The Tyrone stock, composed of quartz monzonite, which intruded the pre-Cambrian granite in late Cretaceous or early Tertiary time, is exposed on the northeast side of the Big Burro Mountains, less than a mile southwest of Tyrone. (See fig. 30.) The exposed part of the stock is elliptical, is 4 miles wide and 6 miles long, and trends northeast. Most of the stock is a homogeneous, light gray medium-grained equigranular or locally porphyritic quartz monzonite with abundant quartz, orthoclase, oligoclase, and biotite. Megascopic crystals of sphene are characteristic, and a few megascopic apatite crystals are present. Magnetite is common. In many places the quartz monzonite is porphyritic, containing prominent poikilitic orthoclase phenocrysts that may be an inch or more in diameter. The poikilitic orthoclase crystals contain inclusions of quartz, plagioclase feldspar, biotite, magetite, apatite, and sphene.

Along the north and east edges of the stock are small bodies of rocks that are similar to the main quartz monzonite body but are distinct from it. These may be segregations near the borders of the main stock or may represent separate intrusions. One type contains no sphene and only scattered biotite, and another contains large plagioclase phenocrysts, hornblende, and no orthoclase. Aplite dikes of quartz monzonitic composition intrude the stock and the surrounding granite.

Porphyritic dikes, petrographically similar to the main quartz monzonite stock and to its border phases, cut the pre-Cambrian granite, the earlier dikes, and the Tyrone stock. At least three distinct types have been recognized: granodiorite dikes; quartz monzonite porphyry dikes containing abundant chloritized biotite and accessory sphene; and quartz monzonite porphyry dikes having small amounts of chloritized biotite and no sphene.

The granodiorite is a dark gray porphyritic rock that consists of about 50 percent phenocrysts and 50 percent aphanitic groundmass. The phenocrysts are predominantly small white crystals of oligoclase and dark greenish chloritized biotite. A few small embayed and corroded quartz grains are present.

Both types of the quartz monzonite porphyry are light-colored porphyritic rocks that are characterized by large hexagonal crystals of quartz and large poikilitic phenocrysts of pink orthoclase. The quartz crystals are as much as a quarter of an inch in diameter and have a well-developed bipyramidal crystal habit. Many of the crystals are embayed and have slightly rounded edges, and clusters of two or more crystals are common. The poikilitic orthoclase phenocrysts are euhedral, as much as 3 inches long, and contain inclusions of quartz, oligoclase, biotite, and the accessory minerals. Carlsbad twin crystals and simple crystals occur. They are very common and in many places weather free. Small white oligoclase phenocrysts are also present in both types of the quartz monzonite porphyry, as are magnetite and apatite. The two types differ in the character of the biotite and the presence of sphene. One type contains abundant dark green chloritized biotite in subhexagonal books the thickness of which equals or exceeds the diameter, and abundant sphene crystals that in many places are megascopic in size. The other type contains small amounts of chloritized biotite in small flakes and books, the diameter of which is three or four times the thickness, and no sphene.

Volcanic rocks are found in three distinct areas within the Burro Mountains district: in the Little Burro Mountains, at the Shrine mine, and as a northwest-trending belt at least 25 miles long and 1 to 2 miles wide south and west of the Big Burro Mountains. The volcanic rocks south and west of the Burro Mountains and those in the Little Burro Mountains are middle Tertiary in age, but the volcanic rocks at the Shrine mine may be older. Sands, gravels, and tuffs overlain by a series of andesites, latites, and rhyolites occur in the Little Burro Mountains, and two distinct types of rhyolite are present in the vicinity of the Shrine mine. Both of these types are merely small remnants of what were once more widespread flows.

The belt of volcanic rocks south and west of the Burro Mountains consists of a series of flows interbedded with pyroclastic rocks. Rhyolites, latites, quartz latites, andesites, and basalts are present, but the exact order is not known. Beds of perlite occur in the upper part of the sequence. Conglomerates, sandtones, and tuffs are present near the base of the sequence in the vicinity of Thompson Canyon (see fig. 30), and a thick volcanic breccia occurs near the top in Gold Gulch and Thompson Canyon and also north of the American fluorspar deposit. The flows, breccia, and tuffs dip gently northeast in the southern part of this belt, but to the northwest the dip steepens and in Knight Canyon the dip is 70° NE. A minimum thickness of 3,500 feet is estimated for the sequence. The volcanic rocks overlie the granite to the southwest or are in contact with it along the Malone fault. They are overlain disconformably on the northeast by the Gila conglomerate and later unconsolidated gravels.

Associated with the Tertiary volcanic rocks, probably as feeders to the flows, are many dikes of diverse composition. White chalky-looking rhyolite dikes, having well-developed flow structure that is commonly contorted and ropy-looking, greatly resemble the earlier white rhyolite dikes. The former contain fewer quartz phenocrysts, however, and the flow-banding is better developed. Slightly different dikes of latitic and quartz latitic composition are present in the vicinity of the Shrine mine. These are banded and buff-colored, and some are porphyritic. Andesitic and basaltic dikes are present in the vicinity of the Spar Hill, Long Lost Brother, Knight Peak, and JAP Ranch fluorspar deposits and elsewhere. Rhyolite plugs, similar in composition and appearance to the rhyolite dikes, occur in the Little Burro Mountains, near White Signal, and elsewhere. The dikes and plugs are sericitized, and in a few places chloritized, but they are not epidotized.

SEDIMENTARY ROCKS

Sedimentary rocks are of limited areal extent within the area, and consist of the Bliss (?) sandstone of Cambrian (?) age, the Beartooth quartzite and the Colorado shale of Cretaceous age, the Gila conglomerate of late Tertiary and early Quaternary age, and Quaternary unconsolidated gravels.

Quartzites of the Bliss (?) sandstone occur southeast of the Burro Mountains in the vicinity of the Hines fluorspar deposit. The Beartooth quartzite and the Colorado shale that crop out in the Little Burro Mountains consist of quartzite, shale, arenaceous shale, sandstone, siltstone, and limestone.

The Gila conglomerate, consisting of distinctly bedded and well-consolidated unsorted boulders and pebbles, is exposed in Gold Gulch (see fig. 30) and in the Mangas Valley near the mouth of Deadman Gulch. In the Gold Gulch area the Gila conglomerate dips about 30° NE. and occupies the broad valley between the Tertiary volcanic rocks on the southwest and the granite on the northeast. In the Mangas Valley it probably underlies the more recent unconsolidated gravels. The Gila conglomerate probably extends to the southeast and underlies much of the area now covered by more recent unconsolidated gravels south and southeast of the Burro Mountains.

FAULTS

Prominent northwest-trending normal faults dominate the structural pattern of the area. (See fig. 30.) The Mangas fault, marked by the southwest scarp of the Little Burro Mountains, dips about 70° SW. The Gila conglomerate and the more recent unconsolidated gravels of the Mangas Valley were down-dropped along this fault and brought against the older rocks of the Little Burro Mountains. The Malone fault, southwest of the Big Burro Mountains, dips 60° NE. and separates Tertiary volcanic rocks on the northeast from pre-Cambrian granite and schist on the southwest. Movement along both faults took place in late Tertiary or Quaternary time. Two miles northeast of the Malone fault, on the southwest side of the Big Burro Mountains, a similar fault may occur between pre-Cambrian granite on the northeast and Gila conglomerate on the southwest. If this fault does exist the Gold Gulch and Walking X Canyon valleys are in a graben within which a thick sequence of volcanic rocks, Gila conglomerate, and unconsolidated gravels has been laid down since the early Tertiary. The boundary faults of the graben and also the Mangas faults are of pre-Gila age, with renewed movements in later times.

East-trending and northeast-trending faults are common in the area. Within the Burro Mountains they are commonly marked by mineralized zones, and may be early faults. South and west of the Burro Mountains, however, and also in the Little Burro Mountains many faults of this general strike offset the large northwest faults. The Burro Chief fault, which strikes north-northeast, displaces the Quaternary gravels and may represent late movement along one of the earlier northeast-trending faults.

FLUORSPAR DEPOSITS

HISTORY OF MINING

The Burro Mountain area is known primarily for the copper and turquoise mining begun in the 1870's, but fluorspar was also known in the early days and was mined from the Burro Chief claim in the 1880's for use as flux in the smelting of the copper ores. In 1913 the Phelps Dodge Corporation took over the Burro Chief claim, and fluorspar was mined sporadically by numerous lessees until 1941. In June 1943 H. E. McCray leased the property and operated it continuously until January 1948, when the Phelps Dodge Corporation started an extensive development program that was still in progress in December 1949.

The only other fluorspar mine in the Burro Mountains operated before 1941 was the Shrine mine. This deposit was discovered by L. L. Osmer in 1936 and was worked by him until 1942. In February 1942 the property was sold to the General Chemical Company; it is now [1950] operated by the General Chemical Division of the Allied Chemical & Dye Corp.

The Spar Hill, Pine Canyon, Moneymaker, and Long Lost Brother properties were operated for short periods in 1941–45 but have been shut down since 1945.

South of the Burro Mountains, the Bluebird, American, Continental, and Double Strike deposits were operated during World War II. No accurate information on the extent of previous operations at these deposits is available to the author, but some of them were worked for fluorspar and for gold as early as World War I. The American deposit has been mined from time to time since 1945.

PRODUCTION

Production records of fluorspar from the Burro Mountains and vicinity are incomplete, but 115,000 tons of fluorspar is estimated to have been shipped since mining first was started. Of this total, over 100,000 tons was shipped from June 1943 to July 1948, and of the total all but about 5,000 tons has come from the Burro Chief and Shrine mines. The rest was shipped from the Bluebird, Spar Hill, Moneymaker, Long Lost Brother, American, Continental, and Double Strike deposits. Maximum production was in 1945 when 36,208 tons of fluorspar was shipped from the Burro Chief and Shrine mines.

In January 1948, when the Phelps Dodge Corporation took over the operation of the Burro Chief mine, production was stopped and the development program started that was still in progress at the end of 1949. In July 1948 a fire stopped production by severely damaging the surface installations and the shaft at the Shrine mine. When operations were resumed in the spring of 1949 a development program was started here also. Excepting the shipments from the Shrine mine during the first 6 months of 1948 and small shipments from the American mine during the summer of 1948, there was no production of fluorspar from the Burro Mountains region in 1948 and 1949. Production, however, was resumed in 1950.

MINERALOGY

Fluorite in the Burro Mountains and vicinity may be white, yellow, green, violet, or purple, but various shades of green and purple predominate. The fluorite is characteristically massive, but columnar and granular varieties occur. Well-crystallized fluorite is common, particularly at the deposits south of the Burro Mountains in T. 22 S., R. 15 W. (See fig. 30.) The cube and octahedron are the most abundant crystal forms, but the dodecahedron modifying the cube is common at the Double Strike, American, and JAP Ranch deposits. At the Double Strike deposit cubes of fluorite modified by dodecahedrons, tetrahexahedrons (fluoroids), and hexoctahedrons occur.

Two and probably three stages of fluoritization took place, closely spaced in time. With a few exceptions the violet fluorite represents the last stage.

The most common mineral associated with fluorite in the Burro Mountains and vicinity is quartz, either as crystalline quartz or as the cryptocrystalline varieties chalcedony and jasper. Quartz is found in all deposits and in places forms the greater part of the vein material. Other associated minerals, all in very small amounts, include calcite, pyrite, chrysocolla, turquoise, malachite, hematite, limonite, native gold, silver, manganese oxide, halloysite, autunite, and possibly uranophane.

LOCALIZATION

Several factors were responsible for the localization of fluorspar at the many deposits in the Burro Mountains and vicinity, but the chief amongst these were wall-rock control, irregularities of the fault along which the fluorspar occurs, and the presence of small linkage faults (small faults that extend obliquely across the gap between two larger faults) and somewhat larger but similar faults that split off the major faults into the footwall and are called footwall splits.

Granite, owing to its greater porosity and its greater competency and resultant shattering when stressed, was the rock variety most conducive to the development of extensive ore shoots and thus is the most prevalent wall rock. At the Shrine, Spar Hill, Pine Canyon, and other deposits the veins pinch noticeably where both walls are rhyolite, monzonite, andesite, or schist and swell where at least one wall is granite. Along the Malone fault all the deposits are in granite except the small Knight Peak deposit, which is in the volcanic rocks. At the Burro Chief mine the breccia fragments within the mineralized zone are preponderantly granite, although locally monzonite porphyry is present on the hanging wall of the fault zone.

Irregularities of the fault surfaces control the widths of the ore shoots at the Shrine, Moneymaker, and Oak Grove deposits.

The almost complete absence of fluorspar along the major faults and its presence along the footwall splits are clearly shown along the Malone fault (see pl. 56). The ore is localized along the faults that split off the Malone fault into the footwall, and only minor amounts of fluorspar are present along the major structure. A similar example is the Ace High deposit in the Little Burro Mountains (see fig. 30), which is probably along a footwall split of the Mangas fault.

At the Burro Chief mine the fault along the footwall side of the mineralized zone and the subparallel faults within the mineralized zone are footwall splits of the major hanging-wall fault. The fluorspar is found along the footwall splits, and in more detail, along smaller footwall splits and linkage faults that lie between the major hanging-wall fault and the large subparallel footwall splits. (See pls. 46–48.)

The grosser features of ore control, which affected the regional distribution of the fluorspar deposits, were the major structural features of the area and possibly the preparation of the ground by the intrusion of the Tyrone stock. An example of both the regional distribution of the fluorspar along a major structure and its localization by some of the factors mentioned before is the series of deposits occurring along the Malone fault southwest and south of the Burro Mountains.

The JAP Ranch, Continental, American, Windmill, Double Strike, Bluebird, and Knight Peak deposits occur along the Malone fault at intervals through a distance of 15 miles. (See pl. 56.) Fluorspar deposits northwest of the Knight Peak deposit, beyond the area included within this report, may also be associated with this fault. The Malone fault strikes northwest and where measured at the American mine dips 60° NE. For much of its length within the area studied this fault forms the boundary between the Tertiary volcanic rocks to the northeast and the pre-Cambrian granite, schists, and quartzites to the southwest. Locally, however, areas of granite occur northeast of the fault and areas of volcanic rocks are present southwest of the fault. The Malone fault has been displaced by numerous cross faults striking northeast and east.

In the vicinity of the fluorspar deposits several cross faults and north-trending footwall split faults intersect the Malone fault. The fluorspar occurs along these cross faults and footwall split faults, although at the JAP Ranch deposit some of the fluorspar occurs along what may be the Malone fault. Excepting the Knight Peak deposit, all the fluorspar veins are in granite and schist on the southwest side of the Malone fault. The small Knight Peak deposit is in the volcanic rocks on the northeast side of the fault.

More detailed discussion of the factors affecting the regional distribution of the fluorspar deposits must await the completion of the study of the area.

DESCRIPTION OF DEPOSITS

BURRO CHIEF

The Burro Chief fluorspar deposit is 1½ miles southwest of Tyrone in the SE¼ sec. 15, T. 19 S., R. 15 W. Fluorspar was first mined from the deposit in the 1880's for use as flux. In 1913 the Phelps Dodge Corp. took over the Burro Chief claim, and fluorspar was mined sporadically for a number of years thereafter. By 1928 several carloads of metallurgical spar had been shipped from the property. Mining was resumed in 1937 and continued until 1941 by L. L. Osmer and by F. O. Bacon and E. D. Osborn. In June 1943 H. E. McCray leased the property from the Phelps Dodge Corp. and operated the mine continuously until January 1948, producing about 75,000 tons of fluorspar which averaged more than 60 percent CaF_2. In January 1948 the Phelps Dodge Corp. started an extensive development program that was still in progress in December 1949.

The deposit is on the Burro Chief and no. 1 Lode claims (see pl. 46) owned by the Phelps Dodge Corp. Workings (see pls. 47–49) consist of a vertical shaft 700 feet deep with drifts on the 260-, 400-, 500-, and 650-foot levels, the 300-foot sublevel, and an adit level 40 feet below the collar of the shaft, connected with the other workings by a winze. The drifts extend a maximum of about 1,000 feet south and 300 feet north of the shaft. Stoping has been extensive above the 260-foot level, and the stopes are open to the surface.

Quartz monzonite porphyry dikes intrude the granite in the vicinity of the mine and are in turn intruded by dikes of fine-grained quartz monzonitic aplite. A small intensely chloritized andesite dike intrudes the granite northwest of the shaft, and a diorite dike intrudes the granite and the quartz monzonite east of the shaft. Except for a small body of unaltered quartz monzonite porphyry about 300 feet east of the shaft, all the rocks in the vicinity of the deposit are extensively altered, principally to chlorite, sericite, and clay minerals.

The fluorspar occurs in a wide breccia zone along the west side of a north-northeast-trending fault. (See pls. 46–48.) The zone ranges in width from 10 to 100 feet, and the individual ore shoots are as much as 35 feet wide and more than 400 feet long. The west boundary of the zone is marked by a prominent fault about 300 feet west of the shaft, but to the south and north the western edge is not so sharp. (See pl. 47, 260- and 400-foot levels.) Two large faults, subparallel to the hanging wall, occur within the ore zone, and numerous small cross faults offset the individual ore shoots. The ore zone dips about 75° E. and plunges about 50° S.

Four distinct types of ore are distinguished on the mine maps: (1) veins of high-grade fluorspar containing 75 to 90 percent CaF_2; (2) soft fluorspar breccia containing 35 to 75 percent CaF_2; (3) hard fluorspar breccia containing 50 to 90 percent CaF_2; and (4) breccia and low-grade ore containing as much as 35 percent CaF_2. (See pls. 47 and 48.) The high-grade fluorspar veins consist of unbrecciated, but shattered, clear green fluorite and thin seams of clay and quartz.

The soft fluorspar breccia, or "mud ore," consists of tiny fragments of fluorite and masses of fluorite as much as several feet in diameter, plus fragments of argillized, sericitized, and silicified wall rock, set in a semiconsolidated mud or clay. Halloysite and black oxides of manganese and iron are abundant locally. The hard fluorspar breccia can be subdivided into: (a) a well-cemented early breccia of dark green or purple fluorite and silicified granite fragments in a groundmass of finer light green fluorite and quartz; and (b) a porous late breccia containing fragments of the early breccia, purple and green fluorite, and silicified granite, all cemented by violet fluorite and quartz. The two types of hard breccia are not distinguished on the maps and sections. The breccia and low-grade ore consist of barren breccia and breccia with small quantities of flourspar scattered through it. No attempt was made to separate the barren breccia from the breccia containing some fluorspar because much of the barren-appearing breccia contains as much as 35 percent CaF_2 as finely crushed fluorite.

The individual ore shoots appear to be controlled by linkage faults that extend southwestward from the hanging wall of the zone. These faults dip 55° to 85° W. as they diverge from the hanging wall, but as they continue downward and to the south they roll over and become vertical or dip east. (See pl. 48, cross sections *B–B′* and *C–C′*.) The largest ore shoots consist primarily of the soft breccia fluorspar.

The two types of hard breccia are confined to the footwall side of the ore zone and have not yet been found in the southern part of the zone. The early breccia type is present in the upper part of the zone, above the 400-foot level, and the late breccia type has been found about 40 feet above the 400-foot level and on the 500- and 650-foot levels. The late violet fluorite, which is the cementing material in the late breccia type, also occurs as veinlets and incrustations on granite boulders throughout the ore zone.

Two and probably three stages of fluoritization occurred separated by periods of brecciation and silicification. The early fluorite is green and purple, but the latest fluorite is violet. The violet fluorite has octahedral crystal faces in many places within the mine.

Pyrite and chalcopyrite occur in small quantities in some of the breccia fragments and also as small veinlets in the surrounding country rock. As a result of the oxidation of these minerals, chrysocolla, turquoise, and copper carbonates are present within the ore zone, associated with the fluorspar. Late pyrite, in part altered to limonite, coats some of the fluorite, and the black color of much of the soft fluorspar breccia is due to the limonite. Halloysite is common, and calcite is associated with fluorspar at one locality on the adit level. (See pl. 47.)

The Burro Chief deposit is now being developed at a depth 800 feet vertically below the surface outcrop of the vein (see pl. 48, cross section A–A′), and shows no evidence of any change in the mineralization with depth. Except for the fact that the soft fluorspar breccia is more compact at lower levels, no change is apparent in the character or tenor of the ore. The ore certainly continues to still greater depths, and production of fluorspar from the mine should continue for many years.

SHRINE

The Shrine fluorspar deposit is on Willow Creek, near its junction with Iron Gulch, on the north side of the Burro Mountains, near the center of sec. 13, T. 19 S., R. 16 W. (See fig. 30.) The mine is 25 miles from Silver City and 12 miles from Tyrone by good all-weather roads. The property, consisting of four patented claims, the Shrine no. 1, Shrine no. 2, Shrine no. 4, and the Rome no. 2 (see pl. 50), is owned by the General Chemical Division of the Allied Chemical & Dye Corp., which purchased the property in 1942, as the General Chemical Co., and since has operated it continuously. Before 1942 the property was owned by L. L. Osmer of Silver City, who first opened the deposit in 1936 and operated it until 1942, except for a short period in 1940–41, when D. F. McCabe of Lordsburg had a lease on it.

A shaft, inclined about 55° S., extends downward for 430 feet along the dip of the vein. Seven levels have been driven both east and west of the shaft along the vein, and the ore stoped out between levels. The upper levels have been backfilled and are inaccessible. The vein has been followed a maximum of 325 feet east and 600 feet west of the shaft underground and an additional 100 feet both east and west on the surface.

In the vicinity of the Shrine mine there are pre-Cambrian granites of three distinct varieties. A coarse-grained hornblende granite is intruded by a medium-grained biotite granite, which in turn is intruded by small bodies of an extremely coarse porphyritic granite and aplite dikes. The porphyritic granite contains large orthoclase crystals, some quartz, and chloritized biotite. An andesite porphyry plug, intensely altered to chlorite and epidote, epidotized basalt and diabase dikes, and a quartz monzonite porphyry dike intrude the granites. Tertiary rhyolite flows of two types overlie the older rocks; and latite, quartz latite, and rhyolite dikes related to the flows as apophyses, or feeder dikes, cut the older rocks and some of the flows. (See pl. 50.)

The fluorspar occurs along a fault striking N. 75° W. and dipping 46° to 68° S. This fault cuts the granites, the andesite porphyry plug, the rhyolite flows, and the latite, quartz latite, and rhyolite dikes. The vein narrows perceptibly where it passes through the plug, and it appears to widen where both walls are granite rather than rhyolite. The fluorspar occurs within a breccia and gouge zone on the south or hanging-wall side of the fault. The ore shoots widen where the gouge and breccia zone narrows, and vice versa. The shoots are as much as 10 feet wide and 500 feet long. They appear to be controlled by irregularities along the fault surface and by the porosity and composition of the wall rock.

The ore consists of clear green granular crystalline fluorite and only small amounts of quartz. Locally the vein contains pyrite and traces of gold and silver. Pyrite is also abundant in some of the rhyolite dikes and flows adjacent to the vein. Above the 335-foot level in the mine the ore averaged 72 percent CaF_2, but below that level the average grade is slightly less.

Subparallel veins, 400 and 600 feet north of the main fluorspar vein, contain abundant quartz and pyrite, some gold, and traces of fluorite.

CALIFORNIA GULCH

The California Gulch deposits are on the north side of the Burro Mountains in the NE¼ sec. 17, T. 19 S., R. 15 W. (See fig. 30.) Most of the deposits are on the ridge west of California Gulch, but one deposit is east of the gulch. Some of the deposits are on the Fluorspar Lode patented claim, owned by A. A. Leach of Lordsburg, and the rest are on unpatented claims owned by R. P. Thompson of Tyrone. In October 1949 the deposits on the west side of the ridge west of California Gulch were under lease to the Morrow brothers of Lordsburg, who built a road to the property and were contemplating sinking a shaft, and Thompson was driving an adit on the small deposit shown near the lower right corner of the map. (See pl. 51.) Small pits, trenches, and shallow shafts are the extent of the workings on the properties.

The steep granite hillsides are thickly covered with talus, and exposures of fluorspar are rare; the best exposures are in the pits and cuts that have been excavated along the veins. Thus, the exact relationships of the various deposits to one another and the alinement and correlation of one deposit with another are not known. Most of the individual veins strike slightly east of north and almost due east, but the one seemingly continuous mineralized zone strikes northwest.

Massive crystalline green and purple fluorite, commonly having octahedral crystal faces, occurs in veins 6 inches to 3 feet wide and as masses and small stringers within breccia zones as much as 30 feet wide in the granite. The abundance of purple fluorite is characteristic of the deposits. A breccia of purple and green fluorite cemented by chalcedony and later light-green fluorite is also present. Quartz appears to be the only mineral associated with the fluorite in the deposits west of the gulch, but copper-bearing minerals (described below) occur near the deposit on the east side of the gulch in the southern part of the area. (See pl. 51.)

At an old inclined shaft 115 feet east-southeast of the old Thompson copper shaft east of California Gulch, fluorspar is associated with copper minerals. Two faults in granite, dipping 40° to 60° S. 62° E. are separated by 2 to 6 feet of breccia that has been silicified and mineralized by copper- and iron-bearing solutions. The breccia contains malachite, chrysocolla, limonite, and hematite. A vein of fluorspar 2 to 8 inches wide occurs along the lower side of the breccia zone, just above the fault. Below the fault is a 2- to 3-inch gouge zone. Fluorspar also occurs as small lenses along the underside of the uppermost fault, above the breccia zone, and as encrustations around some of the breccia fragments. The fluorite is fine- to medium-crystalline, banded, columnar, and light green, purple, or pale violet. Chalcedony and chrysocolla are associated minerals. No primary copper minerals were observed, but pyrite was found on the dump. Fluorspar is exposed along the same vein at the inclined shaft 60 feet to the southwest, and specimens of fluorite associated with chalcedony and chrysocolla were found on the dump of the vertical Thompson shaft. Although fluorspar and copper-bearing minerals are common throughout the Burro Mountains, this is the only locality known, except the Burro Chief mine, where they are found in such close proximity.

The California Gulch area, particularly that part on the ridge west of the gulch, is a promising one for additional exploration.

SPAR HILL AND PINE CANYON

The Spar Hill and Pine Canyon fluorspar deposits are on the west side of the Burro Mountains in the S½ sec. 27, T. 19 S., R. 16 W., about 27 miles by road from Lordsburg and 29 miles by road from Silver City. (See fig. 30.) Access is over partly graded and partly ungraded roads. The properties are owned by Marshall N. Kuykendall of Lordsburg.

The Spar Hill deposit was first opened by Mr. Kuykendall in 1941. An inclined shaft 40 feet deep, a drift extending 90 feet southwest from a point near the bottom of the shaft, a large glory hole, and numerous pits and trenches constitute the workings on the deposit. A few shallow trenches are the extent of the workings on the Pine Canyon deposit. About 800 tons of fluorspar was shipped from the Spar Hill deposit between February 1942 and March 1944. No shipments have been made from the Pine Canyon deposit.

Two or three rhyolite dikes intrude the granite in the vicinity of the Spar Hill deposit. (See pl. 52.) The fluorspar is along a fault that strikes N. 60° E., dips 70° NW., and cuts the granite and rhyolite.

The fluorspar is more abundant where one or both walls of the fault zone are granite.

A prominent slip face forms the southeast side of the fault zone, and a fault breccia consisting of fragments of granite, rhyolite, and andesite cemented by fluorspar lies immediately northwest of this prominent slip face. This breccia zone is 20 feet wide in the vicinity of the shaft. Northwest of the breccia zone the granite is greatly shattered and argillized and the cracks and crevices are filled with fluorspar veins as much as 6 inches wide. The shattering is more intense closer to the breccia, and the quantity of fluorspar relative to the country rock varies inversely with the distance from the fault.

The fluorite is predominantly purple in the area where the wall rock is granite but is predominantly green where the wall rock is rhyolite. Quartz is the only mineral other than fluorite that is present. Two or three stages of fluoritization alternating with silicification took place.

The mineralized zone at Spar Hill can be traced for about 500 feet along the strike, and the width of minable ore has great range. In the vicinity of the shaft and the glory hole, ore has been mined over a width of at least 30 feet. Southwest of the shaft, where the fluorspar occurs within the rhyolite, the ore zone is much narrower and the fluorspar more siliceous. Numerous small veinlets subparallel to the main breccia zone occur northwest of the main zone.

The Pine Canyon deposit is about 0.5 mile southwest of Spar Hill and probably is along the same mineralized zone. (See pl. 52.) The country rock here consists of granite, intruded by an andesite or fine-grained diorite dike or plug, small monzonitic masses, and rhyolite dikes. The fluorspar occurs in numerous small subparallel veins and stringers intimately associated with quartz. It cuts all of these rock types, but is more widespread in the granite. None of the veins is wide enough to be mined commercially.

LONG LOST BROTHER

The Long Lost Brother fluorspar deposits are northwest of the Burro Mountains proper, in the SE¼ sec. 14, T. 19 S., R. 17 W. (See fig. 30.) The deposits are owned by Charles Ray and Sid Watson of Lordsburg, who operated them for a short time in 1943–44. The 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 fluorspar occurs in veins, along two subparallel nearly vertical faults striking N. 45° E. and N. 45° to 65° E. that cut mica schist and granite of pre-Cambrian age and andesite dikes of pre-Tertiary age. (See pl. 53.) 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 indicate near-surface and low-temperature deposition and suggest that the deposits were probably associated with hot springs.

MONEYMAKER

The Moneymaker fluorspar deposit, owned by Charles Russell of Tyrone, is in secs. 19 and 30, T. 20 S., R. 15 W., 22.5 miles southwest of Silver City, and 0.5 mile north of State Highway 180, at the foot of the south side of the Burro Mountains. (See fig. 30.) The deposit is on the Moneymaker no. 1 and no. 2 and the St. Patrick no. 1 and no. 2 claims. (See pl. 54.) Numerous shallow cuts and shafts have been excavated on the property, which has been worked by Russell intermittently since 1939. A total of about 300 tons of fluorspar averaging approximately 50 percent CaF_2 has been shipped.

The main fluorspar exposures can be readily divided into two groups, those on the Moneymaker claims and those on the St. Patrick claims. If the dip of the fluorspar is taken into consideration, it will be seen that these two groups of exposures are almost alined and are probably along the same vein. (See pl. 54.) The fluorspar on the Moneymaker claims occurs in granite along a fault that strikes N. 65° E. and dips 65° SE. The fault has a pronounced bend in the vicinity of the workings on the Moneymaker 1 claim, and the width of the fluorspar vein increases greatly within this bend. The fluorspar vein is divided into two component parts: a nearly continuous zone 800 feet long and 2 to 8 feet wide of coarsely crystalline fluorite and much quartz, and a breccia zone containing fragments of silicified granite and rhyolite cemented by fluorite and quartz. This breccia zone is on the south side of a fault that separates it from the coarsely crystalline fluorspar. It ranges greatly in width, but the amount of fluorspar decreases outward from the fault. The breccia is exposed only within the bend of the vein, but northeast of the exposures it may be present though obscured by float. Adjacent to the fluorspar vein on the north is a wide silicified zone which probably represents a major fault zone.

The exposure of fluorspar on the St. Patrick claims occurs along the southeast side of a silicified fault zone. The fluorspar vein, as exposed for more than 60 feet along the strike and 20 feet in depth, consists of coarsely crystalline green fluorite and quartz. The vein strikes N. 55° E. and dips 53° SE.

Fluorspar crops out at intervals along the vein for about 2,000 feet northeast of the most easterly workings, but southwest of the exposures on the St. Patrick claims the vein is covered by Recent fill.

The fluorspar is a green, granular coarsely crystalline aggregate containing abundant quartz. Clear quartz crystals as much as an inch or more in length, coated with a thin film of white opaque quartz, are characteristic of the deposit and are intimately associated with the fluorite. Small amounts of pyrite and galena are present in the silicified zone adjacent to the vein. A large quartz vein, which was extensively worked for copper and gold in the 1900's, is 150 feet west of the portal of the tunnel in the northwest corner of the mapped area (pl. 54 shows location of portal). This vein is probably a continuation of the silicified zone adjacent to the fluorspar vein. Pyrite, galena, chalcopyrite, bornite, covellite, gold, and silver are present in this vein, but no fluorite has been found.

Dikes of rhyolite, andesite, and dacite occur within the area. Although no fluorspar was found cutting the rhyolite, the presence of rhyolite breccia in the fluorspar vein and the involvement of rhyolite in the fault along which the fluorspar occurs indicate the post-rhyolite age of the fluorspar.

BLUEBIRD

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. (See fig. 30.) 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 Lordsbürg. Numerous narrow stopes that open to the surface, shafts, and shallow pits have ben excavated along the vein for a total distance of 2,050 feet. (See pl. 55.)

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 85° 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 fractures 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 occurs 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.

CONTINENTAL, AMERICAN, DOUBLE STRIKE, JAP RANCH, AND WINDMILL

South of the Burro Mountains, in T. 22 S., R. 15 W. (see fig. 30), is a series of fluorspar deposits, the Continental, JAP Ranch, American, Windmill, and Double Strike. (See pl. 56.) All occur in pre-Cambrian granite and are obviously related. They occur along, or are closely associated with, the Malone fault and are similar mineralogically. The Continental (see pl. 57), American (see pl. 58), and Double Strike (see pl. 59) deposits have been worked for both fluorspar and gold and are explored by numerous shafts, open pits, and trenches. The other two are small and are explored only by shallow workings.

These fluorspar deposits are obviously the ones referred to by Johnston (1928, 103–105) and Rothrock (1946, p. 67) as small fluorspar veins occuring "on Young Bound's ranch" in T. 23 S., R. 15 W., Johnston's description of a shaft and trench situated about a mile northeast of Bound's ranch is a description of the American fluorspar deposit.

The Double Strike deposit, formerly known as the Valley Spar deposit, was first opened for gold in the early 1920's, but fluorspar was mined during World War II. Some of the shafts are 50 to 60 feet deep. Some fluorspar was produced from the American mine during World War I, and one carload was shipped by Ira Wright of Silver City in the early 1930's. The deposit was also worked for gold, but the gold content was too small for continued operation. Fluorspar was again produced during World War II and has been mined sporadically since. In 1949 two diamond-drill holes were put down by R. W. Mathis of Silver City to explore the vein at the American mine. At the Continental deposit fluorspar was produced during World War II and probably earlier from two shafts along the vein. There has been no production from the JAP Ranch or Windmill deposits. No production figures are available for any of these properties, but the total amount of fluorspar produced probably did not exceed 2,000 tons. The workings, with the exception of the shaft at the American mine, are inaccessible.

The Continental fluorspar deposit (sec. 27, T. 22 S., R. 15 W.) has been explored by three shafts and many trenches. The central and northernmost shafts extend to a depth of about 50 feet but the southernmost shaft is only 20 feet deep. The fluorspar occurs at intervals through a distance of 3,200 feet in veins associated with silicified gouge and breccia along a prominent fault.

The fault has many bends, splits, and branches but trends roughly north and dips 60° to 85° E. The fault extends through pre-Cambrian granite and lenses of pre-Cambrian schist and quartzite, and through middle-Tertiary volcanic rocks. At the southernmost shaft the fluorspar is between the granite and the volcanic rocks, thus indicating that it is postmiddle-Tertiary.

The fluorite is clear green or yellow-green coarsely crystalline and commonly has etched cubic crystal faces. Quartz is the only mineral associated with the fluorite. Scheelite is present in a quartz vein within schist 600 feet west of the fluorspar vein.

At the American fluorspar deposit (sec. 15, T. 22 S., R. 15 W.) the fluorspar occurs in veins and breccia zones along faults that strike approximately N. 20° E. to N. 35° W. These faults are splits off the footwall side of the Malone fault and are all on the southwestern side of the Malone fault within the pre-Cambrian granite. Pegmatite, aplite, diabase, and rhyolite dikes intrude the granite. Tertiary volcanic rocks are on the northeast side of the Malone fault and a few isolated remnants of the volcanic rocks cap the granite southwest of the fault.

The fluorite is most abundant within 300 feet of the Malone fault and has not been found farther than 700 feet from the fault. The veins are as much as 3 feet in width and the breccia zones as much as 30 feet.

A shaft inclined 55° N. 65°E. has been sunk about 100 feet down the dip of a breccia zone. About 85 feet from the entrance drifts have been driven 30 feet both northeast and southwest. The fluorspar occurs as almost pure coarsely crystalline green fluorite occupying veins about a foot wide on both the hanging wall and footwall of the zone and as the cementing material, with quartz, of the breccia between the high-grade veins. The fluorite content of the breccia is about 35 percent. The total width of the zone at the collar of the shaft is 15 feet.

Two prominent veins have been explored by trenching. One, about 40 feet northeast of the shaft, strikes N. 15°–20° E. and dips about 65° SW. The vein consists of 1½ to 2 feet of coarsely crystalline green fluorite with very little diluent and has been mined to a depth of about 40 feet. The other vein is about 1,000 feet southeast of the shaft. The fluorspar here is similar to that in the trench near the shaft. It is as much as 3 feet wide and can be traced for about 450 feet along the strike. The vein strikes N. 5° E. to N. 15° W. and dips 75° E.

In the area shown near the southeastern edge of the map (pl. 58) small fluorspar veins cut a rhyolite and a diabase dike, affording evidence of the late age of the fluorite. Elsewhere in the Burro Mountains area the rhyolite dikes are known to be late Tertiary in age.

At the Double Strike fluorspar deposit (sec. 4, T. 22 S., R. 15 W.) the fluorspar occurs within three silicified fault gouge and breccia zones 1 to 4 feet wide in pre-Cambrian granite. Two of these are subparallel in echelon zones that trend roughly north. The westernmost of the two zones dips 75° E. but the easternmost zone ranges in dip from 75° W. to 80° E. The third zone trends northeast, dips 76°–80° NW., and links the two subparallel zones. Small branches split off from the main zones.

The fluorspar occurs in lenses along the zones, either as veins cutting the silicified gouge and breccia or as an integral part of the breccia. Two types of fluorite are present: an earlier purple or dark green coarsely crystalline fluorite, and a later pale green or white fluorite showing excellent crystal form. Good crystals of the late fluorite are abundant and exhibit a cubic habit modified by the dodecahedron and commonly by tetrahexahedrons and hexoctahedrons.

The JAP Ranch fluorspar deposit is explored by three small pits in granite adjacent to and west of the Malone fault in sec. 26, T. 22 S., R. 15 W. The small veins, which strike north to N. 20° E. and dip 65°–80° E., contain a few inches to a foot of clear green coarsely crystalline fluorite having good cube and dodecahedral crystal faces, and quartz. The deposit is small and the fluorspar cannot be traced more than 100 feet along the strike of the veins.

The Windmill deposit (sec. 9, T. 22 S., R. 15 W.) in pre-Cambrian granite is along an extension of the mineralized zone of the Double Strike deposit. The fluorspar at this locality is exposed in a small trench and in a well that was sunk originally as a shaft on the fluorspar. The exposure is limited to about 100 feet along the strike and reportedly narrows to a few inches at a depth of about 20 or 30 feet. At the surface, the fluorspar is in a breccia zone about 2 feet wide. It is green, coarsely crystalline, strikes N. 5° W., and is vertical.

GRANDVIEW, BOUNDS, FENCE LINE, AND GRANT COUNTY

The Grandview, Bounds, Fence Line, and Grant County fluorspar deposits (fig. 30) are small deposits that are 2 to 4 miles southwest of the Malone fault, south of the Burro Mountains.

The Grandview deposit, in secs. 13 and 24, T. 22 S., R. 16 W., is 4 miles southwest of the Malone fault. A few small pits and an inclined shaft 30 to 40 feet deep have been excavated along a fluorspar vein that strikes N. 45° E. and dips 60° SE. in granite. The fluorspar occurs as a vein of clear green coarsely crystalline fluorite 2 feet wide and as a zone 1 to 2 feet wide of disseminated fluorite in granite on the footwall side of the vein. About 100 feet northeast of the shaft a diabase dike strikes N. 45° W. The fluorspar occurs in the diabase only as narrow stringers less than 6 inches wide. About 400 feet north of the shaft, across the section line, a trench more than 100 feet long exposes numerous veins of fluorspar 1 inch to 1 foot wide cutting the granite and the diabase. Some of the fluorspar is a fluoritized and silicified breccia, similar to that at the Double Strike and Continental fluorspar deposits.

The Bounds fluorspar deposit is in the SE¼ sec. 20, T. 22 S., R. 15 W. Coarsely crystalline green fluorite occurs as a vein 1 to 2 feet wide in granite. The vein strikes N. 15° E., dips very steeply east, and can be traced for about 300 feet on the surface. Smaller veins crop out nearby. Two shafts, 40 to 50 feet deep, have been sunk along the main vein. A rhyolite dike, trending northeast, cuts the granite 500 feet east of the shafts.

The Fence Line fluorspar deposit, in the extreme SE. cor. sec. 6, and the NE. cor. sec. 7, T. 22 S., R. 15 W., and the Grant County fluorspar deposit in the NE¼ sec. 8, T. 22 S., R. 15 W., are along the same mineralized zone. A wide valley filled with Recent gravels separates the two deposits. The fluorspar occurs as coarsely crystalline green fluorite veins in granite. Two shallow trenches have been excavated along one of the veins at the Fence Line deposit, and at the Grant County deposit four subparallel veins have been exposed in many trenches. The veins strike about N. 25° W. and dip about 60° NE. Diabase dikes, trending N. 45° W., cut the granite at the Grant County deposit.

LANGFORD AND HINES

The Langford and Hines fluorspar deposits (fig. 30) are small and unimportant economically, but are of interest because of the uranium minerals that are associated with the fluorspar. The Langford fluorspar deposit is in the S½ sec. 25, T. 22 S., R. 16 W., and the Hines fluorspar deposit is in the NE¼ sec. 34, T. 21 S., R. 14 W.

The fluorspar at the Langford deposit is in granite in a silicified breccia zone 5 feet wide that strikes N. 15° W. and dips 62° NE. The fluorite is dark purple, fine grained, and occurs as incrustations and as veinlets less than an inch in width between the breccia fragments. It is associated with quartz and calcite. Uranium minerals also occur within the breccia zone, and apparently are concentrated in the vicinity of the fluorite. Only a few crystals of autunite have been seen, however. Possibly the primary uranium-bearing mineral is within the dark purple fluorite. Rhyolite dikes striking northeast cut across diabase dikes striking northwest at a point a quarter of a mile south of the deposit.

At the Hines deposit, the fluorspar is in quartzite of the Bliss (?) sandstone within 300 feet of the pre-Cambrian granite. A diabase dike trending northwest cuts the granite, but its relationship to the quartzite is not clear. The fluorspar is in a zone of shattered rock that strikes about N. 70° E. and dips steeply southeast. The fluorite is dark purple, finely crystalline, and is in veins 1 inch to 1 foot wide. The uranium minerals, autunite and possibly uranophane, occur along the fractures in the quartzite within a few inches of the fluorite, but no uranium minerals were found in contact with the fluorite. The vein has been exposed for a depth of 15 feet. About 50 feet to the east a pit has been sunk on a parallel vein containing tungsten and molybdenum.

OTHER FLUORSPAR DEPOSITS

The Ace High fluorspar deposit is in the SE¼ sec. 28, T. 18 S., R. 15 W., 4½ miles northwest of Tyrone, on the east side of the Mangas Valley at the foot of the west scarp of the Little Burro Mountains. (See fig. 30.) Two pits, 300 feet apart, were excavated on the vein by R. Y. Chambers in 1948. In the nothernmost pit the vein strikes N. 35° W., dips 85° SW., and can be traced southeast for 160 feet. In the southernmost pit the vein strikes N. 75° W. and dips 75° N. The two pits are not along the same vein. Small fluorspar stringers are present south of the southernmost pit and also in the canyon northwest of the northernmost pit. The fluorspar occurs as small veinlets in a breccia zone in siltstones and arenaceous shales of the Colorado shale of Late Cretaceous age. Jasper and quartz are associated with the fluorite. The deposits are very close to the conspicuous Mangas fault and are probably associated with it.

The Oak Grove deposit is on the east side of the Burro Mountains in the eastern part of sec. 36, T. 19 S., R. 15 W., a few hundred yards west of State Highway 180 at a point 12½ miles southwest of Silver City. (See fig. 30.) A small pit 10 feet deep exposes a vein of fluorspar 1 foot wide striking N. 70° E. and dipping 60° N. The vein cannot be traced more than a few yards in either direction and it narrows downward. The fluorspar is localized in granite along an opening at an irregularity along the fault.

The Knight Peak fluorspar deposit is near the center of sec. 29, T. 20 S., R. 16 W., southwest of the Burro Mountains. (See fig. 30.) Green and purple fluorite and white calcite occur in a small vein 8 inches wide exposed in two small pits 25 feet apart. The vein strikes slightly north of east and dips 35° S. The country rock is rhyolite, part of the complex of Tertiary volcanic rocks that stretch in a broad northwest-trending belt across the area south and west of the Burro Mountains. A small basalt dike cuts the flows 30 feet north of the vein. The fluorspar vein is about 1,000 feet east of the Malone fault.

The Accident fluorspar deposit in the SE¼ sec. 22, T. 20 S., R. 16 W. (see fig. 30) and the Rustler Canyon fluorspar deposit in the SW¼ sec. 10, T. 20 S., R. 16 W. (see fig. 30), both on the southwest side of the Burro Mountains, are small veinlets of green fluorspar in granite.

The Gardner prospect near the center of sec. 26, T. 19 S., R. 16 W., near the head of Willow Creek (see fig. 30), consists of small veinlets of fluorspar in hornblende granite. The veinlets strike N. 60° E. and may be the northeastward continuation of the zone along which the Spar Hill and Pine Canyon deposits lie.

A vein geologically similar to the Moneymaker vein, but of much more limited extent, is about half a mile north of the Moneymaker vein in the SW¼ sec. 19, T. 20 S., R. 15 W. (See fig. 30.)

The Malpai Tanks deposit is southeast of the Burro Mountains in the NE¼ sec. 26, T. 20 S., R. 14 W. (See fig. 30.) A small vein, 6 to 8 inches wide, occurs along a mineralized zone in granite. The granite at this locality contains numerous pegmatite dikes, but the fluorspar is not associated with the pegmatites. The fluorspar vein is within 200 yards of an old silver mine, and fluoritization may have been related to the silver mineralization.

The Purple Heart fluorspar deposit, owned by John Harrison of Silver City, and the Clover Leaf fluorspar deposit, owned by R. Y. Chambers of Silver City, are northwest of the Burro Mountains in sec. 3, T. 18 S., R. 17 W., about 1½ miles southeast of the confluence of Wild Horse Creek and the Gila River. The locations of the deposits are shown on the map (see fig. 30), but a detailed study of them was beyond the scope of this report. The Purple Heart deposit has been operated since its discovery in 1947, and through 1949 had produced about 400 tons of fluorspar analyzing 80 to 85 percent CaF_2. Two shafts have been sunk on subparallel veins of fluorspar in granite. Shaft 1 extends to a depth of 65 feet and shaft 2 to a depth of 100 feet. In the spring of 1949 drifts on the 100-foot level of shaft 2 extended about 50 feet northwest and southeast of the shaft. At shaft 1 the vein strikes N. 47° W., dips 65° NE., and is about 5 feet wide. According to Mr. Harrison, fluorspar crops out at intervals along the vein for about 500 feet northwest and 2,000 feet southeast of the shaft. The fluorite is green and purple and is associated with quartz and calcite. At shaft 2 the vein strikes N. 40° W. and dips about 88° SW. It can be traced 200 feet southeast and 500 feet northwest of the shaft. The vein is 8 to 10 feet wide on the 100-foot level. The fluorspar occurs as seams, fillings, and crustiform masses surrounding granite boulders within a breccia zone. Much of the fluorspar has been crushed and is mixed with clay and manganese oxide. The wall rock and the granite boulders within the breccia zone are intensely argillized. Lenses of schist occur within the granite in the vicinity of the mine and one of the lenses is exposed within the mine at the southeast end of the drift. The fluorspar vein becomes narrow where it extends through the schist.

The Clover Leaf deposit is about half a mile southwest of the Purple Heart shafts. When visited by the author in the spring of 1949 a vein 6 feet wide of green and purple fluorite and considerable quartz was exposed in a pit 10 feet deep. The vein strikes north, is almost vertical, and can be traced for about 500 feet on the surface. Numerous small fluorspar veins striking N. 35° to 45° W. crop out between the Purple Heart and Clover Leaf deposits.

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