Uranium-Bearing Nickel-Cobalt-Native Silver Deposits, Black Hawk District, Grant County New Mexico

GEOLOGICAL SURVEY BULLETIN 1009-K

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By ELLIOT GILLERMAN *and* DONALD H. WHITEBREAD

A CONTRIBUTION TO THE GEOLOGY OF URANIUM

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A CONTRIBUTION TO THE GEOLOGY OF URANIUM

THE URANIUM-BEARING NICKEL-COBALT-NATIVE SILVER DEPOSITS IN THE BLACK HAWK DISTRICT, GRANT COUNTY, NEW MEXICO

By Elliot Gillerman and Donald H. Whitebread

ABSTRACT

The Black Hawk (Bullard Peak) district, Grant County, N. Mex., is 21 miles by road west of Silver City. From 1881 to 1893 high-grade silver ore valued at more than one million dollars is reported to have been shipped from the district. Since 1893, there has been no mining in the district except during a short period in 1917 when the Black Hawk mine was unwatered and reopened.

Pre-Cambrian quartz diorite gneiss, which intrudes quartzite, schist, monsonite, and quartz monzonite, is the most widespread rock in the district. The quartz diorite gneiss is intruded by many pre-Cambrian and younger rocks, including diorite, granite, diabase, monzonite porphyry, and andesite, and is overlain by the Upper(?) Cretaceous Beartooth quartzite. The monzonite porphyry, probably of Late Cretaceous or early Tertiary age, forms a small stock along the northwestern edge of the district and many dikes and irregular masses throughout the district.

The ore deposits are in fissue veins that contain silver, nickel, cobalt, and uranium minerals. The ore minerals, which include native silver, argentite, niccolite, millerite, skutterudite, nickel skutterudite, bismuthinite, pitchblende, and sphalerite, are in a carbonate gangue in narrow, persistent veins, most of which trend northeast. Pitchblende has been identified in the Black Hawk and the Alhambra deposits and unidentified radioactive minerals were found at five other localities. The deposits that contain the radioactive minerals constitute a belt 600 to 1,500 feet wide that trends about N. 45° E. and is approximately parallel to the southeastern boundary of the monzonite porphyry stock. All the major ore deposits are in the quartz diorite gneiss close to the monzonite porphyry.

The ore deposits are similar to the deposits at Great Bear Lake, Canada, and Joachimsthal, Czechoslovakia.

INTRODUCTION

Mining began in the Black Hawk (Bullard Peak) district in 1881 when high-grade silver ore was found at the Alhambra mine. Most of the silver produced was native silver associated with nickel and cobalt arsenides and sulfides. In 1920 pitchblende was recognized on the dumps of some of the old mines, and since 1949 the district has been of interest as a possible source of uranium, nickel, and cobalt ores.

LOCATION, ACCESSIBILITY, AND CLIMATE

The Black Hawk mining district is mostly in secs. 20, 21, 22, 28, and 29, T. 18 S., R. 16 W., in Grant County, N. Mex. (fig. 44), and is 21 miles by road west of Silver City, the terminus of a branch line of the Atchison, Topeka and Santa Fe Railway.

The district is in the northeastern foothills of the Big Burro Mountains at an altitude of 5,450 to 6,150 feet. Scattered junipers, scrub oak, small pines, and brush cover the hillsides, but no trees suitable for use in mining are present. Most of the district is drained by way of Black Hawk Canyon which bisects the area and flows northward to Mangas Creek, but the eastern part is drained by tributaries of Silver Dale Creek, which flows northeastward to Mangas Creek. Mangas Creek flows into the Gila River about 9 miles northwest of the mouth of Black Hawk Canyon. All the streams, except the Gila River, are intermittent. Annual precipitation at Silver City is about 16 inches, most of which comes as heavy thundershowers in July, August, and September.

SCOPE AND PURPOSE OF WORK

Fieldwork in the Black Hawk district was done by the writers as part of the program for investigation of radioactive minerals by the U. S. Geological Survey on behalf of the Division of Raw Materials of the U. S. Atomic Energy Commission. A preliminary reconnaissance confirmed the presence of radioactive minerals in the district (H. C. Granger, written communication). Additional examinations of mine dumps, pits, and shafts for radioactivity by A. J. Gude 3d, and Elliot Gillerman during the spring of 1951 resulted in the finding of small quantitites of pitchblende on the dumps of the Black Hawk and Alhambra mines. About 4 months were spent in the field on the present study which was begun in December 1951. The investigations consisted principally of geologic mapping of an area of about 2½ square miles at a scale of 1:6,000. Detailed surface maps of the Black Hawk and Alhambra mines at a scale of 1:1,200 were made by plane table and alidade.

ACKNOWLEDGMENTS

Mr. Ira L. Wright, General Manager of the Black Hawk Consolidated Mines Co., and Mr. and Mrs. A. A. Leach, owners of the Alhambra group of claims, made available to the writers old maps and reports of the mines in the district and also specimens of ore taken

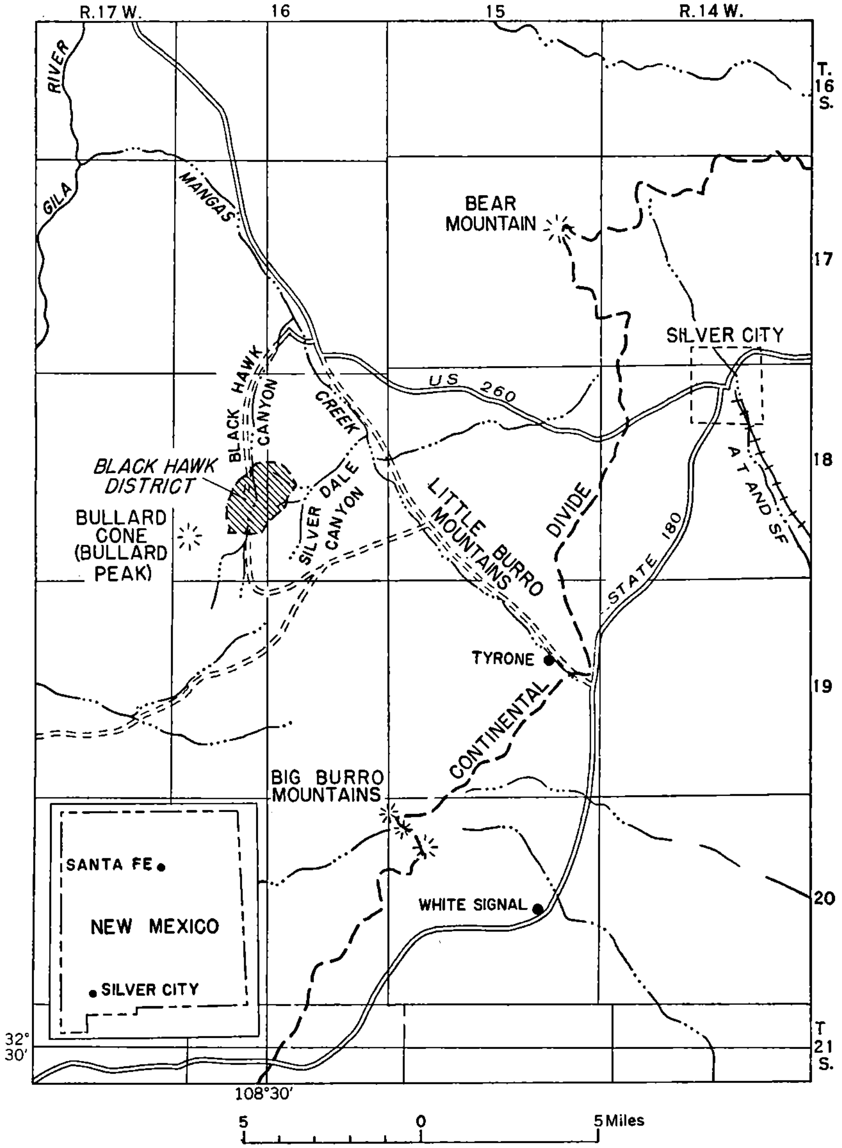


FIGURE 44.—Index map showing the location of the Black Hawk mining district, Grant County, N. Mex.

from the Black Hawk and Alhambra mines. Chemical analyses were made by the New Mexico Minerals Laboratory of Silver City, N. Mex.

OWNERSHIP

The principal deposits in the district are covered by patented claims. The Black Hawk group, owned by the Black Hawk Consolidated

Mines Co., Milwaukee, Wis., consists of the Black Hawk, Silver Glance, Surprise, Kent County, Little Rhody, Chicago, and Extension patented claims. The Alhambra group, owned by Albert A. and and Frances I. Leach of Lordsburg, N. Mex., consists of the Alhambra and Good Hope patented claims and the Silver King (Hobson) unpatented claim. The Rose claim is owned by Mrs. Elizabeth J. McCabe, Pasadena, Calif., and Elizabeth C. (Mrs. William Howard) Meade, San Francisco, Calif. The ownership of some of the claims in the district is not known.

HISTORY AND PRODUCTION

In 1881 float of high-grade silver ore was found at the Alhambra mine, and subsequent prospecting soon resulted in the discovery of the Black Hawk, Rose, Silver King (Hobson), Good Hope, and other deposits. Mining began in the district in 1881 and continued until 1893, when a decline in the price of silver and the depletion of the rich silver ore caused the mines to be closed. Nearly all the ore produced had a high silver content, and shipments of ore assaying as much as 15,000 ounces of silver per ton are reported (Jones, 1904, p. 55).

In 1917, when a new owner acquired the property, the Black Hawk mine was unwatered and opened to the lowermost levels, where undeveloped high-grade ore was reported (W. R. Storms, written communication). Some drifting was done on the upper levels to search for an ore body that had not been developed during the earlier operations. W. H. Weed, (written communication), consulting geologist, and A. A. Leach (written, communication), then geologist for Phelps Dodge Corporation at Tyrone, N. Mex., examined the mine and recommended further work. Shortly thereafter, all work ceased. In 1917 there was also a short-lived interest in some of the smaller properties in the eastern part of the district. The district has been idle since 1917.

Because of the need for additional nickel, cobalt, and uranium, interest in the district was revived in 1949. In the spring of 1952 a Government exploration loan was granted to the Black Hawk Consolidated Mines Co. to explore the Black Hawk mine, and three diamond core-drill holes were completed by November 1952. The three holes were drilled to a depth of 1,000 feet; hole 3 intersected sparse ore minerals in carbonate gangue, but the other two holes were barren.

The silver production from the district before 1893 is estimated to have been between $1,000,000 and $1,500,000 (Lindgren, Graton, and Gordon, 1910, p. 324; Leach, A. A., 1916). The Black Hawk mine is reported to have yielded $600,000 to $650,000 (Jones, 1904, p. 55;

Leach, 1916); the Alhambra mine about $400,000 (A. A. Leach written communication); the Rose mine about $140,000; and the Silver King (Hobson) about $40,000 (A. A. Leach written communication). The remainder of the production came from the Good Hope and other properties.

GEOLOGY

The Black Hawk district is within the pre-Cambrian Burro Mountains batholith, which is exposed over an area of about 400 square miles in southwestern Grant County. The batholith is a composite body made up chiefly of granite with inclusions of gneiss, schist, quartzite, and intrusive rocks. Many stocks and dikes intrude the batholith.

The predominant rock in the Black Hawk district is pre-Cambrian quartz diorite gneiss—part of the batholith—that intrudes quartzite, schist, monzonite, and quartz monzonite. These rocks are cut by many igneous rocks of pre-Cambrian and younger age, the most common of which is monzonite porphyry of probable Late Cretaceous or early Tertiary age. The Beartooth quartzite of Late(?) Cretaceous age overlies the pre-Cambrian rocks. Many faults, most of which trend northeast, cut the rocks of the district.

The ore deposits are in fissure veins that are most commonly in the quartz diorite gneiss. Native silver is the major ore mineral and is associated with nickel and cobalt arsenides and sulfides in a carbonate gangue. Pitchblende, associated with the silver, nickel, and cobalt minerals, has been identified from the Black Hawk and Alhambra mines. The metalliferous deposits are spatially related to the monzonite porphyry and are considered Tertiary in age.

The rock units and their relationships to one another are shown on the geologic map (pl. 14).

IGNEOUS AND METAMORPHIC ROCKS

QUARTZITE AND SCHIST

Pre-Cambrian quartzite, schist, and other metamorphic rocks are shown on the geologic map (pl. 14) as quartzite and schist. These rocks form two broad irregular east-trending bands in the southwestern part and small isolated patches throughout the southern part of the mapped area. The beds strike N. 40° W. to west and dip 37°–64° NE. at most places; but locally, near the western edge of the mapped area, they strike N. 50°–65° E. and dip 62° NW. The quartzite is a thin-bedded, fine-grained, gray to buff rock consisting mostly of angular quartz grains and a few flakes of mica and grains of magnetite. Thin mica schist layers that contain some magnetite and quartz, amphibolite, and knotted schist are associated with the quartzite. Epidote is present locally in the schist and amphibolite.

MONZONITE AND QUARTZ MONZONITE

A rock of monzonitic and quartz monzonitic composition is exposed over a wide area in the southeastern part of the mapped area (pl. 14). This rock is predominantly homogeneous, fine grained, and equigranular, but near its contact with the quartz diorite gneiss it commonly has a porphyritic texture with phenocrysts of orthoclase as much as an inch in diameter. This porphyritic texture is especially well developed in areas where there has been lit-par-lit injection of gneissic material. Foliation is obscure, but a layering that possibly represents relict bedding is present locally. This layering suggests that the rocks designated in this report as "monzonite and quartz monzonite" may be migmatized sedimentary rocks.

The monzonite and quartz monzonite consist essentially of fresh-looking pink and white feldspars, biotite, and hornblende. Some quartz is present in places and epidote occurs sparsely.

The age relationships of the monzonite and quartz monzonite to the quartzite and schist are unknown; these rocks are found in contact at only two localities and the relations at these places are obscure. The monzonite and quartz monzonite are cut by the quartz diorite gneiss.

QUARTZ DIORITE GNEISS

Quartz diorite gneiss of pre-Cambrian age constitutes the country rock in most of the district (pl. 14). The gneiss is a widespread phase of the Burro Mountains batholith and intrudes the quartzite, schist, monzonite, and quartz monzonite. About equal amounts of plagioclase and biotite comprise 85 to 90 percent of the rock mass. The plagioclase is white to pinkish gray and appears to be andesine. It occurs mostly as anhedral grains averaging 2 centimeters in length, but subhedral to euhedral crystals as much as 2 inches in length are common as phenocrysts elongated parallel to the foliation. The feldspar is slightly altered to sericite in places. The biotite occurs as aggregates of small flakes between the feldspar grains, and some of it is altered to chlorite. Anhedral quartz, which makes up 5 to 10 percent of the rock, occurs with the biotite, and orthoclase is present in minor amounts. Hornblende crystals as much as 2 centimeters in length constitute 2 to 3 percent of the rock, and is found chiefly in the biotite aggregates. Zircon and magnetite are present, and some epidote is associated with the magnetite.

Both the individual flakes, and the aggregates of biotite are oriented parallel or subparallel to the foliation of the rock. The long axes of the hornblende crystals are oriented parallel to the foliation but there is no preferred linear orientation.

The gneissic structure, believed to be a primary flow structure, strikes northeast and dips steeply northwest except in the southeastern part of the mapped area and in areas contiguous to the older rocks, where there are local variations from the regional trend (pl. 14).

BIOTITE-QUARTZ DIORITE

Two small masses of biotite quartz diorite crop out along the southern edge of the district (pl. 14). The rock differs from the quartz diorite gneiss in the following respects: it contains more biotite; it does not contain large feldspar phenocrysts; and it has a less pronounced gneissic structure. The contacts of the rock with both the quartz diorite gneiss and the diorite are obscured by surficial material, and the age relations are unknown.

DIORITE

Many small, irregular bodies of diorite have been mapped in the southern part of the district (pl. 14). The diorite is a course-grained, dark-green to black rock with a characteristic greenish-brown and white mottled weathered surface. It consists predominately of chloritized biotite and hornblende, anhedral grains of plagioclase feldspar, and minor amounts of quartz.

The diorite intrudes the quartzite and schist; also it probably intrudes the quartz diorite gneiss and the biotite quartz diorite, but conclusive evidence of an intrusive relation is lacking. At an excellent exposure of the diorite and the quartz diorite gneiss in Black Hawk Canyon, slightly more than half a mile southwest of the Black Hawk shaft, the diorite appears to intrude the quartz diorite gneiss. The age relations, however, are partly obscured by pegmatite dikes that have been emplaced along the contact.

SYENITE

Seven small bodies of syenite that range in size from short dikes 20 to 75 feet wide to masses about 200 feet wide and 450 feet long are present about 2,000 feet southeast of the Black Hawk mine (pl. 14). The syenite is a medium-grained equigranular brown rock that consisted originally of pink orthoclase feldspar and biotite, but which now is highly altered. The biotite commonly is altered to a brown limonitic powder and the feldspar is kaolinized. The syenite is intruded by the granite; it intrudes the quartz diorite gneiss, but its age in relation to the other pre-Cambrian rocks is unknown.

GRANITE

Many irregular bodies and dikes of granite intrude all the older rocks throughout the mapped area (pl. 14). The rock is similar to the granite that forms the main mass of the Big Burro Mountains to the south and constitutes most of the Burro Mountains batholith. The granite is a fine- to medium-grained, equigranular, pink rock that consists of quartz, orthoclase, and small amounts of plagioclase and biotite; apatite, sphene, and an unidentified mineral are minor constituents. Many pegmatite and aplite dikes cut the granite and the older rocks.

DIABASE AND BASALT PORPHYRY

Many diabase dikes have been mapped in the southern part of the district (pl. 14). These dikes, generally less than 25 feet wide, trend northwestward in most places. A basalt porphyry dike, exposed intermittently from near the center of the western edge of the mapped area to the southeast corner, has not been distinguished from the diabase dikes on the map (pl. 14). A few diabase dikes are present in the northern part of the district. The diabase is a fine-grained, dark-gray rock that contains laths of plagioclase in a matrix of pyroxene and magnetite. The basalt porphyry consists of a dark-gray, fine-grained, equigranular groundmass of pyroxene, plagioclase feldspar, biotite, and phenocrysts of light-gray feldspar as much as 0.5 centimeter in diameter. The phenocrysts constitute from 10 to 15 percent of the rock.

RHYOLITE

A white chalky-appearing, fine-grained rhyolite dike that ranges from 5 to 25 feet in width crops out intermittently from east to west across the mapped area, about midway between the northern and southern boundaries (pl. 14). The dike is texturally similar to aplite, and has a chilled border facies. The rock consists mostly of feldspar, with some quartz and a few flakes of mica.

QUARTZ MONZONITE

Small masses of quartz monzonite have been mapped along the northern edge of the district and near the southwestern corner (pl. 14). The quartz monzonite in the northern part is fine-grained, equigranular, and gray, and consists predominantly of white and gray subhedral feldspar with subordinate quartz and altered euhedral books of biotite. Hornblende is sparse to absent. The rock in the southern part of the mapped area contains more hornblende. The two types of quartz monzonite have not been distinguished on the map. Dikes of monzonite porphyry cut both types of quartz monzonite.

MONZONITE PORPHYRY

Monzonite porphyry, the second most abundant rock in the Black Hawk district, is present as a stocklike mass in the northwestern part of the area and as dikes and irregular masses throughout the rest of the area (pl. 14). The rock consists of a grayish-white fine-grained groundmass with abundant white anhedral to subhedral feldspar crystals as much as 0.5 centimeter in diameter, and black hornblende needles as long as 1 centimeter. Small amounts of biotite are present in some places; quartz is rare. Locally the long axes of hornblende needles are alined to produce a linear structure. In the dikes the groundmass is mostly aphanitic, and the feldspar forms conspicuous phenocrysts.

In altered monzonite porphyry the groundmass is aphanitic, the feldspars are soft and earthy; and the hornblende is chloritized, epidotized, or converted to an iron-stained clay. Pyrite, in places altered to limonite, is common in the altered monzonite porphyry between Black Hawk Canyon and the Silver King mine. The altered rock is greenish gray, light gray to white, or reddish brown.

The monzonite porphyry is considered early Tertiary or Late Cretaceous in age on the basis of correlation with lithologically similar stocks in the Silver City area. No intrusive relations with the Beartooth quartzite were observed in the vicinity of the Black Hawk district, but some of the other stocks intrude the Upper(?) Cretaceous Beartooth quartzite and Colorado shale of Late Cretaceous age. Eight or more similar stocks of monzonite, quartz monzonite, and granodiorite are known in the Silver City area. All are considered early Tertiary or Late Cretaceous in age (Paige, 1916).

The monzonite porphyry stock, known as the Twin Peaks stock, is topographically higher than the surrounding country and constitutes the high peaks called Twin Peaks (pl. 14).

QUARTZ DIORITE

Several easterly trending dikes of quartz diorite have been mapped in the northeastern part of the district (pl. 14). The rock is fine grained, equigranular, brown to gray, and consists mostly of plagioclase feldspar, horneblende, and quartz. At places scattered grains of magnetite and some epidote are present. The quartz diorite dikes cut the monzonite porphyry, and are in turn cut by the ore-bearing veins.

ANDESITE

Two small stocklike masses of andesite crop out in the northeastern part of the district (pl. 14). Two dikes to the south of these andesite bodies and one dike about 1,500 feet to the west of them are believed to be of the same composition. The andesite is fine grained and dark gray; it consists mostly of feldspar. A few phenocrysts of feldspar and hornblende, altered to a yellow-brown claylike material, are present. The andesite intrudes the pre-Cambrian rocks, but its age relation to the Beartooth quartzite has not been determined. The megascopic appearance of the andesite is similar to the diabase, but for the most part it is less altered. The andesite contains abundant vertical joints at the edges of the stocks.

SEDIMENTARY ROCKS

BEARTOOTH QUARTZITE

The Beartooth quartzite of Late(?) Cretaceous age crops out along the top of a long ridge in the northeastern part of the mapped area (pl. 14). The quartzite overlies the quartz diorite gneiss, granite, and quartz monzonite. The formation strikes N. 60° W. and dips from 15° to 25° N. 30° E. and consists of alternating beds of conglomerate, sandstone, shale, calcareous sandstone, and quartzite. The quartzite extends both east and west of the area and lies between the older igneous rocks to the south and west, and volcanic rocks, probably of Tertiary age, to the north and east.

ALLUVIUM

Recent stream deposits, consisting of silts, sands, and gravels, are found in Black Hawk Canyon throughout much of its course.

STRUCTURE

Folds are of minor importance in the Black Hawk district, but faults are common in all parts of the area. Many faults are filled with vein material or dikes. Foliation, planar structures, and jointing are common in some of the igneous rocks.

FOLDS

The pre-Cambrian quartzite and schist that occurs as inclusions in the quartz diorite gneiss are homoclinal blocks; most of the blocks are tilted northeast at angles ranging from 37° to 64°. The beds in general strike N. 40° W. to west. The two large east-trending blocks are oriented at a slight angle to the predominant strike of the strata, and extend for about a mile west of the mapped area. The dip and strike of the beds are consistent throughout the outcropping masses.

The Beartooth quartzite also occurs as a homoclinal block striking N. 60° W. and dipping 15° to 25° NE. The inclined beds can be traced for at least 1 mile east and 2 miles west of the mapped area. The homoclinal attitude of the beds is probably the result of faulting and the Beartooth quartzite exposed in the district is part of a tilted fault block.

FAULTS

Faults and shear zones are abundant in the Black Hawk district. Most of the veins and dikes are along faults, although evidence of movement along many of the fractures is difficult to determine. The dominant trend is north-northeast to east, but a few of the fractures, particularly in the southwestern part of the area, trend northwest. Most of the dikes and veins dip 70°–90°; a few dip at angles as low as 55°. There is no uniformity in the direction of dip of the veins or dikes.

Two fairly conspicuous fault systems trend slightly east of north across the area. Each system of faults consists of one rather persistent fault, from which branching faults split off to the northeast. One extends from the southern boundary of the map at the point where Black Hawk Canyon enters the mapped area, to near the northern edge. This system of faults passes a few hundred feet west of the Black Hawk shaft. Near the northern edge of the mapped area it is interrupted by two parallel east-trending vein-filled faults.

Another conspicuous fault system lies about 1,600 feet east of the Black Hawk shaft and extends from the southeastern boundary of the mapped areas to beyond the northeastern edge of the district. Faults of both systems extend into the Beartooth quartzite along the northeast edge of the district, and cut the quartz diorite dikes, which, with the exception of the andesite, is the youngest rock unit in the district. The easternmost fault system is interrupted by an andesite stock through which no evidence of faulting could be traced.

Between the two fault systems and also in the area west of Black Hawk Canyon most of the faults and dikes strike northeast, however, in the eastern part of the area the dikes and faults trend more nearly east.

Within the monzonite porphyry stock the fractures trend northeast parallel to the elongation of the stock, and part of the southeastern boundary of the stock is formed by the northeast-trending fault and shear zone.

The diabase and basalt dikes in the Black Hawk district, which correspond in composition and in age to similar dikes throughout the Burro Mountains, trend northwest. This orientation is characteristic of these dikes throughout the Burro Mountains area, and apparently reflects conditions of regional stress during late pre-Cambrian or early Paleozoic time, which produced northwest-trending fractures later filled with the basaltic and diabasic magmas.

Most of the faulting was later than the intrusion of the monzonite porphyry stock and probably later than the quartz diorite. Many of the faults follow the granite dikes which were intruded during pre-Cambrian time and suggest a reopening in post-Cretaceous time along old pre-Cambrian breaks. The granite dikes fill fractures trending predominantly northeast to east, and this same structural orientation characterizes the later intrusions and faults.

Post-ore faults cut some of the veins. In the Black Hawk mine a flat-dipping fault, striking N. 75° E. and dipping 25° to 30° NW., cuts the vein on the eighth level. The ore in the stopes below this level ends sharply against the fault (A. A. Leach, written communication). At the Alhambra mine a northeast- and a northwest-trending fault cut the vein and displace it (fig. 48). Underground, on the first level, fragments of broken and brecciated ore are reported along these faults (W. C. Dyer, oral communication). These fragments may have resulted from movement along the cross faults after the material was deposited in the vein.

FOLIATION, PLANAR STRUCTURE, AND JOINTING

The foliation of the quartz diorite gneiss, in general, trends northeast and dips from 60° NW. to vertical. Locally the dips are less steep. South and southeast of the Rose and Alhambra mines the foliation trends northwest and dips northeast (pl. 14). At places the foliation is parallel to the contacts of the gneiss with the older rocks. This, combined with the absence of a regional foliation in the older rocks and the absence of a cataclastic texture in the gneiss, is interpreted as indicating that the gneissic foliation is a primary flow structure.

The foliation in the quartz diorite gneiss may have been the main controlling structure for subsequent igneous instrusions in pre-Cambrian and possibly after pre-Cambrian times. Most of the granite and associated aplite and pegmatite dikes were intruded parallel to the foliation. An excellent example of this parallelism of dikes and foliation is half a mile southeast of the Black Hawk shaft (pl. 14).

The planar structure in the northeastern part of the monzonite porphyry stock strikes parallel to the elongation of the stock and dips northwest at steep angles. The stock in this area appears to dip northwest also and at least the upper part of the stock appears to have been emplaced as a tabular body.

Vertical joints parallel the boundaries of the two andesite stocks in the northeastern part of the area. The joints are best developed in the northernmost stock and are concentrically arranged within the stock (pl. 14).

ORE DEPOSITS

Deposits of uranium-bearing nickel-cobalt-silver ore in the Black Hawk district occur in fissure veins, most commonly in the quartz diorite gneiss. The veins are numerous in an area about 1 mile wide and 2 to 3 miles long contiguous to the southeast side of the Twin Peaks monzonite porphyry stock. Two intersecting systems of veins are present, one striking north to north-northeast and the other striking northeast to east. The veins are pitchblende, native silver, argentite, nickel and cobalt sulfides and arsenides, pyrite, and small amounts of other sulfides, in a gangue of carbonates, and some quartz and barite. The veins known to contain pitchblende and the nickel and cobalt minerals are closely associated spatially with the monzonite porphyry. All except one of the major silver producers are known to contain nickel and cobalt minerals and pitchblende.

The ore deposits belong to the nickel-cobalt-native silver ore type described by Bastin (1939) and are similar to the major pitchblende-producing deposits at Joachimsthal, Czechoslovakia, and Great Bear Lake, Canada.

MINERALOGY

The vein minerals that have been reported from the Black Hawk district are listed in table 1. This list has been compiled in part from previous reports; the minerals that have been observed by the present writers are indicated in the table.

All the mines were inaccessible in 1951 and 1952 and only a few of the ore minerals were found on the dumps. Thus little information could be gathered in the field relative to the kind and quantities of the vein minerals and their paragenetic relations. Most of this information is taken from previous published reports and from personal communications.

Pitchblende is present on the dumps of the Black Hawk and Alhambra mines. Radioactivity was noted on the dumps of the Rose and Good Hope mines and at five other localities, but no uranium minerals have been identified. The pitchblende at the Black Hawk mine, in the specimens observed, occurs as black shiny grains less than 2 millimeters in diameter, intimately associated with sphalerite, a nickel arsenide (probably nickel skutterudite), and other ore minerals. The minerals were identified by X-ray and polished-section methods.

Native silver is the most abundant ore mineral in the veins. Masses of arborescent silver as much as 60 to 70 feet long, 6 to 18 inches wide, and 1 to 2 feet thick are reported (Hess, 1917, p. 753). According to Bastin (1939, p. 27), silver in deposits of this type is generally primary.

Argentite, which was a commercially important ore mineral at the Black Hawk and Rose mines (written communication, Weed, W. H.), is present as fillings in fractures at the Alhambra mine (Leach, 1916). According to Leach, crystals of argentite occurred on the niccolite and carbonate gangue at the Alhambra mine.

Cerargyrite, proustite, pyrargyrite, and pyrostilpnite are reported only from the Rose mine. The cerargyrite was reported in the upper levels and the antimonial sulfides of silver on the 200-foot level.

TABLE 1.—*Minerals reported from the Black Hawk district*

ORE MINERALS	*Chemical formula*
Pitchblende [1]	UO_2
Native silver [1]	Ag
Argentite	Ag_2S
Cerargyrite	AgCl
Proustite	$3Ag_2S \cdot As_2S_3$
Pyrargyrite	$3Ag_2S \cdot Sb_2S_3$
Pyrostilpnite	$3Ag_2S \cdot Sb_2S_3$
Niccolite [1]	NiAs
Millerite	NiS
Skutterudite [1]	$CoAs_3$
Nickel skutterudite [1]	$(Ni,Co,Fe)As_3$
Smaltite(?)	$CoAs_2$
Chloanthite(?)	$NiAs_2$
Erythrite	$Co_3As_2O_8 \cdot 8H_2O$
Annabergite	$Ni_3As_2O_8 \cdot 8H_2O$
Rammelsbergite [1 2]	$NiAs_2$
Sphalerite [1]	ZnS
Chalcopyrite	$CuFeS_2$
Galena [1]	PbS
Stannite	$Cu_2S \cdot FeS \cdot SnS_2$
Bismuthinite	Bi_2S_3
GANGUE MINERALS	
Pyrite [1]	FeS_2
Calcite [1]	$CaCO_3$
Dolomite [1]	$CaMg(CO_3)_2$
Siderite	$FeCO_3$
Rhodochrosite	$MnCO_3$
Manganoancalcite	$(Ca,Mn)CO_3$
Ankerite [1]	$CaCO_3 \cdot (Mg,Fe,Mn)CO_3$
Barite [1]	$BaSO_4$
Quartz [1]	SiO_2

[1] Minerals observed by the writers.
[2] Tentatively identified as rammelsbergite, but probably nickel skutterudite.

Appreciable amounts of antimony are present in a specimen from the Black Hawk dump.

Nickel and cobalt minerals are reported from all mines for which records are available, namely the Black Hawk, Alhambra, and Rose mines. Leach (1916) describes millerite at the Alhambra mine as tiny capillary crystals containing some silver. Niccolite associated with native silver and argentite is reported from the Black Hawk and Alhambra mines. Hess (1917, p. 753) reports that "in one place in the Alhambra vein a shoot,—from 2 to 3 feet wide is said to have carried from 15 to 20 percent nickel, in the form of niccolite, and the ore was rich in silver." In general nickel-skutterudite and skutterudite appear to be the major primary nickel and cobalt minerals in the district. The only other occurrence of skutterudite in the United

States listed by Ford (1932, p. 437) is at Franklin, N. J., and nickel-skutterudite is known in the United States only from the Black Hawk district, its type locality. According to Waller and Moses (1892), who first described this mineral, nickel-skutterudite from the Black Hawk mine is a silver-gray granular mineral with a tubercular structure, the interior of the tubercle being commonly filled with carbonate. Waller and Moses (1892), and Krieger (1935) state that native silver also fills the tubercle. Smaltite and chloanthite have been reported from the Rose and Alhambra mines (Leach, 1916), but probably were confused with skutterudite and nickel-skutterudite (Northrop, 1942, p. 283). The rammelsbergite is only tentatively identified and may be nickel-skutterudite. Erythrite and annabergite, the hydrous cobalt and nickel arsenates, form crustiform masses at the Alhambra mine (Leach, 1916) and have been found on some of the dumps (W. R. Storms and I. L. Wright, oral communication).

Sphalerite may be present in appreciable quantities in the lower levels of the Black Hawk mine (W. H. Weed, written communication). The other ore minerals are of minor importance, and little is known of their occurrence and characteristics.

The principal gangue minerals reported in the veins are calcite, dolomite, siderite, and ankerite; less abundant gangue minerals include barite, quartz, rhodochrosite, and manganoancalcite. The quartz is either crystalline quartz, dull cherty quartz, or pale-greenish waxlike cryptocrystalline quartz. Black manganiferous oxide, containing some iron, is present on some of the dumps (W. R. Storms, written communication).

DISTRIBUTION OF THE VEINS

Veins are abundant within the Black Hawk district and they may be traced for a short distance south and southwest of the mapped area. In general they are limited on the northwest edge of the mapped area by the stock of monzonite porphyry in the vicinity of Twin Peaks, and on the northeast by the Beartooth quartzite. The veins are younger than both these rock units and a few veins cut them.

Most of the veins in the district are confined to an area about 1 mile wide that lies contiguous to the southeast side of the Twin Peaks monzonite porphyry stock (fig. 45). Several of the mineralized veins (pl. 14) are in faults in the quartz diorite gneiss close to its contact with the monzonite porphyry of the Twin Peaks stock, with the small stocklike body at the Rose mine, and with the small stocklike body near the Alhambra mine, which is probably a cupola on the Twin Peaks stock.

The veins are most common in the quartz diorite gneiss and in the granite. They are generally absent in the quartzite and schist, and in

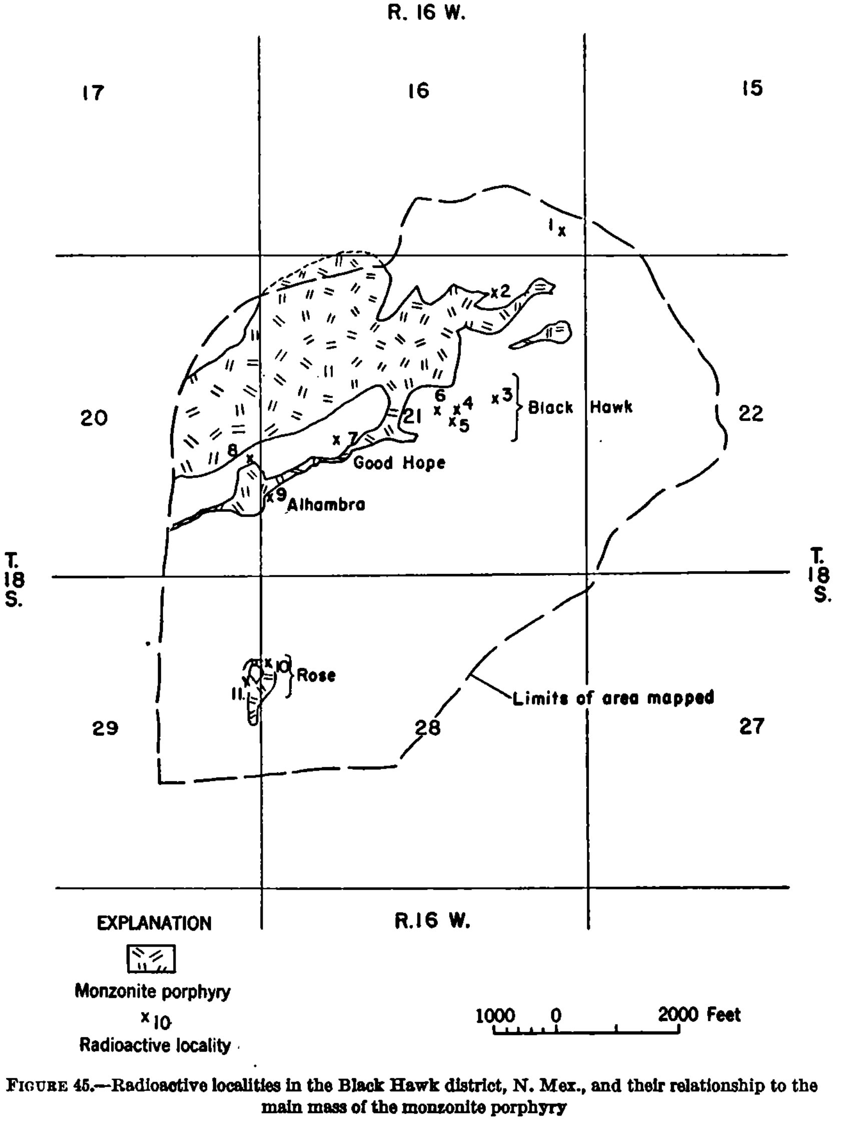


FIGURE 45.—Radioactive localities in the Black Hawk district, N. Mex., and their relationship to the main mass of the monzonite porphyry

the monzonite and quartz monzonite. Ore shoots are reported to be almost entirely confined to the gneiss.

The veins occupy faults and fractures and thereby reflect the structural pattern of the district. An examination of the vein pattern reveals two intersecting sets of veins, one trending north to north-northeast, and the other trending northeast to east. The north-northeast set of veins is best developed along the two north-northeast belts of faulting, but the Alhambra vein and the subparallel veins south and southwest of the Alhambra mine probably also belong to this set. The northeast-trending veins are arranged in three major belts: one that lies along the southeast side of the Twin Peaks stock, and widens northeastward to include the Black Hawk vein; another that extends from the Rose mine to just south of the southernmost andesite stock in the northeastern part of the area; and a third in the southern part of the area. These are not continuous belts, but are zones of many discontinuous parallel and subparallel veins. Toward the northeast the veins trend more easterly, particularly in the southern belt.

The ore minerals are mostly confined to the northeast set of veins, but the Alhambra vein, one of the most productive, is a north-northeast vein. There appears to be no correlation between the intersection of the two sets of veins and the presence of ore minerals. The northeast-trending veins, which in general parallel the laminations of the gneiss, appear to be cut by the north-northeast veins, but the relationships are obscure in many places.

The distribution of the uranium-bearing veins in a zone contiguous to the southeastern side of the Twin Peaks stock suggests there may be a similar zone on other sides of the stock, and prospecting in these areas might be productive. Prospecting to the southwest along the continuation of the mineralized zone might result in the finding of additional deposits containing nickel, cobalt, and uranium minerals.

CHARACTER OF THE VEINS

The veins in the Black Hawk district are fissure fillings along faults and fractures with only minor replacement of the wall rock. They are similar throughout the district, and differ only in the presence or absence of some of the ore minerals. On the geologic map (pl. 14) the veins are divided into three groups: veins known to contain uranium, silver, nickel, and cobalt minerals; veins known to contain nickel, silver, or cobalt minerals (oral communication Leach, A. A.); and veins not known to contain any ore minerals. This division is based only on the known presence of the specific metals. Many of the veins containing nickel, cobalt, or silver minerals may also contain uranium minerals, and many of the veins mapped as barren veins may contain ore minerals in unobserved portions. A single vein may in part belong to one group and in part belong to another group. The information on the character of the veins and the mineralogy, except that deduced from surface observation, was obtained from written communications by W. H. Weed, E. D. Lidstone, and A. A. Leach.

Many of the veins are only a foot or less in width but they may open up suddenly into ore shoots 3 to 10 feet wide. The veins are wider in the quartz diorite gneiss and granite and pinch noticeably upon entering the monzonite porphyry. Many of the veins can be followed for more than 1,000 feet, but others are only a few hundred feet long. The greatest vertical extent known is in the Black Hawk vein which has been mined to a depth of 600 feet vertically below the collar of the shaft and which crops out to the northeast on ground 175 feet higher than the collar of the shaft.

The veins are inconspicuous in the outcrop and are marked generally by soft brown-stained carbonate fillings. In places a crude banding is developed but most commonly the vein filling lacks any definite structure. Oxidation is not deep, and primary minerals are found within a few feet of the surface. The boundary between barren gangue minerals and ore shoots rich in silver is sharp. The oreshoots within the veins are reported to be poddy and lense-like in character and conform to no known pattern.

Carbonates make up most of the vein filling and are associated with some quartz, fragments of the country rock, and locally, ore minerals. The carbonates, which are chiefly calcite, dolomite, siderite, and ankerite, weather brown in the outcrop. The quartz is generally a dull waxlike yellow-green chert or chalcedony; the rock fragments are mostly altered gneiss. The ore minerals are chiefly native silver, argentite, and nickel and cobalt minerals, with a small amount of base metal sulfides present. On the surface small specks of galena, some pyrite, and small amounts of native silver make up the metallic minerals. In the major mines the pyrite was common only in the waste, and galena was reported to be scarce.

Native silver was abundant in the veins in the upper parts of the mines and constituted the major portion of the ore. Argentite increased in the lower levels, and nickel and cobalt minerals appeared below 100 feet. Pitchblende in the veins is probably associated with the nickel and cobalt minerals.

RADIOACTIVITY

Almost all pits, shafts, adits, and dumps that were accessible in the Black Hawk district in 1952 were examined with a geiger counter, equipped with a 2- by 20-inch copper probe. Many of the deeper shafts were tested by lowering the probe, attached to a 100-foot cable, into the shaft. The localities that show anomalous radioactivity are listed in table 2 and are shown in figure 45.

A black shiny mineral in a specimen from the dump of the Black Hawk mine (loc. 6) was identified in the field as pitchblende. This identification was later confirmed by X-ray powder analyses. An orange incrustation that coats the surface of one of the specimens from the dump of the Alhambra mine (loc. 9) was identified in the field as a secondary uranium mineral. Pitchblende was later identified by the laboratory in this and another specimen from this locality.

No uranium minerals were identified in the specimens from localities 4 and 7. Table 3 shows chemical analyses of some of the radioactive samples.

TABLE 2.—*Localities showing anomalous radioactivity*

No. on figure 45	*Locality*	*Scale reading*	
		Radioactive material (0.2 scale)	*Normal background (0.2 scale)*
1	Pit, 450 feet N. 45° W. of southeast corner sec. 16	3	1½
2	Pit, 1,600 feet S. 68° W. of northeast corner sec. 21	2½	1–1½
3	Dump, Hunecke shaft, Black Hawk vein	3½–4	1½
4	Dump, Copper vein, Black Hawk mine	3½	1½
5	Vein outcrop at shaft, Black Hawk mine	4–5	1½
6	Dump, Black Hawk mine	5–6	1½
7	Dump, Good Hope mine	8	1½
8	Shaft and pit, 750 feet N. 22° W. of Alhambra new shaft, sec. 20.	3	1½
9	Dump, Alhambra mine	5–6	1½
10	Dump, Red vein adit, Rose mine	3	1–1½
11	Dump, Main shaft, Rose mine	3	1–1½

TABLE 3.—*Chemical analyses of specimens from localities showing anomalous radioactivity*

[See fig. 45 and pl. 14 and table 2 for location of localities listed]

Locality	U_3O_8 (percent)	Ni (percent)	Co (percent)	Ag (ounces per ton)	As (percent)[1]	Sb (percent)[1]	Cu (percent)[1]
No. 4 [2]	0.09	tr.[3]	tr.[3]	2.15		0.1–1.0	0.1–1.0
No. 6 [2]	.24	4.23	0.22	8.20	1.0–10.0	1.0–10.0	
No. 7 [2]	.07	1.58	.48	8.40	1.0–5.0	tr.[3]	
No. 9 [2]	.15	0.35	.27	3.45			
Rose mine dump [4]		0.07	.08	10.55			
Alhambra mine dump [4]		0.18	.10	34.70			

[1] Percents are approximate.
[2] Samples analyzed by the New Mexico Minerals Laboratory, Silver City, N. Mex.
[3] Indicates less than 0.001 percent.
[4] Samples collected and analyzed by the U. S. Bureau of Mines.

COMPARISON WITH FOREIGN DEPOSITS

Nickel-cobalt-silver deposits have been described from many places throughout the world (Bastin, 1939, p. 3–19). In some of these deposits, pitchblende occurs with the nickel, cobalt, and silver minerals. A brief comparison is made between the Black Hawk deposits and the deposits of two notable districts, namely, Great Bear Lake, Canada, and Joachimsthal, Czechoslovakia.

The mineral assemblages, both ore and gangue minerals, in the three districts are remarkably similar in that a predominance of silver in the ores with appreciable quantities of nickel and cobalt arsenides and minor amounts of sulfides and pitchblende are common to all. Iron and manganese oxides are also common.

The veins in the three districts cut foliated rocks of pre-Cambrian age, and most are short and narrow opening abruptly into wide, high-grade ore shoots. Ore in all three districts fills open spaces, and has replaced little or none of the wall rock.

DESCRIPTION OF MINES AND PROSPECTS

BLACK HAWK MINE

PRINCIPAL FEATURES

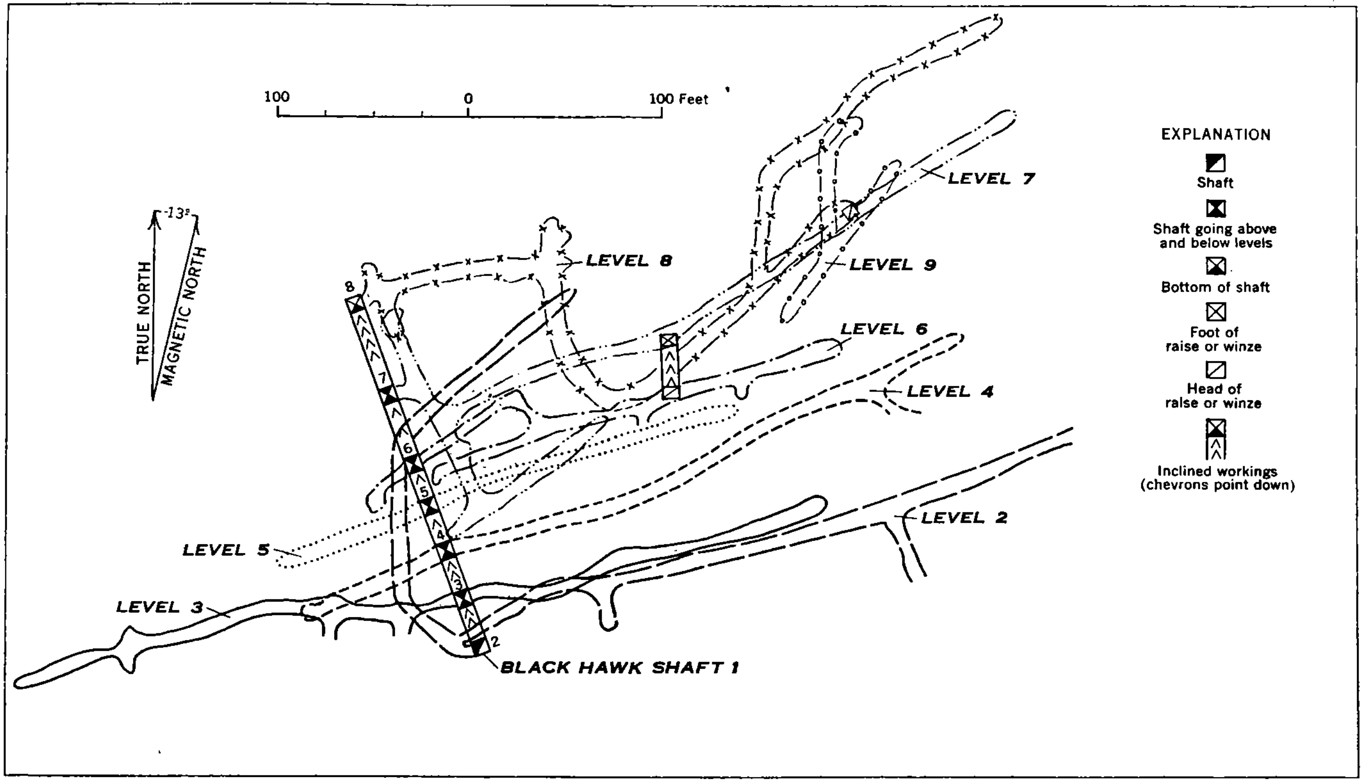
The Black Hawk mine, the largest mine in the district, is along the Black Hawk vein, which is the largest vein on the Black Hawk property (pl. 15).

The workings in the Black Hawk mine are inaccessible. The Black Hawk No. 1 shaft is in the bottom of a dry gulch and is filled with sand and debris. Only a few pipes sticking up above the sand show its location. Information on the underground workings and the nature of the vein has been obtained in written communication from Weed, Leach, and Lidstone.

The Black Hawk No. 1 shaft (pl. 15), the principal opening on the Black Hawk vein, was sunk on the vein to the eighth level, a depth of 497 feet. The shaft is vertical above the second level and is inclined 60° N. 20° W. below that level. An aggregate of about 3,000 feet of drifts were cut on eight levels; most of these workings are east of the shaft. At the east end of the eighth level a winze, inclined about 85° S., was sunk for a distance of 150 feet (fig. 46). The ninth and tenth levels, 50 feet vertically apart, were driven from the winze. A crosscut on the second level extends about 120 feet north to the copper vein.

The Black Hawk No. 2 shaft (pl. 15), also filled, is about 300 feet southwest of the Black Hawk No. 1 shaft. It is 100 feet deep, with short workings on the 100-foot level and probably is not on the Black Hawk vein. The Hunecke shaft (pl. 15), 800 feet northeast of the Black Hawk No. 1 shaft, is on the Black Hawk vein, but is not connected with the other workings. The shaft is caved and no information on the underground workings is available.

The Black Hawk vein strikes N. 70° E. and dips 60°–70° NW. According to the mine maps the dip flattens with depth. The vein was followed for more than 1,000 feet on the surface and has been followed underground for as much as 700 feet (fig. 46 and pl. 15). Ore has been mined in the vicinity of the No. 1 shaft for about 500 feet



Modified from W. H. Weed, 1917

FIGURE 46.—Underground workings of the Black Hawk mine.

along the strike and at least 600 feet down dip and also at other localities along the vein.

The vein for the most part, ranges from an inch to about a foot in width but the ore shoots are 3 to 10 feet wide. The vein consists of a series of imbricate and subparallel fractures. The high-grade ore within the ore shoots is in streaks and bunches separated by low-grade ore.

On the eighth level a fault that strikes N. 78° E. and dips about 30° NW. appears to displace the vein 30 feet to the south and to the left. The vein segment below the fault dips about 85° S. The winze, sunk from the eighth level, is along this segment of the vein. The correlation of the veins above and below the flat-dipping fault is uncertain because the two segments dip in opposite directions.

The mine workings indicate that although the ore shoots in the upper levels do not persist downwards, other ore shoots of as great or greater length and width were found on the lower levels (W. H. Weed written communication).

According to W. H. Weed and A. A. Leach (written communications) the ore occurs as fissure fillings, and there is only minor replacement of the wall rock. Included fragments of country rock are common, but crusts of ore around the fragments are rare. The vein contains a central core of carbonate and quartz bordered by a few inches of altered wall rock and opens abruptly into the wide ore shoots without any apparent change in the general character of the vein. The ore within the shoots was mainly altered gneiss netted with tiny veinlets of ore minerals. The high-grade ore was in streaks and bunches, principally along the footwall.

Native silver constituted 80 percent of the value of the ore that was mined. Appreciable quantities of argentite were present, and galena, pyrite, chalcopyrite, and sphalerite were minor constituents. Niccolite and smaltite are recorded, but most of the nickel and cobalt are probably present as nickel skutterudite (Northrop, 1942, p. 283). Old reports state that the nickel minerals were found below the 100-foot level (Waller and Moses, 1892, p. 49). An analysis of a 100-pound sample taken by E. D. Lidstone (written communication) from the bottom of the winze and analyzed by Smith, Emery and Co., San Francisco, Calif., is as follows:

Bismuth	Present, small amounts
Arsenic	Present, large amounts
Antimony	Traces
Copper	Trace
Nickel	8.92 percent
Cobalt	0.90 percent
Zinc	8.81 percent
Silver	2,542.00 ounces per ton

No analysis for uranium was made on this sample, but two specimens of high-grade massive silver from the mine were tested and found to be radioactive. These samples were from the mineral collections of Messrs. Ira L. Wright and William Rowlee of Silver City; their source in the mine is unknown. Pitchblende from the dump is associated with a nickel arsenide and sphalerite. One of the specimens of high-grade silver and the specimen of ore containing pitchblende from the dump were examined with a geiger counter equipped with a 6-inch probe. A count of 10 on the 0.2 scale was recorded for the high-grade silver specimen and a count of 5 on the 2.0 scale was recorded for the specimen of ore from the dump. The background count was 1 on the 0.2 scale. The specimen from the dump contained 0.24 percent U_3O_8 (table 3, specimen 6). Radioactive material also was found on the dump of the Hunecke shaft (fig. 45 and table 3).

The Copper vein on the Black Hawk property strikes N. 50° E. and dips about 80°–85° NW. It may intersect the Black Hawk vein to the west of the Black Hawk No. 1 shaft (pl. 15). It is explored by surface trenching, shallow shafts, and by a 100-foot drift from the second level of the Black Hawk No. 1 shaft. The Copper vein did not contain silver in the underground workings, according to W. H. Weed (written communication); however, radioactive material was found on the dump of the westernmost of the surface workings (table 3 and fig. 45).

RESULTS OF DRILLING

In May 1952 the Black Hawk Consolidated Mines Co. began a program of diamond drilling at the Black Hawk mine. Three 1,000-foot holes were drilled to intersect the Black Hawk vein below the mine workings. Holes 1 and 2 were directed N. 20° W. and inclined 70°; hole 3 was directed N. 20° W. but was inclined 63° (pls. 15 and 16). The three holes were alined parallel to the strike of the vein. The position of underground workings was determined from mine maps made from a Brunton-and-tape survey by A. A. Leach (written communication.)

Diamond-drill holes 1 and 2 were drilled at angles calculated to intersect the vein at depths of about 750 feet and 800 feet, respectively. However, the holes were drilled to 1,000 feet without intersecting any vein material recognizable as the Black Hawk vein. Hole 3 passed through a vein containing carbonate gangue minerals and a few specks of galena, pyrite, and native silver between 641 and 651 feet. Assays showed a trace of silver but no cobalt or nickel. The samples were not assayed for uranium and no anomalous radioactivity of the vein material was detected. Near 750 feet the hole passed through 6 inches of carbonate gangue containing galena, pyrite, and niccolite. This material was not assayed and it showed no anomalous radioactivity.

All three holes penetrated quartz diorite gneiss cut by dikes of monzonite porphyry, pegmatitic granite, and diabase. Pyrite was abundant in seams and disseminated in the gneiss, and narrow calcite veinlets were present throughout the core. None of the core was anomalously radioactive.

In February 1953, the three holes were probed with a Geiger-Mueller tube but no anomalous radioactivity was found.

The failure of holes 1 and 2 to intersect the vein may have been due to deflection of the hole or to the inaccuracy of the underground maps upon which the location, inclination, and direction of the drill holes were based. Although hole 3 intersected two carbonate veins, the thicker of which resembles the Black Hawk vein, attempts to correlate the intersection with the position of the Black Hawk vein as shown on the underground maps were unsuccessful.

ALHAMBRA MINE

The Alhambra mine (fig. 48) has been worked by at least four shafts and an adit driven along the vein (W. R. Storms and A. A. Leach, written communications). The New shaft is reported to be 420 feet deep, with short levels at 25, 50, 100, and 150 feet (fig. 47). A total of about 750 feet of drifts on these levels is shown on old maps. Deeper levels that do not appear on available maps are reported. The shaft is caved around the collar, and water stands about 40 feet below the surface.

The Alhambra vein strikes N. 15° E., dips 80°–85° SE., and is from 1 to 5 feet wide at the surface. The vein cuts quartz diorite gneiss near a large easterly trending monzonite porphyry dike. The vein can be traced south from the New shaft for about 500 feet. A weakly mineralized vein, possibly an extension of the Alhambra vein, is found about 400 feet north of the shaft and can be followed northeasterly for about 300 feet.

Massive native silver, similar to that mined at the Black Hawk mine, was the chief ore mineral in the Alhambra vein. Mr. Alex Woodburn, the mine superintendent at the time of abandonment, reported there was good ore on the 350-foot and 400-foot levels of the mine when it was shut down (A. A. Leach, written communication). Niccolite is reported to be associated with the silver. Pitchblende was found on the dumps (fig. 45, tables 2 and 3) by the writers, and had previously been reported by Leach.

ROSE MINE

The Rose mine is in the northeastern part of sec. 29, in the southwestern part of the mapped area (pl. 14). The mine has not been operated since 1889 and the shaft is now filled. High-grade silver ore, and ore containing nickel and cobalt minerals were reported to remain in the lower workings when the mine was abandoned. The mine was worked from a shaft sunk near the intersection of two veins, the Red vein and the Spar vein, and by an adit driven on each vein. The shaft is reported to be 200 feet deep, and to have levels at 50 feet and 100 feet on the Spar vein and levels at 150 feet and 200 feet on both veins. The most extensive workings were on the 150-foot level.

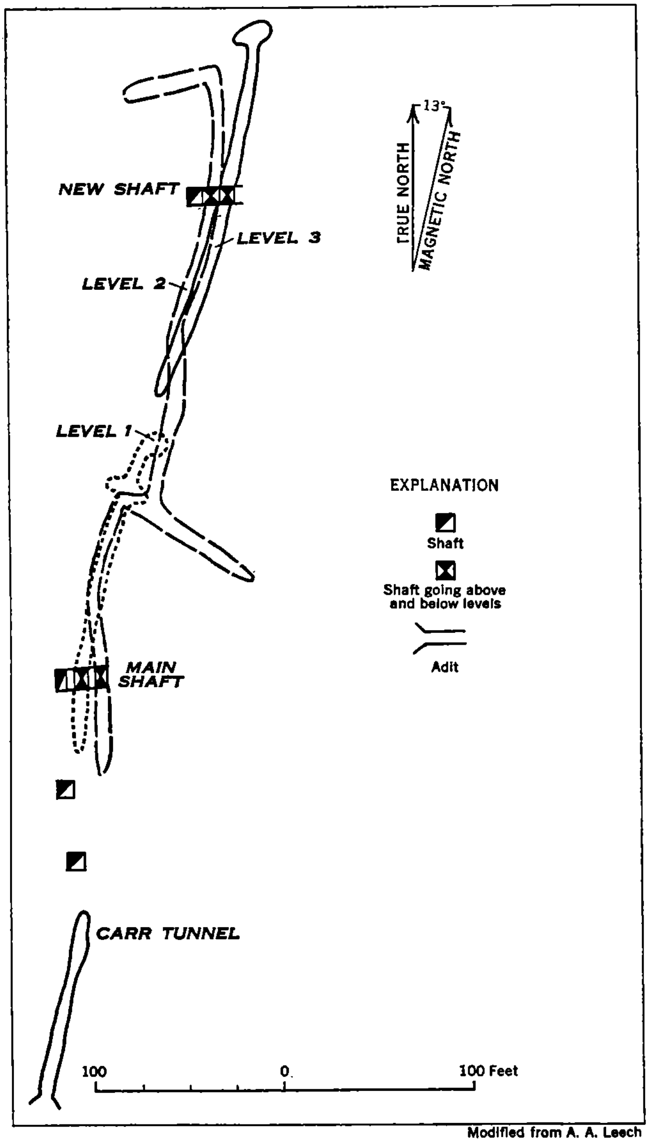
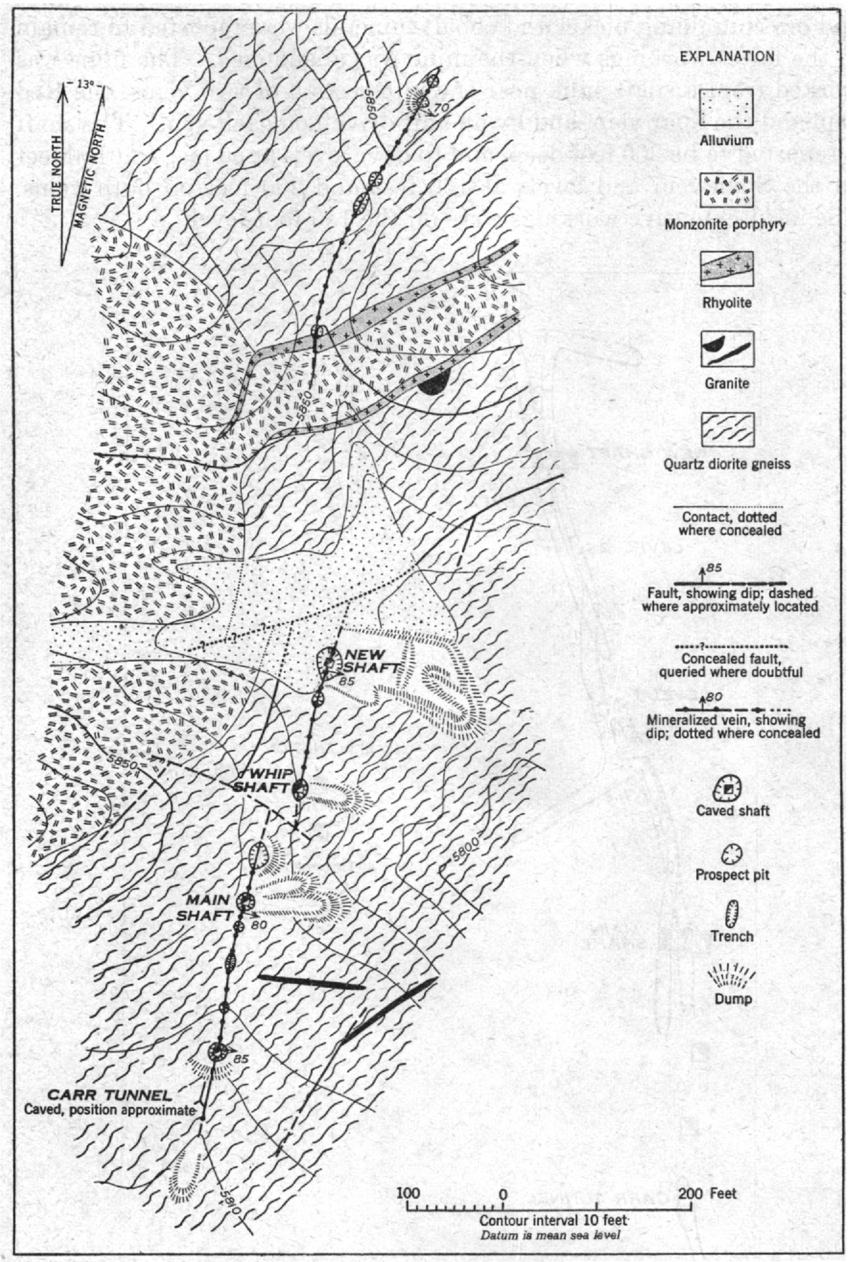


FIGURE 47.—Underground workings of the Alhambra mine.



Topography by Elliot Gillerman, June 1952 Geology by D. H. Whitebread, June 1952

FIGURE 48—Geologic map of the Alhambra mine and vicinity, Grant County, N. Mex.

Both veins at the Rose mine cut granite, quartz diorite gneiss, and monzonite porphyry (pl. 14). The Spar vein strikes about N. 75° E. and dips 75° to 80° NW. At the surface it can be traced for about 700 feet east and 400 feet west of the old Rose shaft. The Red vein strikes N. 30° E. at the shaft, but at a point 200 feet northeast it turns N. 70° E. and is mappable in this direction for about 250 feet. It dips 60°–75° SE. The veins range from 2½ feet to 4 feet in thickness; they have well defined hanging walls and irregular footwalls.

The ore consisted of native silver, argentite, and cerargyrite in a quartz and carbonate gangue. High-grade silver ore that contained a large proportion of nickel and cobalt was mined on the 150-foot level. On the 200-foot level the argentite was associated with pyrargyrite, proustite, and pyrostilpnite.

Radioactive material was found on the dumps of the main Rose shaft and at the portal of the adit on the Red vein (fig. 45 and table 2).

SILVER KING (HOBSON) MINE

The Silver King mine, formerly known as the Hobson mine, is about 1,300 feet north of the Black Hawk mine (pl. 14). According to R. J. Holmquist and M. J. Sheridan (written communication), the vein was worked from an adit 300 feet long and an inclined shaft. A raise and a winze about 200 feet from the portal of the adit explore the vertical extent of the vein. Part of the adit is accessible.

The vein is along a fault that strikes N. 50°–65° E. and dips 65° NW. and cuts quartz diorite gneiss. The fault intersects the main body of the monzonite porphyry stock 200 feet northeast and 150 feet southwest of the shaft. Northeast of the shaft a quartz diorite dike is along the contact of the monzonite porphyry and the quartz diorite gneiss.

In the adit the vein has a well-defined hanging wall and extends along a strong shear zone for 200 feet northeast of the portal, and along an irregular series of branching fractures for an additional 100 feet. The width varies from 2 to 4 feet and is reported to have been followed for 300 feet down the dip. Argentite, associated with some native silver, was the principal ore mineral. No nickel, cobalt or uranium minerals are recorded, and none were found on the dumps.

GOOD HOPE MINE

The Good Hope shaft, now filled, is about 1,900 feet S. 82° W. of the Black Hawk no. 1 shaft (pl. 14). Lindgren, Graton, and Gordon (1910, p. 325) state that the workings attained a maximum depth of about 120 feet. The vein, which strikes N. 65° to 75° E. and dips 65° SE., is in quartz diorite gneiss, about 400 feet south of the monzonite porphyry stock. Radioactive material, which could not be identified mineralogically, was found on the dump. Chemical analysis of the radioactive material shows uranium, nickel, silver, and cobalt (fig. 45, and tables 2 and 3).

OTHER PROSPECTS

Many other veins in the district have been explored by surface cuts and shafts (pl. 14). Waste rock on some of the dumps shows some ore minerals, but production of ore has probably been small. Cobalt bloom has been reported (W. R. Storms and I. L. Wright, oral communication) on the dump of a shaft 1,100 feet south of the Black Hawk shaft. Radioactive material was found at two small pits, 3,550 feet N. 30° E. and 2,200 feet N. 18° E. of the Black Hawk No. 1 shaft. Radioactive material was found also in a shallow shaft and pit, 750 feet N. 22° W. of the Alhambra New shaft.

SUGGESTIONS FOR PROSPECTING

Should any future investigations be undertaken in the Black Hawk district, the pinching and swelling of the veins along the strike and with depth must be kept in mind. At the Black Hawk and Alhambra mines, the veins generally are from a few inches to a foot in width, but they are reported to swell abruptly into ore shoots 3 to 10 feet wide. Because of the discontinuous nature of the ore in the veins and the absence of geologic data to determine where ore shoots are localized, results of diamond drilling would be inconclusive. Therefore, it is suggested that any further work should commence with shaft unwatering and reconditioning of the larger mines in the district and then by mapping and sampling of veins.

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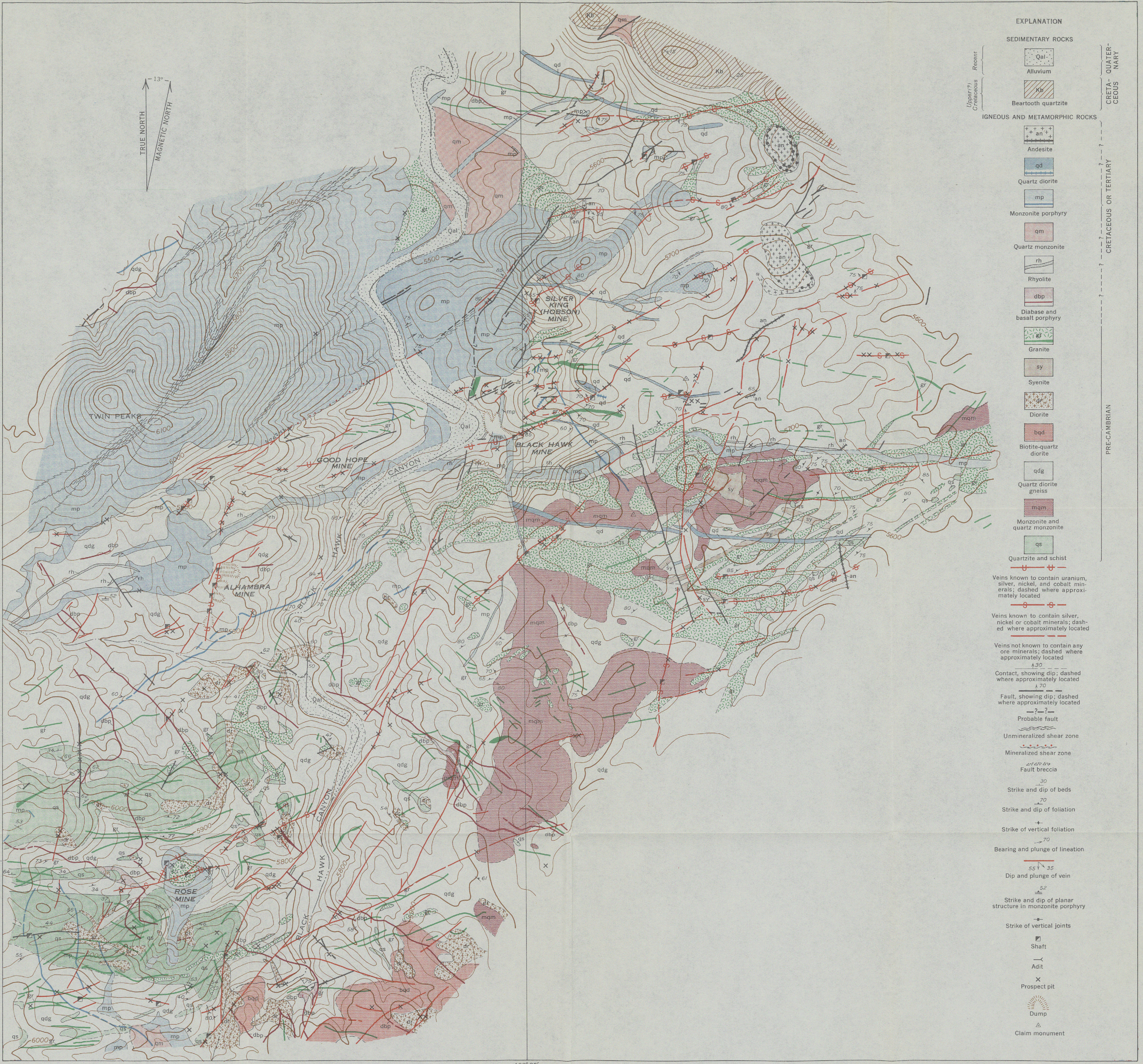


Topography by U. S. Geological Survey, 1951

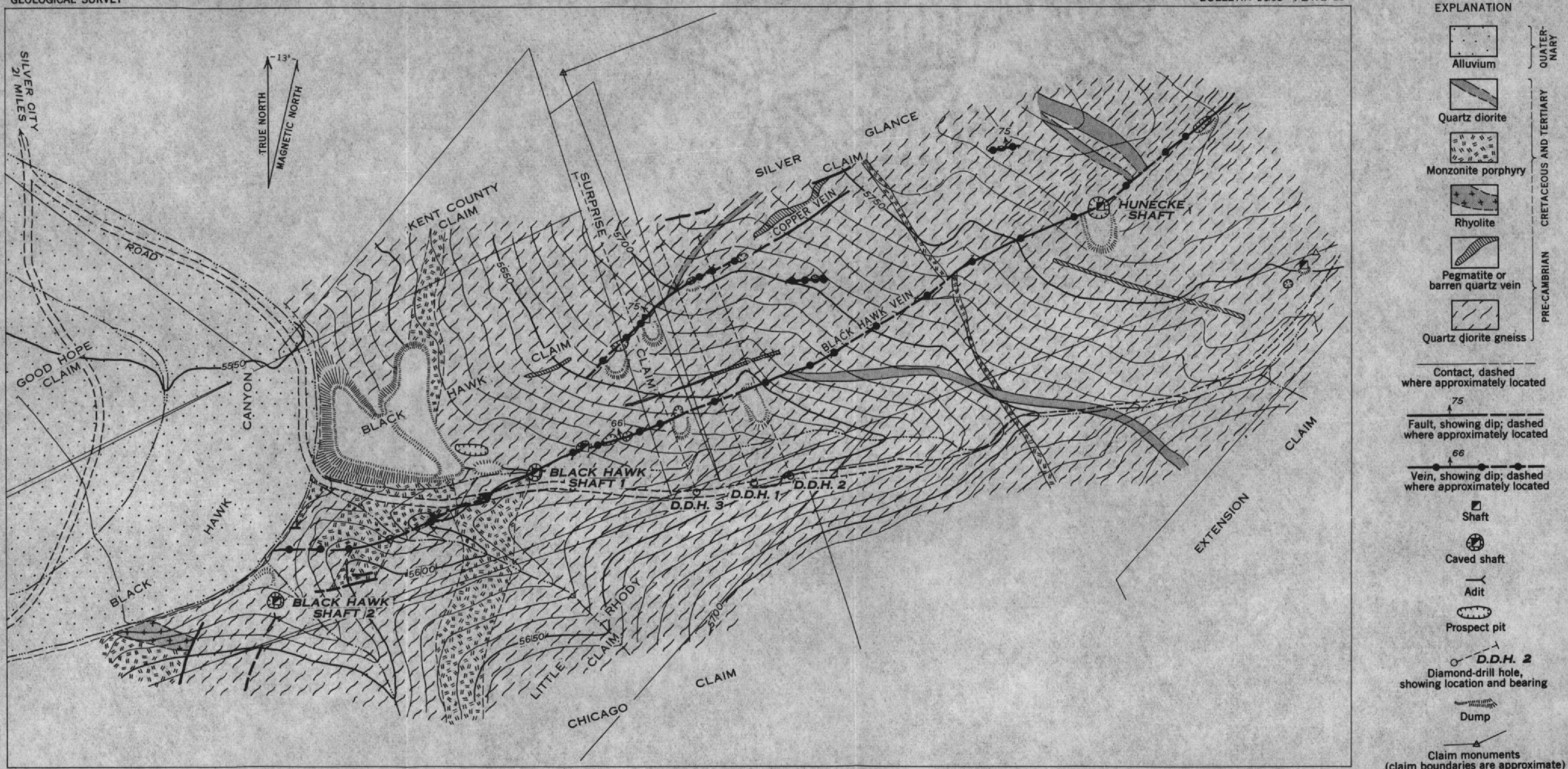
INTERIOR—GEOLOGICAL SURVEY, WASHINGTON, D. C.

Geology by Elliot Gillerman and D. H. Whitebread, 1952

GEOLOGIC MAP OF THE BLACK HAWK MINING DISTRICT, GRANT COUNTY, NEW MEXICO

500 0 1500 Feet

Contour interval 20 feet
Datum is mean sea level



Topography by D. H. Whitebread, May 1952

Geology by Elliot Gillerman, May 1952

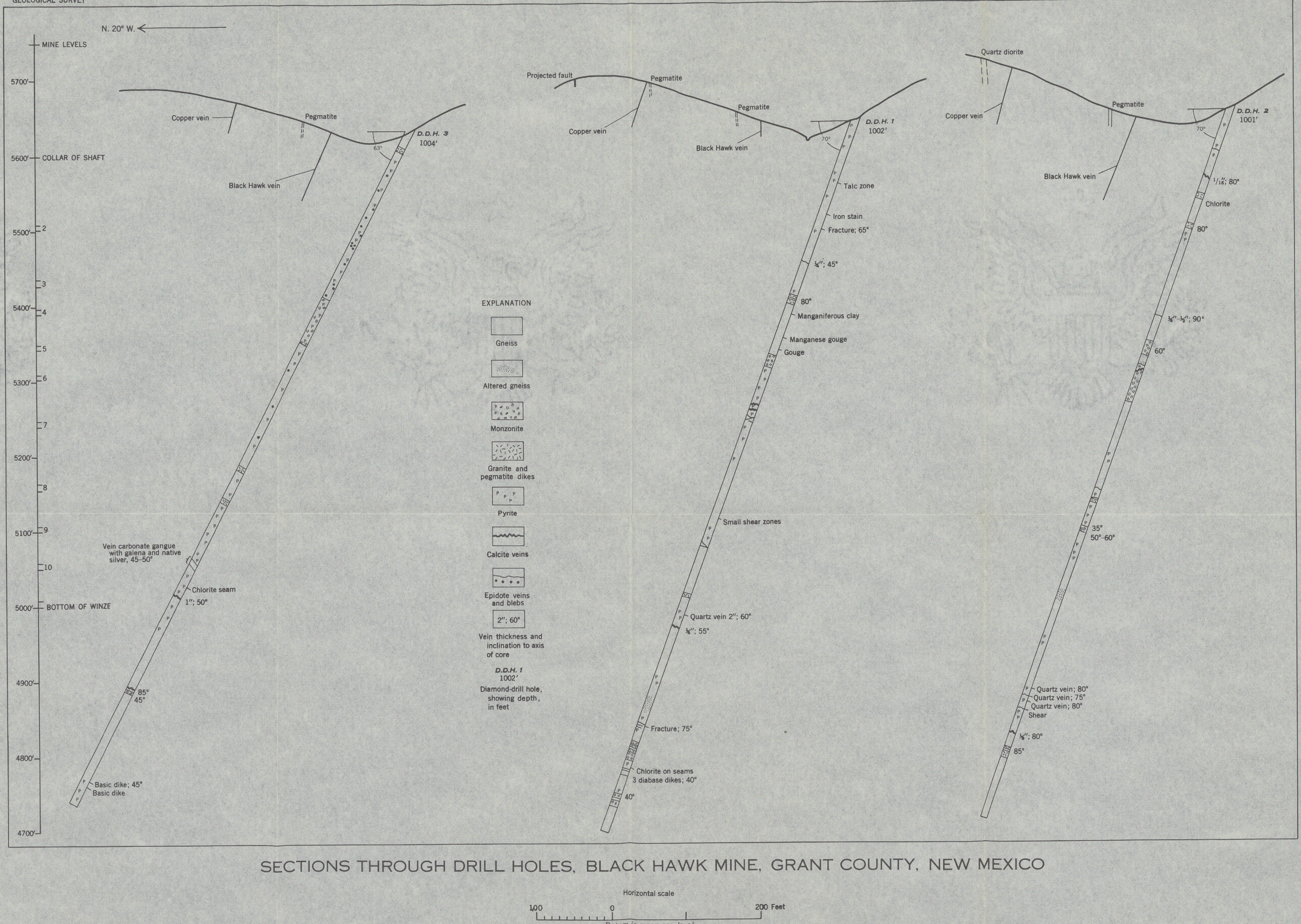
GEOLOGIC MAP OF THE BLACK HAWK MINE AND VICINITY, GRANT COUNTY, NEW MEXICO

100 0 300 Feet

Contour interval 10 feet

Datum is mean sea level

353745 O - 55 (In Pocket) No. 1



SECTIONS THROUGH DRILL HOLES, BLACK HAWK MINE, GRANT COUNTY, NEW MEXICO

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