



Mineral deposits and structural pattern of the Big Burro Mountains, New Mexico

Elliot G. Gillerman

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MINERAL DEPOSITS AND STRUCTURAL PATTERN OF THE BIG BURRO MOUNTAINS, NEW MEXICO

By

ELLIOT GILLERMAN

The University of Kansas

Mineral deposits in the Big Burro Mountains are dominated by the Tyrone ore body. Smaller deposits of copper, gold, fluor spar, uranium, and other commodities, however, have been mined in the past. Structural features are most important in the localization of the ore bodies, lithology being only of minor importance. A knowledge of the structural pattern and the tectonic history of the area is basic to an understanding of the distribution and character of the various deposits, and is a necessary prerequisite to future exploration. The different types of mineralization present in the mountains, their age, distribution, and relationships to igneous intrusions are discussed within the tectonic framework as determined by an empirical analysis of faults, fractures, and intrusive activity. A brief description of the lithology is included as necessary background for the discussion of structure and mineral deposits.

LITHOLOGY

The Big Burro Mountains consist mostly of granite, quartz diorite, and associated rocks of the Precambrian Burro Mountain batholith. The Tyrone stock, smaller plugs and numerous dikes, intrude this complex. An isolated area of volcanic rocks crop out within the Big Burro Mountains, and volcanic rocks and Cretaceous sedimentary rocks overlie the Precambrian rocks in the Little Burro Mountains, and north of the Big Burro Mountains. Gila Conglomerate and Recent gravels fill some of the valleys. Small isolated masses of Precambrian metamorphic rocks of the Bullard Peak series, which antedate the intrusion of the batholithic rocks, occur along the Mangas fault in the Little Burro Mountains, in the southern Big Burro Mountains, and are extensively exposed in the northern Big Burro Mountains.

Rocks of the batholithic complex are mostly granite, but extensive areas of quartz diorite occur, particularly in the northern part of the mountains (Gillerman, 1964, p. 14; Hewitt, 1959, p. 65). The granite is not homogenous and although several variants have been recognized, little detailed work has been done and at present only one variant is distinguished as a separate unit. The quartz diorite is the oldest rock of the batholithic complex and the Shrine granite (the separated variant), predates the heterogeneous Burro Mountain granite.

QUARTZ DIORITE

Quartz diorite, including quartz diorite gneiss (Gillerman and Whitebread, 1956, p. 288; Gillerman, 1964, p. 14) and tonalite (Hewitt, 1959, p. 65), crops out extensively in the northern part of the Big Burro Mountains and is the

oldest rock unit within the batholithic complex. The rock is white to pinkish-gray, coarse-grained, porphyritic, and has a distinct foliated structure. It weathers tan, and outcrops are generally rounded and characterized by a knobby surface due to the projecting feldspar phenocrysts.

The rock consists of euhedral to subhedral pinkish-gray crystals of andesine up to 5 cm in length set in a coarse-grained matrix of smaller crystals of andesine, oligoclase, quartz, and biotite. The plagioclase feldspars constitute about 45-50 percent of the rock, biotite 25-30 percent, and quartz 15-20 percent. Hornblende (2-3 percent) and microcline are minor constituents; apatite, zircon and magnetite occur as accessory minerals. Chlorite and sericite are alteration products of biotite and the plagioclase feldspars respectively.

The biotite occurs as aggregates of small flakes between the feldspar crystals. Individual flakes and aggregates are parallel to subparallel and impart a distinct foliation to the quartz diorite. The andesine crystals are oriented parallel to the foliation and have a distinct linear trend. The long axes of hornblende crystals also are oriented parallel to this foliation but there is no preferred linear direction. In the vicinity of the Black Hawk mine in the northern Big Burro Mountains, the foliation dips steeply to the northwest, but this regional dip is modified contiguous to older metamorphic rocks.

The foliation is believed to be a primary flow structure, the result of emplacement of the rock as a semi-solid mush of biotite and andesine crystals. Twisted and bent lamellae of andesine support such a hypothesis. Presence of two plagioclase feldspars, the more calcic as phenocrysts and the more sodic intergrown with quartz in the matrix, suggest a rock which was partially crystallized at depth and subsequently emplaced higher in the crust where crystallization was completed. Stresses may have existed during emplacement or perhaps slightly after solidification, but the foliation is a result of the emplacement history. The local deflection of the regional dip of the foliation around xenoliths, protrusions, roof pendants, and near the walls of the emplacement chamber is additional evidence supporting the interpretation of the foliation as primary flow structure.

SHRINE GRANITE

A light-gray to grayish-black, coarse-grained, equigranular, hornblende granite crops out along Willow Creek in the vicinity of the Shrine Mine in sec. 13, T. 19 S., R. 16 W.

in the northeastern part of the mountains. Mafic minerals constitute about 15 percent of the rock, with hornblende predominating over biotite. Grayish-pink potassium feldspar and quartz are the other major constituents. The granite is mineralogically distinct from other granites observed in the Big Burro Mountains and is intruded by Burro Mountain granite. The distinct mineralogy and the definitive intrusive relations warrant distinguishing this as a separate rock unit from the rest of the granite in the Big Burro Mountains.

BURRO MOUNTAIN GRANITE

Granite, which comprises about 90 percent of the batholithic complex, occupies the greater part of the Big Burro Mountains, forming the high central peaks as well as the lower flanking hills and the sloping plain south of the main mountainous mass. It is characterized by its variancy rather than its homogeneity, and no detailed petrographic or field studies have been made to analyse statistically the different variants. Designated as Burro Mountain granite, the rock differs locally in color, texture, mineral and chemical composition, degree of weathering and alteration, fracturing and jointing, and topographic expression. These differences are in part due to the normal variations in a rock mass which crops out over such a large area. They may also be due, however, to local differentiation within the magma chamber, to the inclusion and assimilation of the invaded rock, to differences in depth of erosion, to separate pulses of intrusion from the same parent magma, or to possible separate intrusions widely spaced in time and originating from different parent magmas.

The granite is typically a medium- to coarse-grained, equigranular rock, but it is locally porphyritic with phenocrysts of euhedral feldspar up to 5 cm in length. The color is commonly pink, light tan, orangish-brown, or gray-orange. Where altered, the rock is bleached light gray or white, or if iron oxide is abundant, dark red. The granite consists mostly of quartz and potassium feldspar, with smaller amounts of plagioclase feldspar and mafic minerals. Quartz constitutes 25-40 percent of the rock and occurs as irregular masses filling the interstices between the feldspar grains. Where the rocks have been intensely altered, the irregular shape of the quartz is of particular value in distinguishing granite from quartz monzonite and other quartzose intrusive rocks.

Microcline is the principal potassium feldspar, but orthoclase occurs in some places, and both feldspars have been observed together. Much of the microcline is microperthite. In porphyritic varieties, the microcline occurs as euhedral crystals up to 5 cm long; elsewhere it is anhedral to subhedral. The large microcline phenocrysts are poikilitic, with inclusions of quartz, plagioclase, biotite, and accessory minerals. An excellent example of the porphyritic granite, with large microcline (and plagioclase) phenocrysts is exposed in the vicinity of the old Copper King shaft, 2,000 feet southwest of the Azure Turquoise pit, 11/2 miles west of Tyrone.

Most of the plagioclase occurs in the microperthite, and it is megascopically unimportant except locally. The large amount present in the perthite, however, results in it being

an important constituent of the rock. Hewitt (1959, p. 68) calculates 12-29 percent oligoclase in granite in the northern Big Burro Mountains, and Somers (1916, p. 610) states that "in the granite as a whole, plagioclase is usually more abundant than orthoclase." Where identified, it appears to be oligoclase.

Mafic minerals constitute up to 10 percent of the rock, but in places are essentially absent and the rock approaches an alaskite. Where present, biotite is predominant, mostly to the exclusion of hornblende. Accessory minerals are sphene, zircon, tourmaline, apatite, magnetite, rutile, ilmenite, and allanite.

Hydrothermal alteration and weathering is widespread in the granite. The feldspars are argillized, but near mineralized areas, they are more commonly sericitized and silicified. Biotite is altered to chlorite or sericite and hornblende is altered to chlorite or epidote. Limonite staining is common. The granite weathers to a soft crumbly rock and eventually to a gravelly soil, except where it has been silicified along faults, fractures, or mineralized zones.

Paige (1922, p. 11) describes several variants of the granite, and Gillerman (1952, p. 265) also has observed differences in granites, partially based on the presence or absence of some of the accessory minerals. Hewitt (1959, pp. 66-69) also describes several separate variants. Insufficient study has been done to be able to describe the relationships between the different types.

RHYOLITE

Rhyolite plugs and associated dikes intrude the Burro Mountain granite in the vicinity of White Signal in the southeastern Big Burro Mountains. The plugs form prominent hills that rise as much as 350 feet above the surrounding countryside. Many of the dikes also are topographically prominent, standing up as discreet dike-like walls or forming the cores of ridges.

The rhyolite forming the plugs and associated dikes and apophyses ranges in texture from felsitic to porphyritic with phenocrysts locally constituting as much as 50 percent of the rock mass. Most of the rhyolite, however, is a fine-grained, dense, hard, light-gray rock with a few small quartz and potassium feldspar phenocrysts. Many of the feldspars are argillized and appear as soft white spots in the rock. In a few places small sericitized flakes of biotite are present. Limonite stains and limonite-filled cavities are abundant, the limonite being derived from introduced pyrite and specular hematite. Slightly vesicular rhyolite is present in some places, and flow banding, locally contorted and rope-like in appearance, is common. Rhyolite breccia is present locally along the borders of the plugs and dikes, and within the plugs. The rhyolite autoliths are angular to subangular, and commonly show flow-banding.

Numerous parallel dikes of rhyolite (and other rock types), ranging from less than a foot to over 50 feet wide, extend across the countryside northeast of White Signal north of the plugs. Individual dikes can be traced for over two miles along strike. The dike rocks are more resistant than the granite and act as the core of ridges. The rhyolite

dikes consist mostly of chalky, white, aphanitic rhyolite with a few phenocrysts of quartz, feldspar, and sericitized biotite. A few are characterized by a gray, aphanitic groundmass with phenocrysts of quartz, chloritized biotite, and reddish-brown, euhedral crystals of garnet up to 20 cm in diameter.

The age of the plugs and dikes is not known except that the plugs and most of the dikes are intruded by, and thus are earlier than, the quartz monzonite which forms the Tyrone stock. They are thus pre-Late Cretaceous or early Tertiary.

QUARTZ MONZONITE

Quartz monzonite is essentially the sole rock type constituting the Tyrone stock, which is exposed on the northeast side of the Big Burro Mountains one mile southwest of Tyrone. The stock is the largest of the small plutonic masses that intrude the batholith and occupies an area 4 miles wide and 5 miles long, elongated northeasterly. A small offset portion of the stock crops out northeast of the Mangas fault in the Little Burro Mountains, and dikes of quartz monzonite extend throughout the mountains.

The quartz monzonite is a light gray, medium-grained, equigranular or locally porphyritic, phanocrystalline rock consisting of 15-20 percent quartz, 20-25 percent orthoclase, about 50 percent oligoclase, up to 5 percent biotite and minor amounts of hornblende. Megascopic crystals of sphene are characteristic and a few megascopic crystals of apatite can be observed. Magnetite, zircon, and allanite are other accessory minerals. In many places the rock is porphyritic with many prominent poikilitic orthoclase phenocrysts up to 2.5 cm in diameter. The poikilitic crystals contain inclusions of quartz, plagioclase feldspar, biotite, magnetite, apatite, and sphene. Many are zoned, and show Carlsbad twinning. Euhedral crystals of quartz, in which the positive and negative rhombohedrons are equally developed almost to the exclusion of the prism also are common as phenocrysts and are a distinguishing criterion of the rock.

Along the northern and eastern edges of the stock, small bodies of rock that are similar to, but distinct from, the stock are present. These may be segregations near the border of the stock or they may represent separate intrusions. One type contains no sphene and only scattered biotite; another contains large plagioclase feldspar phenocrysts, hornblende, and no orthoclase; and a third is deficient in quartz. Porphyritic dikes, petrographically similar to the stock or to its border phases, traverse the stock and the granite. At least three distinct types are present: granodiorite dikes; quartz monzonite dikes containing abundant chloritized biotite and sphene; and quartz monzonite dikes containing only small scattered flakes of chloritized biotite and no sphene.

The quartz monzonite intruded the granite in Late Cretaceous or early Tertiary times. Although no contact relationships with Cretaceous rocks are present in the Big Burro Mountains, similar rock types intrude Late Cretaceous sediments in the Silver City area. Quartz monzonite from the Santa Rita stock, 25 miles northeast, has been dated at 53 ± 13 m.y. (Moorbath, Hurley, and Fairbairn, 1967, p. 232).

STRUCTURE

The Big Burro Mountains occupy the highest topographic and structural part of a complex northwesterly trending fault block. At least part of the block is tilted northeastward, and Precambrian and younger rocks constituting the block extend beneath Tertiary gravels in the Mangas Valley to the Mangas fault, which limits the block on the northeast. The Little Burro Mountains occupy a parallel northeasterly tilted block northeast of the Mangas Valley. The Mangas fault dips steeply southwestward.

The southwestern side of the Big Burro Mountain block is bounded by a narrow graben lying between the Taylor fault, which limits the Big Burro Mountain block, and the Malone fault which is the northeastern bounding fault of the Gold Hill block. A thick sequence of tilted Tertiary volcanic rocks, the Knight's Peak series, overlain by possibly as much as 2,500 feet of tilted Gila Conglomerate fill the graben. The Gold Hill block to the southwest consists of Precambrian rocks similar to those exposed in the Big Burro Mountain block, but includes many roof pendants and pods of older metamorphic rocks. Intrusive plugs or stocks are absent. It is believed to represent a higher part of the batholith than that which occupies the central Big Burro Mountains.

Within the Big Burro Mountain block, faulting and fracturing appear to have been concentrated in three distinct directions—northwesterly, northeasterly, and east-northeasterly to east. Each set is reflected and portrayed differently. They appear to be of different ages, although movement along at least the northwesterly set of shear zones has been repeated.

NORTHWEST STRUCTURES

The earliest evidence of fracturing and shearing is that furnished by northwest-trending diabase dikes, particularly numerous in the White Signal area. These are Precambrian in age and attest to the early age of the fractures and faults which they occupy. Some of the dikes appear to be emplaced along simple fractures, but others seem to fill faults. Evidence of movement, represented by slickensided and silicified walls, appears to be pre-dike. Later mineralizing solutions moving along many of these dikes however, have obscured much of the evidence.

The Walnut Creek-Uncle Sam fault lies within the block. It is apparently post-Tyrone stock intrusion in age, but pre-lead-silver mineralization and thus is believed to be older than late Tertiary.

The bounding faults of the Big Burro Mountain block, the Mangas, Taylor, and Malone faults also trend northwest. They involve Gila Conglomerate and latest movement is thus late Pliocene or Pleistocene. Within the Knights Peak graben discrepancies in dip between the Knights Peak volcanic rocks and the overlying Gila Conglomerate indicate two periods of movement during the Tertiary, one prior to the deposition of the Gila and one in

post-Gila time. Whether the Malone and Taylor faults bounding the graben are of slightly different ages or whether repeated movement occurred along one or both faults is not known. Possibly these are sites of earlier zones of weakness, and the graben may have been initiated prior to the outpouring of the volcanic rocks.

Normal faulting in late Tertiary time along the Mangas fault tilted and uplifted the Little Burro Mountains relative to at least the central, northeasterly-tilted part of the Big Burro Mountains. Probable earlier movement along this fault may have been the reverse.

EAST-NORTHEAST TO EAST STRUCTURES

The east-northeast-trending set of fractures are most prominent in the White Signal area. Numerous dikes fill fractures in the area north of White Signal and impart a distinct east-northeast grain to the geology and the topography. South of White Signal, the Blue Jay fault, prominent dikes, and the alignment of small rhyolite plugs in an east-northeasterly direction emphasize that trend. The dikes are filled with rhyolite, latite, dacite, quartz monzonite, and other rock types. With few exceptions, the youngest of the dike rocks is quartz monzonite, identical to that which forms the Tyrone stock, indicating that the fractures and faults that the dikes fill were formed prior to the Late Cretaceous or early Tertiary.

An east-trending fault of post-Gila age is exposed in California Gulch 3 miles west of Tyrone. The fault limits the northern extent of the granite and tilts the Gila Conglomerate about 50° northward. The fault dips 57° to the north. The straight trace of the granite-Gila Conglomerate contact eastward toward Tyrone suggests that the fault extends eastward probably as far as the Mangas fault. The continuation of this fault east of the Mangas fault is suggested by a valley filled with Gila Conglomerate lying between the southern terminus of volcanic rocks and the northern limits of the offset segment of the Tyrone stock.

NORTHEAST STRUCTURES

Northeast-trending faults, fractures, and shear zones are prominent in the central part of the mountains and include the major structural elements of the area excluding the boundary faults. Five major northeast-trending faults have been recognized. From southeast to northwest these are: the Sprouse-Copeland, Burro Chief, Austin-Amazon, Bismuth-Foster-Beaumont, and Osmer. The Sprouse-Copeland and Austin-Amazon faults include between them an upthrown block and the mountains are thus effectively divided into 3 blocks: the White Signal block to the southeast, the upthrown central Burro Peak-Tyrone block, and the Willow Creek block to the northwest. (cross section, Fig. 1) The central block includes the high central peaks and also the area of outcrop of the Tyrone stock; the boundary faults of this block also mark the approximate southeastern and northwestern boundaries of the stock. Emplacement of the stock in its present position is thus due largely to faulting rather than to intrusive activity.

The central Burro Chief-Tyrone block is cut by numerous fractures and shear zones in its northeasterly part. The Burro Chief fault effectively divides the northeastern part of the block into two sub-blocks. The sub-block southeast of the fault is downthrown, but the amount of displacement along the fault appears to decrease southwestward and might be slightly reversed before the central peaks are reached. Numerous fractures parallel the Burro Chief fault and it is these that are the major sites of mineralization within the mountains. They are closer spaced and more numerous southeast of the fault within the Tyrone mining district. Repeated movement through a long period of time along the Burro Chief fault is indicated by at least 3 periods of brecciation and mineralization within the Burro Chief mine. Latest movement is post-Gila Conglomerate.

The Willow Creek block, lying northwest of the Austin-Amazon fault is also a compound block, and is broken by the major Bismuth-Foster-Beaumont and Osmer faults. Parallel-trending mineralized zones indicate additional fracturing in a northeasterly direction. The Bismuth-Foster-Beaumont fault is a major structure and the zone of faulting can be traced almost continuously across the entire Big Burro Mountains. It is mineralized and silicified, but no conclusive nature of the direction or amount of movement along the fault could be obtained. It dips mostly southeasterly but in places the dip is reversed.

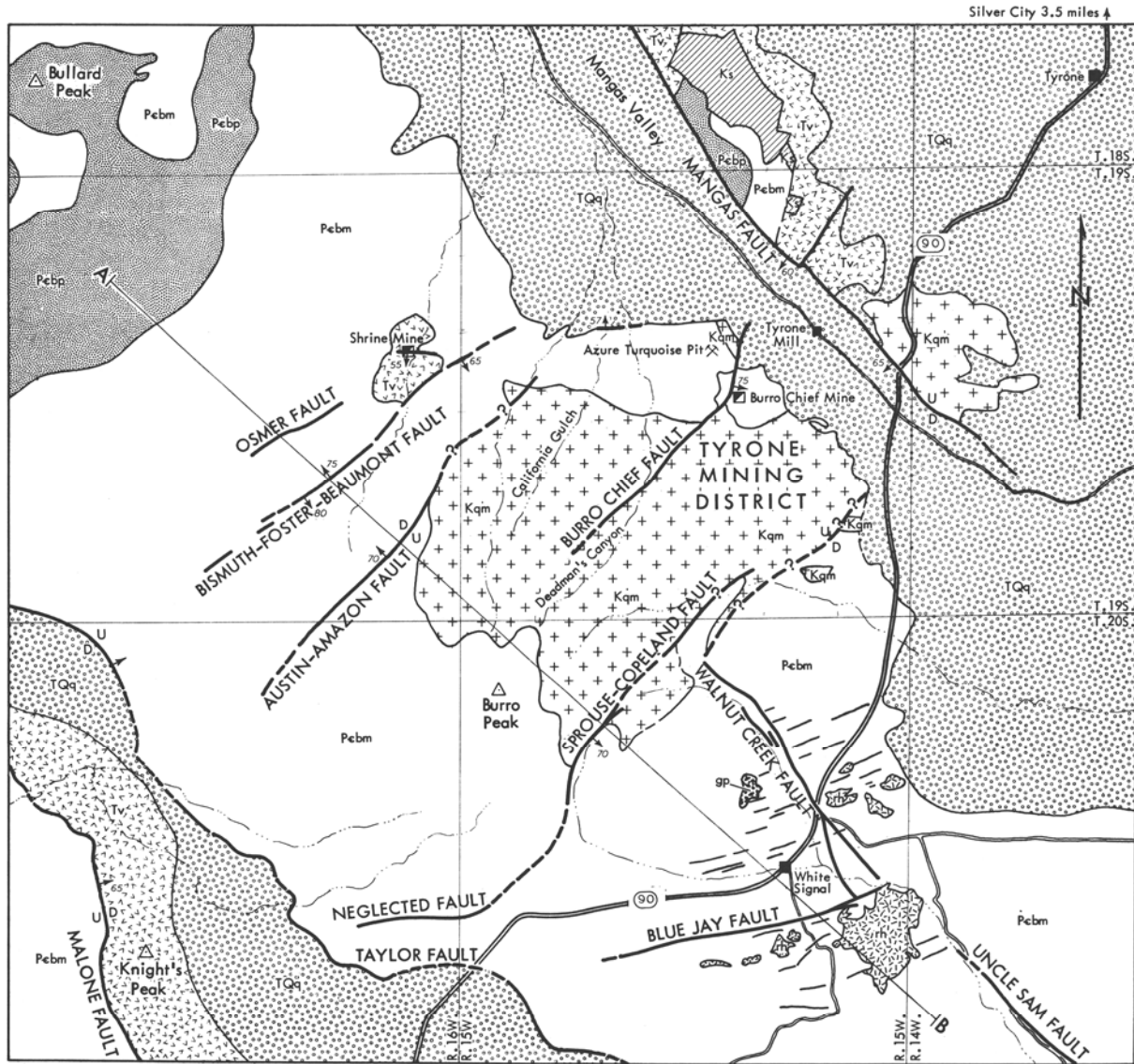
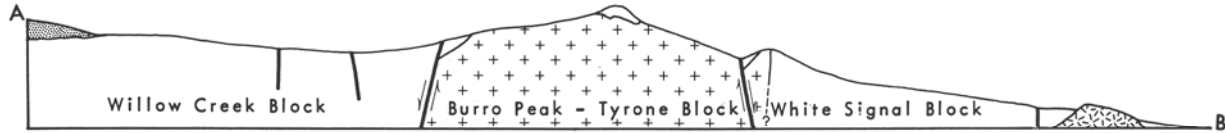
MINERAL DEPOSITS

Mineral deposits in the Big Burro Mountains are localized by structural features and the type, character, and intensity of mineralization can be better understood when related to the structural pattern. Intrusive activity, although important to mineralization, is also localized by structural features, and emphasizes the dependence of structural control on loci of mineralization.

As outlined in earlier reports (Gillerman, 1964, p. 38; 1967, p. 373) two distinct periods of primary mineralization have been identified in the Big Burro Mountains—dominantly base-metal mineralization in the Late Cretaceous or early Tertiary, and fluorite-gold mineralization in the late Tertiary. The first is post-stock intrusion, pre-volcanic activity. The later is post-vulcanism. Uranium mineralization is believed associated with the later period. A third period can also be distinguished—a Precambrian period characterized by pegmatites and contact metasomatic deposits in schists, probably associated with some phase of batholithic emplacement.

The early pegmatitic mineralization is characterized by zoned pegmatites containing minor amounts of rare-earth minerals, magnetite, and fluorite, in addition to the normal quartz, feldspar, and mica concentrations. The probably closely allied contact metasomatic deposits are confined to schists of the Bullard Peak series and contain scheelite and minor amounts of tourmaline and garnet. Both types of deposits are concentrated on the fringes of the Big Burro Mountains and are absent in the central area. They are most numerous to the north, south, and southwest.

Base-metal mineralization, characteristic of the Late Cretaceous or early Tertiary, includes silver and possibly



GEOLOGIC MAP OF THE BIG BURRO MOUNTAINS

SCALE IN MILES



- | | | | |
|-----|---------------------------------|------|---|
| TQa | Gila Conglomerate | rth | Intrusive Rhyolite |
| Tv | Tertiary volcanic rocks | Pebm | Burro Mountain granite and associated rocks of the Burro Mountain batholith |
| Ks | Cretaceous sedimentary rocks | Pebp | Bullard Peak series (schists, quartzites, and amphibolites) |
| Kqm | Quartz Monzonite (Tyrone Stock) | | |
| gp | Granite porphyry | | |



some gold. Other metals deposited were copper, zinc, lead, molybdenum, iron, and bismuth. The mineral deposits are believed to be genetically associated with the Tyrone stock, the ore solutions being late differentiates of the magma which consolidated to form the quartz monzonite body. The character of mineralization differs in different areas within the mountains and as previously described (Gillerman, 1964, p. 39; 1967, p. 373) these differences can be correlated to a remarkable degree with the different blocks into which the mountains have been fragmented.

The important central Tyrone-Burro Peak block is characterized by pyrite and chalcopyrite deposits, and aside from a few specks of sphalerite and molybdenite, no other metallic minerals have been identified. Precious metals are absent. Aside from the ubiquitous pyrite, this is a mono-metal and mono-mineral block. Quartz and country rock are the gangue minerals. Primary deposits are confined to northeast-trending shear zones and fractures.

The White Signal block contains deposits of pyrite, galena, chalcopyrite, argentite, gold, bismuth minerals, specular hematite, magnetite, and small amounts of sphalerite; barite and quartz are the principal gangue minerals. All but sphalerite have been produced commercially. The deposits can be divided into three separate groups: quartz-pyrite, quartz-specularite, and lead-silver and silver. Deposits are in northwest-trending and east-northeast to east-trending fractures, and are often associated with dikes which fill the same fractures.

The Willow Creek block also contains a varied mineralization: gold, chalcopyrite, pyrite, silver minerals, bismuth minerals, sphalerite, galena, and molybdenite. Magnetite and specular hematite are absent. All but molybdenite have been produced commercially. Mineral deposits are mostly along major fractures such as the Osmer and Bismuth-Foster-Beaumont faults. Along the latter fault the character of mineralization changes toward the northeast from bismuth to sphalerite to silver minerals with molybdenite to chalcopyrite—a zonation suggestive of temperature control except for the anomalous molybdenum at the Beaumont shaft. High temperature minerals exist at either end with the lower temperature silver in the center.

Differences in character of primary mineral deposits exposed within the separate blocks reflect variation in the amount of uplift of the separate blocks coupled with vertical zonation of deposition of minerals with decreasing temperatures upward from the stock. Chalcopyrite and pyrite were emplaced closest to and in places within the quartz monzonite, other minerals being deposited closer to the surface at lower temperatures. The central block has been uplifted relative to the other blocks and, as the block was uplifted, shallow zinc, lead, and silver minerals which might have been present were removed by erosion. Only the deeper zones containing pyrite and chalcopyrite have been preserved. In adjacent blocks, these shallower zones are preserved, and gold, silver minerals, sphalerite, and galena, as well as some chalcopyrite occur.

The degree, type, and distribution of secondary mineralization within the Burro Peak-Tyrone block also has been influenced by tectonism. After the central block was uplifted, erosion, oxidation, and supergene enrichment above the Tyrone ore body resulted in the formation of a chalcop-

ite blanket. Faulting in post-Gila time tipped this blanket northeastward and continued erosion exposed and partly eroded the sulphide body toward the southwest. To the northeast, deposition of gravels of the Gila Conglomerate in the Mangas Valley buried it to greater depths. This tilting has been described as coincident with the faulting along the Mangas fault in post-Gila time, when the entire Burro Mountain block was tilted northeastward (Paige, 1922, p. 33). It may also have been accompanied by movement along the Burro Chief fault in post-Gila time. As the area occupied by the Tyrone ore body was being tilted northeastward, the sub-block northwest of this fault moved upward relative to the area of the Tyrone ore body, movement probably being greatest in the northeast portion of the block and dying out southwest. The east-trending fault and tilted Gila Conglomerate bounding this area on the north also may have been involved in this upward movement of the block. Increased erosion of this uplifted block removed any supergene zone that might have existed and uncovered primary sulphides. Subsequent oxidation and deposition in the oxidized zone resulted in the abundant chrysocolla, malachite, azurite, and turquoise present in this area. Copper removed by erosion and solution was transported northward by ground and surface waters and some was deposited as malachite, chrysocolla, and crednerite in the Gila Conglomerate of the California Gulch-Deadman Canyon area west of Tyrone (Gillerman, 1964, p. 59).

SUMMARY

The Big Burro Mountains consist largely of Precambrian intrusive rocks of the Burro Mountain batholith which were emplaced into a series of schists, amphibolites, and quartzites grouped as the Bullard Peak series. Separate intrusions are recorded in the batholithic complex, the oldest rock being quartz diorite. Granite, however, comprises about 90 percent of the exposed batholithic rocks. Although it varies locally in texture, mineral composition, and appearance, little detailed study has been done, and most of the granite is grouped as one unit, the Burro Mountain granite.

During the Precambrian, diabase dikes were intruded into the batholithic rocks. In post-Precambrian time the rocks were intruded by rhyolite plugs, rhyolite dikes, smaller plugs and dikes of various rock types, and by the quartz monzonite Tyrone stock. Late Cretaceous sedimentary rocks and Tertiary volcanic rocks covered at least portions of the batholith, and late Tertiary gravels filled the valleys.

A long history of tectonism is recorded in the rocks. Earliest records are evidenced by the fracturing, faulting, and emplacement of the diabase dikes; the latest record by major faulting and tilting involving the Gila Conglomerate. Between are recorded repeated fracturing, faulting, shearing, uplift, and igneous intrusion. Structural elements trend in three directions: northwest, northeast, and east-northeast to east. The northwest set includes both the oldest set of fractures into which the diabase dikes were emplaced, and the major late Tertiary normal faults which bound the Big Burro Mountain block. The east-northeast to east set

occurs mostly in the vicinity of White Signal in the southern Big Burro Mountains. Closely spaced faults and fractures are intruded by innumerable dikes which characterize this area. The large plugs are intruded along the same fracture system and the prominent Blue Jay fault in the same vicinity is also northeast-trending. This group of faults and fractures is earlier than the intrusion of the Tyrone quartz monzonite in Late Cretaceous or early Tertiary times.

The northeast structural elements are later than the stock emplacement. They include major faults that cut across the Big Burro Mountains, and which divide it into blocks and segments, and associated, but less persistent, faults and fractures. These are the major foci of mineralization in the Big Burro Mountains, except in the White Signal area. Two of the faults bound the central Burro Peak-Tyrone block, which has moved upward relative to the surrounding area. Erosion of this horst has exposed the quartz monzonite of the Tyrone stock.

Mineralization in the Big Burro Mountains can be grouped into three periods: Precambrian mineralization characterized by small pegmatites and contact metamorphism associated with the invasion of the batholith; a Late Cretaceous or early Tertiary period of dominantly base-metal mineralization attendant to the emplacement of the Tyrone stock; and a late Tertiary dominantly fluorite-gold mineralization, probably related to late Tertiary volcanism. The second period was the major period of mineralization and accounted for the Tyrone ore body and for many other deposits in the mountains.

Mineralization related to the intrusion of the stock is zoned vertically. Pyrite and chalcopyrite were deposited in the outer portions of the stock and the adjacent granite in an environment of high temperature, and low temperature minerals were emplaced higher in the crust. Erosion of the

structurally high Burro Peak-Tyrone horst exposed the deeper chalcopyrite zone as the Tyrone ore body.

Tilting in post-Gila times attendant to movement along the northwest-trending Mangas fault and the northeast-trending Burro Chief fault altered the position of the chalcocite blanket that had been formed. In the structurally higher area west of the Burro Chief fault, erosion exposed primary sulphide ore. Oxidation of the sulphides resulted in copper minerals being deposited in the oxidized zone, principally as chrysocolla and malachite. Some copper was transported northward and deposited as oxidized minerals in the tilted Gila Conglomerate.

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Sunset scene near Deming.