Mineral Deposits of Nogal and Bonito Mining Districts New Mexico

CIRCULAR 123 1973

NEW MEXICO STATE BUREAU OF MINES AND MINERAL RESOURCES

CIRCULAR 123

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1973

NEW MEXICO STATE BUREAU OF MINES AND MINERAL RESOURCES

Original Printing, 1973
Reprinted, 1983

Published by Authority of State of New Mexico, NMSA 1953 Sec. 63-1-4
Printed by University of New Mexico Printing Plant, June 1983

Available from New Mexico Bureau of Mines & Mineral Resources, Socorro, NM 87801
Deposited in public libraries

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Abstract

The Nogal and Bonito mining districts have yielded approximately $1,000,000 in lead, zinc, silver, and gold. Except for small placer operations, all of the production has come from fissure veins and the Parsons breccia pipe. Today mining operations in the district are sporadic. The district has four types of mineral deposits: 1) lead-zinc-silver fissure veins, 2) gold-copper breccia pipe deposits, 3) disseminated copper-molybdenum "porphyry" deposits, and 4) gold-bearing placers. Except the latter, hydrothermal alteration is extensive. Silicification, argillization, propylitization, and pyritization are common. The mineral deposits occur within the Sierra Blanca Volcanics or within three hypabyssal silicic stocks, the Rialto, Bonito Lake, or Three Rivers stocks. Localization of the fissure veins occurs along the Bonito fault, an east-west shear zone. Disseminated mineralization is associated with fracturing, brecciation, contact features, or late-stage intrusive phases within the stocks. Ore mineralization was consistent in the fissure veins with galena preceding sphalerite. Zinc to lead ratios show distinct zoning about the northern half of the Rialto stock. These zones are concentric to magnetite, molybdenite, and copper zones within that portion of the Rialto stock. The mineralogy and exsolution textures of sphalerite-chalcopyrite indicate mesothermal ore deposition conditions. The narrow lenticular fissure veins are poor. Also the excessive cost of transporting ore to milling facilities is a significant deterrent. The district has some potential, however, for high-tonnage, low-grade copper-molybdenum "porphyry" production.

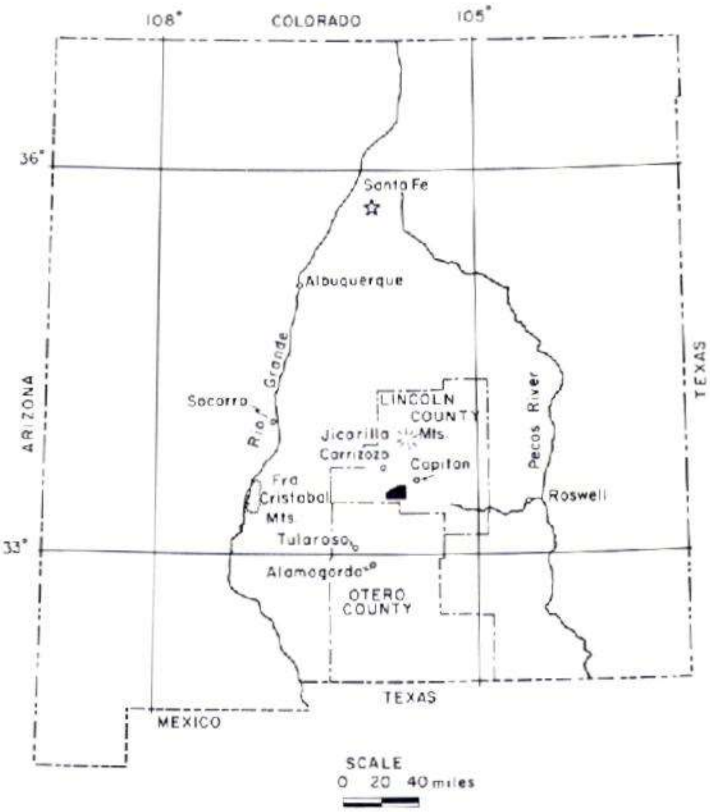


Figure 1
LOCATION MAP.

Introduction

PURPOSE

The mineral deposits of the Nogal and Bonito mining districts have lain dormant for more than thirty years. This study shows the structural controls, zoning, and types of deposits present within the district. Assessment of the commercial potential is not attempted.

Field work began in 1963 and continued to 1968, most of the work being done during summer and early fall. Areal geology, individual mines, and prospects were mapped.

PREVIOUS WORK

The mineral deposits of Nogal and Bonito mining districts have been studied by Jones (1904), Lindgren, and others (1910), Griswold (1959), and Griswold and Missaghi (1964). Regional structure was discussed briefly by Darton (1922) and in detail by Kelley and Thompson (1964). A detailed study of the areal structural geology and mineral deposits was done by Thompson (1966). Coal resources of the Sierra Blanca basin were studied by Wegemann (1914), and further study of coal resources was not attempted.

ACKNOWLEDGMENTS

The field study during the summer of 1964 was supported financially by the Roswell Geological Society. The cost of thin sections was partly defrayed by a grant from the New Mexico Geological Society. Field expenses for July of 1967 were covered by a grant from the Research Foundation at Oklahoma State University where the author is presently on the staff.

A number of local people contributed to this study. Among these are Messrs. Ralph Forsythe, F. G. McCrory, Arvel Runnels, Harold Pischel, and John Wright.

LOCATION

The Nogal and Bonito mining districts are located south-southeast of Carrizozo in south-central New Mexico (fig. 1). As considered here, it extends southward from Church Mountain to a little beyond Mon Jeau Peak (fig. 2, in pocket). It is bounded on the east by State Highway 37, and on the west by the mountain divide of Sierra Blanca. The area, about 100 square miles, is in Lincoln County, mostly in Lincoln National Forest.

CLIMATE, VEGETATION, AND ANIMAL LIFE

One of the greatest climatic extremes in the region exists between Tularosa Valley up to Sierra Blanca Peak (fig. 1). Precipitation in Carrizozo averages 13.62 inches per year (Reeder and others, 1959, p. 249) with recorded maximum and minimum temperatures of 110°F. and -5°F. Ruidoso, on the other hand, has recorded maximum and minimum temperatures of 97°F. and -27°F. and has an average annual precipitation of 21.25 inches. Snow accumulation for the high country is estimated from five to seven feet per year. The growing season of Carrizozo averages 192 days whereas that for Ruidoso is only 100 days. Although temperatures are not recorded for the high country, some idea of extremes can be visualized from fig. 3 and the following table.

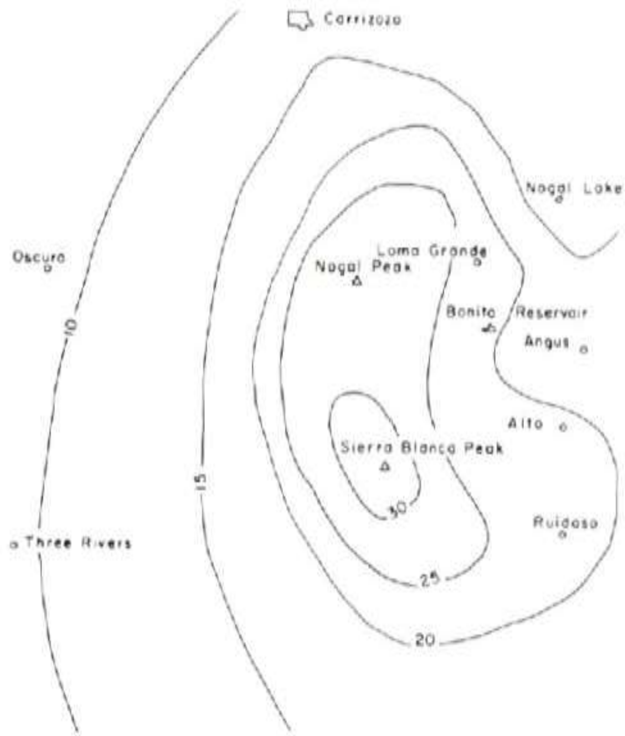


Figure 3
AVERAGE ANNUAL PRECIPITATION (INCHES) IN THE SIERRA BLANCA AREA (*compiled from New Mexico State Engineer, 1956*).

Average temperatures (°F)
(New Mexico State Engineer, 1956)

Location	July max.	Jan. min.	Annual
Carrizozo	81.6	29.3	55-58
Tularosa	83.9	35.2	58.9-66.7
Mescalero	69.1	28.7	47.8-53.2
Ruidoso	67.8	28.6	27.4-49.7
Loma Grande	64.6	27.2	45.5-49.6
Alto	65.4	28.0	48.7 (1897)

The distribution of plants and animals is varied. Martin (1964, p. 172) illustrated the general distribution of life associations for the Sierra Blanca area. The major types of trees include spruce, fir, pine, aspen, pinon, and juniper. Oak brush and buckthorn are thick enough in many places to make mapping difficult.

Geology

The dominant structural feature around the area of the Nogal and Bonito mining districts is the Sierra Blanca basin (fig. 4). The basin contains down-warped and faulted Mesozoic to early Tertiary sediments unconformably overlain by a blanket of flat-lying Oligocene (?) volcanics. The volcanics, in turn, have been intruded by late Oligocene silicic intrusives. Late Tertiary uplift to the south, and faulting within the district, complicate the picture. Of particular interest is the Bonito fault, an east-west zone, along which many of the vein deposits have been localized.

SEDIMENTARY ROCKS Pre-Cretaceous

Pre-Cretaceous rocks are not exposed at the surface within the mapped area, but a knowledge of subsurface stratigraphy is essential when considering the tectonics of the Sierra Blanca basin. The Sierra Blanca is at the intersection of two stratigraphic trends: 1) the east-west wedge-edge of lower Paleozoic sediments, and 2) the north-south Late Pennsylvanian Pedemal positive trend which extends northward at least 150 miles. Because exposures of pre-Cretaceous systems are lacking in this area, extrapolations from adjacent areas are necessary.

In the Sacramento Mountains to the south a section of pre-Cretaceous rocks having an aggregate thickness of about 8,000 feet overlies, in places, relatively unmetamorphosed Precambrian sediments (Pray, 1961). Precambrian rocks, however, are mostly gneissic and granitic, and, doubtless, are the most competent when considering the tectonics of the Sierra Blanca basin. Pre-Pennsylvanian sediments are mainly *marine* dolomite, limestone, and shale; these units are quite variable in thickness with a maximum aggregate of 2,000 feet in the central Sacramento Mountains. The systems thin and gradually wedge out in the subsurface of the Sierra Blanca area. In a test for petroleum by Standard of Texas (No. 1 J.F. Heard-Federal, sec. 33, T. 6 S., R. 9 E.) northwest of Carrizozo, Pennsylvanian sediments were found deposited on Precambrian gneiss. The Pennsylvanian sediments consist of marine limestone and shale with subordinate amounts of sandstone. Generally the unconformity between the Pennsylvanian and Permian rocks is conspicuous because of Pennsylvanian uplift; however, Otte (1959) describes a section in the northernmost Sacramento Mountains where sedimentation was continuous from Late Pennsylvanian into Early Permian. During this time the sediments indicate a gradual emergence of the area, and the Early Permian sediments are clastic redbeds containing material derived from the Pedernal Mountains.

The Leonardian sediments indicate accumulation in a persistent evaporite basin in the area near Carrizozo. The Pedernal uplift to the east undoubtedly was instrumental in isolating the basin. As much as 1,000 feet of halite, as well as gypsum, were encountered in the test well mentioned previously. Continental redbeds are typical of Leonardian rocks to the north; gypsum beds commonly are present in the Oscura Mountains to the west. To the south carbonate rocks dominate in the Leonardian sequence. The continental sediments are buried by as much as 700 feet of limestone with minor clastic sediments (Pray, 1961, p. 3).

The Leonardian sequence is succeeded by a sequence of fine-grained, friable sandstones and siltstones of the Bernal Formation (or Artesia Formation) considered to be Late Guadalupian in age, and from 0 to 350 feet thick in the Sierra Blanca area (Lochman-Balk, 1964, p. 57).

Triassic redbeds, 500 to 600 feet thick, overlie the Permian sediments. Minor Jurassic sedimentation may have occurred prior to the widespread Cretaceous inundation.

Cretaceous System

Mesaverde Group (Upper Cretaceous) conformably overlies the Mancos Shale. Near Capitan three mappable members are present: 1) a lower sandstone unit approximately 200 feet thick containing abundant *lnoceramus* as well as thin intercalated shale beds, 2) a middle coal-bearing shale unit approximately 200 feet thick with minor marine, fossiliferous limestone and sandstone beds, and 3) an upper sandstone approximately 50 feet thick.

This sequence is quite persistent throughout the Sierra Blanca area, with one notable exception. To the northeast, the upper member has thin conglomeratic beds consisting of rounded quartzite, petrified wood, and chert pebbles. Bodine (1956, p. 9) included this conglomeratic sequence in the overlying Cub Mountain Formation. The conglomeratic sequence is interbedded with well-sorted clean sandstone beds typical of the Mesaverde sands whereas the Cub Mountain sandstones are poorly sorted, arkosic, and contain andesite fragments in the lower part. The well-rounded pebbles and cobbles of the conglomeratic beds indicate considerable transportation which could only have been achieved with the type of environment known during Mesaverde time. The conglomeratic beds of the overlying Cub Mountain Formation are composed of very angular to rounded cobbles and boulders. In the Caballo Mountains, Kelley and Silver (1952, p. 112) included conglomeratic beds with quartzite, petrified wood, and chert pebbles in the uppermost Mesaverde Formation. Bushnell (1955) called this upper part of the Mesaverde, the Ash Canyon Member. This finding supports the occurrence of similar environments in both areas during Mesaverde and McRae times.

The maximum thickness preserved in the Sierra Blanca is probably about 550 feet. The Mesaverde Group is unconformably overlain by the Cub Mountain Formation.

Cretaceous and/or Tertiary Systems

Cub Mountain Formation is used by the author to include a thick sequence of continental deposits that unconformably overlies the Mesaverde Group. Cub Mountain Formation has been used by earlier workers (Bodine, 1956; Weber, 1964) for this collection of sediments. The author's field comparison of the Sierra Blanca area sequence with the McRae Formation type locality sequence near Elephant Butte Reservoir (fig. 1) indicated similar lithologies for the two sequences. Possibly both were deposited in a continuous basin. The author feels that the Cub Mountain Formation is equivalent to the McRae Formation. Because of poor exposures, faulting, igneous intrusives, and folding, sections were not measured. The lower contact with the Mesaverde Group was generally chosen where

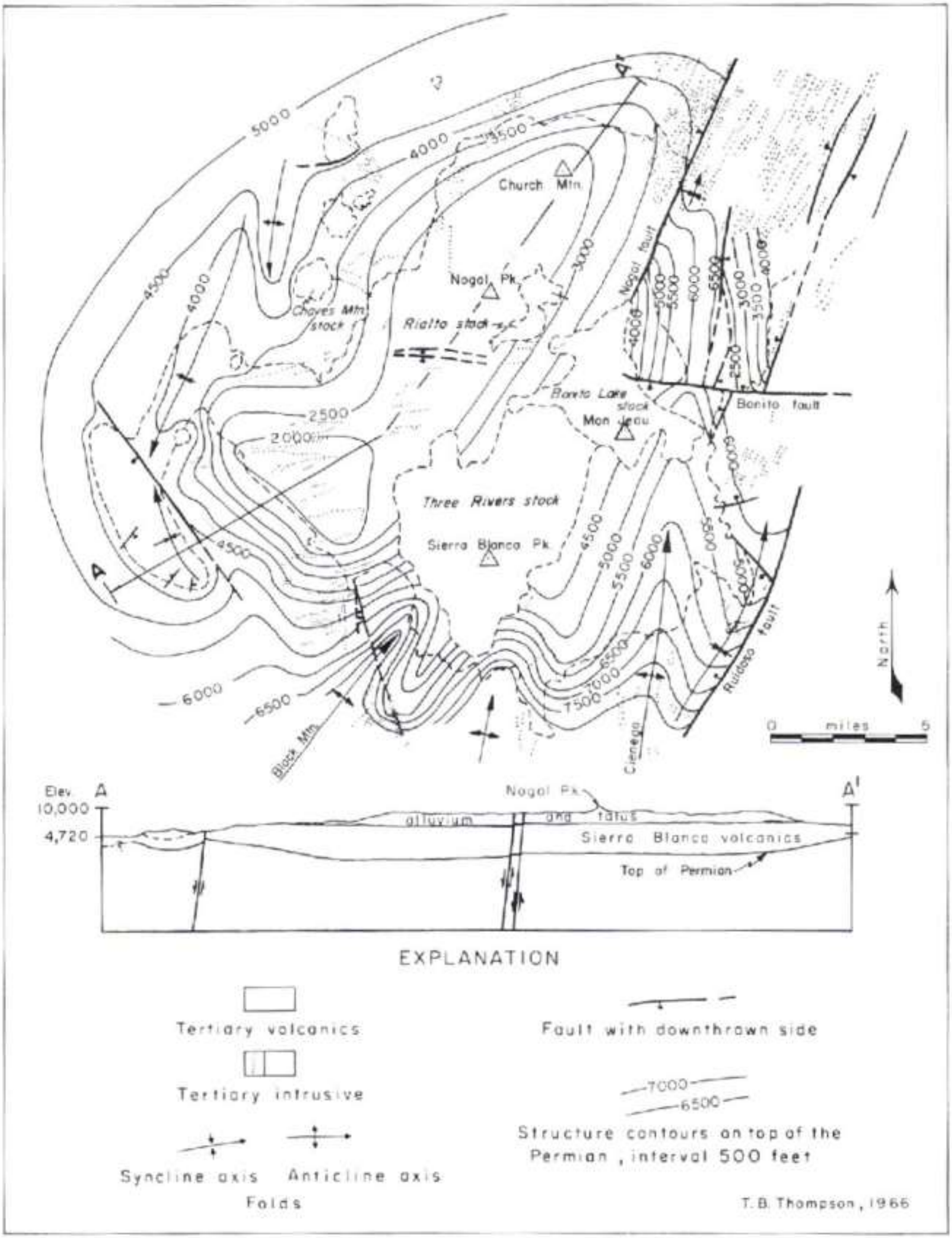


Figure 4
Tectonic map of Sierra Blanca basin.

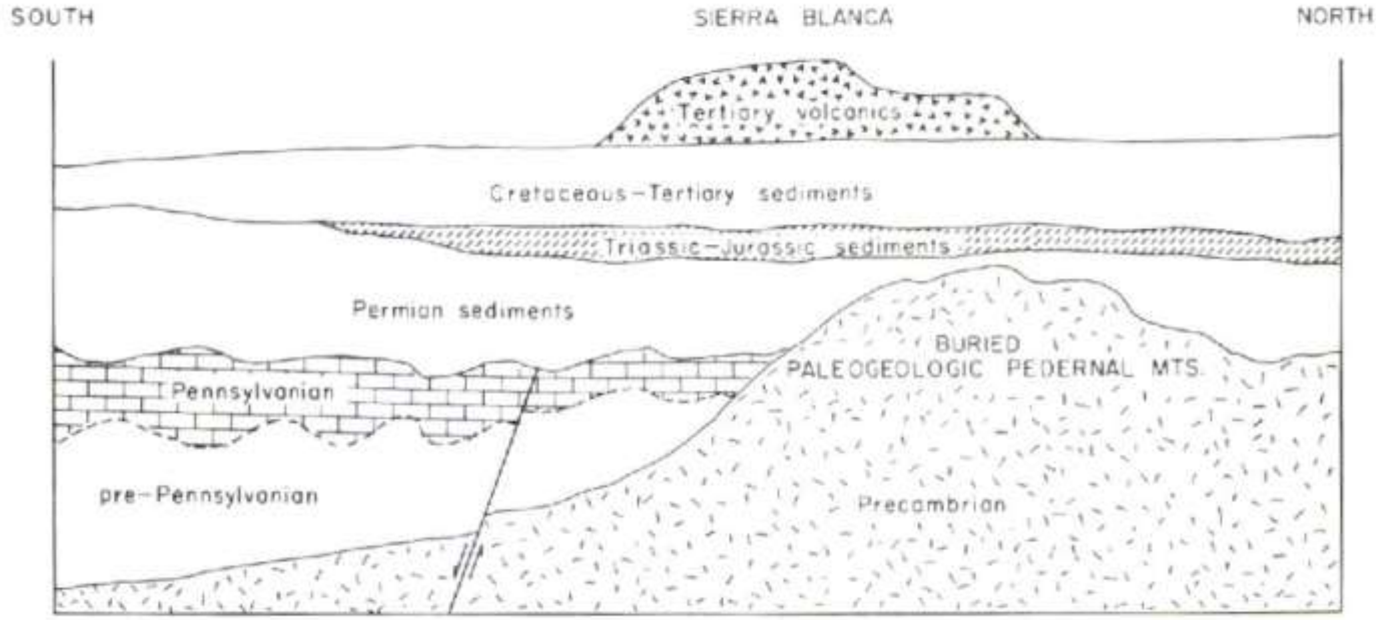


Figure 5

Diagrammatic north-south section of south-central New Mexico showing stratigraphic relationships without Laramide, or younger, structural complexities.

the first maroon shale appears; however, poorly sorted, arkosic sandstone is common at the base of the McRae. Massive white-to-buff sandstone, intercalated with variegated shale, is present only in the lower part of the Cub Mountain and possibly could be used to subdivide it into two members. These sands are well exposed in Sanders Canyon, near the mouth of Indian Creek, and in the area south of Nogal and Capitan to Ruidoso.

The upper part of the Cub Mountain Formation consists of red to maroon sandstone and siltstone, with conglomeratic zones containing andesite fragments. The sands are probably better termed graywackes. Flattened mudballs are abundant throughout the upper section. Petrographic studies indicate the following constituents: quartz, orthoclase, biotite, magnetite, sphene, apatite, calcite, hematite, and rock fragments. Most of the grains are angular with maximum dimension of 1.5 millimeters, and all are hematite-coated. Some pyroxene and plagioclase grains were noted in samples from the upper part of Sanders Canyon and from near Angus. Plagioclase composition varied from An_{24} to An_{32}. The abundance of andesite fragments in the upper sequence indicates nearby volcanism, whereas the lower part of the formation indicates post-Mesaverde uplift and erosion with much of the material derived from the Mesaverde. At Ruidoso a Cub Mountain section is preserved in a syncline. The Cub Mountain here overlies quartzitic conglomerate of the Mesaverde Group.

The upper contact of the Cub Mountain Formation was taken where the maroon andesite breccias of the Sierra Blanca Volcanics appear.

Weber (1964, p. 105) indicated a total thickness of about 2,400 feet for the Cub Mountain Formation just west of the map (fig. 2) area. This thickness is probably somewhat high due to repetition of section by folds and small-displacement faults. Bodine (1956, p. 5) indicated a thickness of approximately 500 feet for the Cub Mountain in the Capitan area.

Tertiary System

An unconformable unit of *fanglomerate* is deposited near the town of Nogal. This unit truncates dikes intruding the Mesaverde. Post-depositional faults break the fanglomerate. Near the town of Nogal the areal extent is approximately one square mile, and its preservation is due to post-depositional faulting. The thickness of 127 feet is the greatest anywhere within the map area. The uppermost unit of the Mesaverde Group at this locality is a 14.8-foot thick gray to buff, cross-bedded, coarse-grained, quartzose sandstone. The fanglomerate consists of angular to rounded pebbles, cobbles, and boulders. The fragments arc composed of syenite porphyry from the Three Rivers stock, quartzite of unknown origin, and andesite breccia and porphyry from the Sierra Blanca Volcanics. The material is poorly sorted and bedded; cut-and-fill channels are numerous. The matrix in the lower part is coarse-grained sand which decreases in grain size upward in the section. Near the top, caliche is abundant and the fragments are fewer and smaller, on the average, than in the lower part.

Consolidated gravel occurs in numerous other localities along the eastern and western margins of the map area. Because of the incorporated local material and the degree of induration all of the fanglomeratic material is considered more or less contemporaneous. These fanglomerates overlie the Mesaverde Group, the Cub Mountain Formation, and the Sierra Blanca Volcanics.

The fanglomerate probably represents the westward extent of the Ogallala Formation (Pliocene). Bretz and Horberg (1949) found that the Ogallala Formation once covered all but the highest points of the Sacramento range. In the Pecos Valley quartzitic conglomerate is common in the basal Ogallala, and gradually changes upward in the section to a conglomerate with a caliche matrix. Similarity of lithologies suggests correlation between the fanglomerate and the Ogallala Formation.

The Mesaverde Group, McRae Formation, and Sierra Blanca Volcanics are overlain by terrace gravel. The gravel forms isolated mesas due to later dissection.

Alluvium occurs along the bottoms of all canyons. In most places it is impractical to map due to the scale of mapping. Many small unmapped talus slides occur in (iffy areas of the large intrusive masses of the Sierra Blanca.

VOLCANIC ROCKS

Sierra Blanca Volcanics

Sierra Blanca Volcanics comprising the major portion of the area, overlie with angular unconformity the Cub Mountain Formation and Mesaverde Group. The maximum thickness preserved is 3,340 feet in the Nogal Peak area (Thompson, 1964, p. 76-78). The location of the measured section is indicated on fig. 2; fig. 6 is a graphic section.

When the preliminary study on the Sierra Blanca Volcanics was published (Thompson, 1964) little petrographic work had been done. As a result some modification is needed. The basal unit of the Sierra Blanca Volcanics is a reddish-brown andesite breccia (volcanic breccia consists of blocks already solidified when emitted—Williams, 1961). The breccia fragments are angular to rounded and range from two to six inches in diameter. They are hematite-coated and constitute more than 50 percent of the rock. The matrix is similar in composition but finely crystalline. Pervasive hematite and zeolites are quite abundant as are phenocrysts of plagioclase and pyroxene.

A series of 35 distinct flows and flow breccias are found in the overlying units of the volcanic rocks. These flow units become more silicic with loss of pyroxene and increase in hornblende and biotite. Some sanidinc is present in the upper units. Units 30, 32, and 34 are massive andesite porphyry flows with minor amounts of breccia fragments. These three units form steep cliffs along the upper part of the western Sierra Blanca. Unit 34 was particularly useful in correlating and measuring the volcanic sequence.

The upper 985 feet of the Nogal Peak section has been mapped separately as the Nogal Peak Trachyte. It consists of five flows, some of which contain andesite breccia fragments. These flow units have distinct fluidal structure around the phenocrysts and fragments. Minerals present include plagioclase, biotite, diopside, sanidine, magnetite, apatite, quartz rimmed by epidote, hematite, and glass.

Four miles northeast of Nogal Peak the andesite breccias of the Sierra Blanca Volcanics are overlain by the Church Mountain Latite which ranges to 750 feet thick. The major constituents are sanidine and hornblende with subordinate magnetite and plagioclase. Phenocrysts of the dominant minerals are common but often are corroded and replaced. Angular crystal fragments are present, too. Flow-banded glass is the major constituent in several of the flow units. The glass banding is accentuated by color variations from dark reddish-brown to black. Accessory minerals are sanidine, plagioclase, biotite, clinopyroxene, hornblende, and magnetite. The Church Mountain Latite may be the lateral equivalent of the Nogal Peak Trachyte; however, lateral tracing is impossible because these units have been removed by erosion between Nogal Peak and Church Mountain.

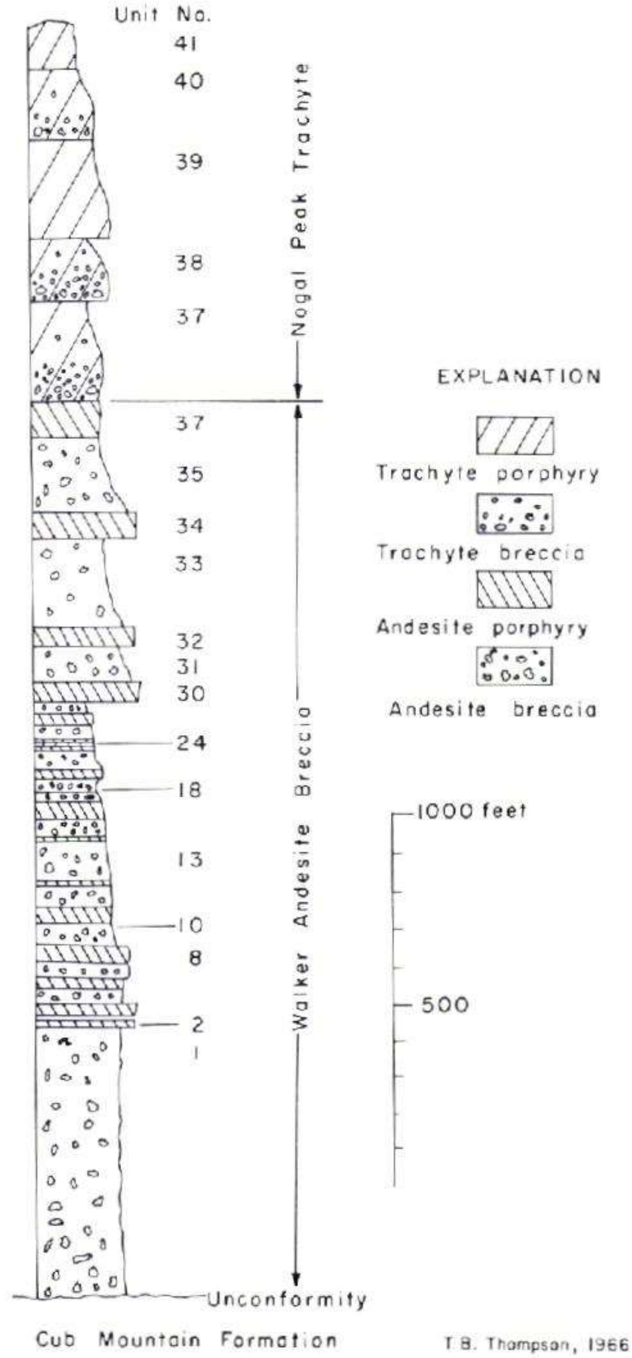


Figure 6
GRAPHIC SECTION OF SIERRA BLANCA VOLCANICS IN THE NOGAL PEAK AREA.

INTRUSIVE ROCKS

The outcrop area of intrusive rocks comprises a little less than 25 percent of the total area. Three large stocks have been mapped in the Sierra Blanca: 1) the Rialto stock, 2) the Bonito Lake stock, and 3) the. Three Rivers stock. Dikes are exceedingly numerous and are shown only where outcrops and scale permit.

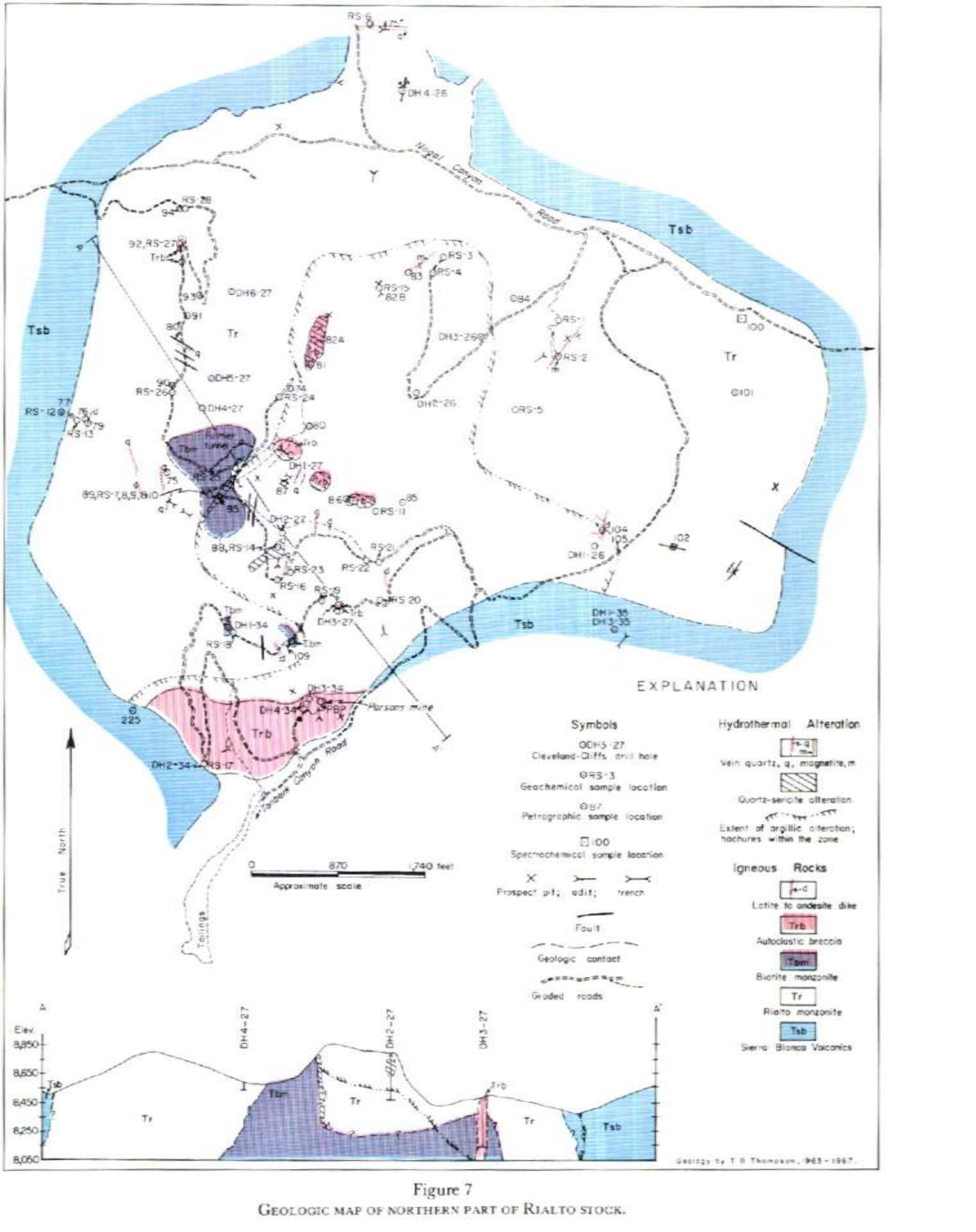


Figure 7
GEOLOGIC MAP OF NORTHERN PART OF RIALTO STOCK.

Rialto Stock

Rialto stock is about half a mile east of Nogal Peak and extends roughly north-northeast over an area of 1.9 square miles. It is predominantly a hornblende-biotite monzonite as indicated by staining of feldspars and by petrographic analyses except for a few small apophyses of biotite monzonite (fig. 7) which appear to be the final crystallization product of the magma. Orthoclase and plagioclase (An_32) constitute 89 percent of the hornblende-biotite monzonite. Biotite and magnetite appear to envelop and replace hornblende. Quartz is present as anhedral grains, but it never constitutes more than five percent in unaltered rock. Accessory minerals include sphene, apatite, rutile, and magnetite. A spectrochemical analysis of S. B. 100 (fig. 2) is given below:

SiO_2	64.1%
TiO_2	1.6
Al_2O_3	15.6
FeO (total Fe)	4.06
MnO	0.14
MgO	0.64
CaO	3.10
Na_tO	6.31
K_2O	4.00
P_2O_s	
Total	99.55%

This analysis corresponds to Nockolds' (1954, p. 1017) average alkali syenite. More detail on this stock will be presented when discussing the mineral deposits.

Bonito Lake Stock

Bonito Lake stock occupies much of the east-central part of the area, 12.6 square miles. Its K-Ar date is 26.6 million years, probably late Oligocene. The rock is biotite syenite with magnetite, apatite, zircon, and traces of pyroxene and hornblende as accessories. Hornblende has extensively replaced the pyroxene, and the hornblende is now dominantly replaced by biotite. Locally, microperthite is the dominant feldspar, but plagioclase (An_{28} to An_{51} in cores of zoned crystals) and orthoclase are more common. Along the margins of the intrusive, euhedral diopside is rimmed by hornblende and magnetite. Along certain fractured zones the presence of hydrothermal quartz (up to 10 percent) gives the rock a granitic appearance in hand specimen; but petrographic examination indicates that the quartz is principally hydrothermal.

Around Bonito Lake several biotite syenite dikes intrude the stock. These dikes have chilled margins averaging two to three inches in width. Aplitic dikes consisting of microperthite, biotite, quartz, zircon, and traces of hypersthene are common in the Mon Jeau Peak area.

Along the western margin of the Bonito Lake stock adjacent to Tanbark Canyon the rock is more monzonitic, and ferromagnesian minerals are commonly chloritized.

Three Rivers Stock

Three Rivers stock is the southernmost and largest, covering 28.9 square miles. It is principally a leuco-syenite porphyry, but with variations in texture. The Sierra Blanca Recreation Area road crossing the eastern part of the stock affords many good exposures. Elsewhere, vegetation, deep weathering, and hillside debris limit exposures except above timberline near an elevation of 10,500 feet.

The following spectrochemical analyses were made of samples (fig. 2) from the Three Rivers stock:

	S.B.C.	S.B. 113	S.B. 2000
SiO_2	63.0%	63.0%	64.1%
TiO_2	1.2	1.2	1.3
Al_2O_3	16.5	16.6	12.7
FeO (total Fe)	3.6	5.15	4.64
MnO	0.15	0.35	0.18
MgO	0.59	0.37	0.49
CaO	3.4	4.24	4.58
Na_tO	6.65	6.25	4.0
K_2O	4.90	5.23	7.66
P_2O_5			
Totals	99.99%	102.39%	99.65%

Comparing with Nockolds (1954, p. 1016), S. B. C. corresponds to an average alkali syenite while S. B. 113 and S. B. 2000 correspond to average peralkaline syenite.

Petrographically, S. B. C. is a miarolitic syenite porphyry with two variations of phenocrysts: 1) anorthoclase rimmed by microperthite, and 2) anorthoclase rimmed by alkali feldspar with a microperthite transition zone between. 2V measurements of the cores of the phenocrysts give angles of approximately 40 degrees while along the rim the 2V is 30 to 35 degrees. These angles were measured from optic axis and acute bisectrix figures. In all cases the isogyre (optic axis) or isogyres (acute bisectrix) remained within the field of view. The phenocrysts, 1.5 centimeters in maximum dimension, constitute as much as 80 percent of the rock. Hornblende, biotite, magnetite, apatite, zircon, orthoclase, and quartz occur as matrix minerals. The hornblende has a blue pleochroism along its outer edges suggesting sodic hornblende. Biotite and magnetite preferentially rim and replace the hornblende. Magnetite veins zircon. The feldspar phenocrysts have a noticeable rim accentuated by light-colored microperthite or sanidine and by the fine-grained matrix adjacent to the phenocrysts. Quartz veins the phenocrysts and is strained showing a very small 2V. Quartz crystals also occur in the vugs. Where alteration of the feldspar occurs quartz is derived from the feldspar, and occurs as minute blebs radiating outward from the phenocryst. Elsewhere quartz and orthoclase were deposited from residual fluids interstitial to the phenocrysts. Flow fractures seen in thin section commonly indicate the direction of flow of the interstitial fluids.

A K-Ar date on alkali feldspar (K-1000 locality, fig. 2) from the Three Rivers stock indicates an Oligocene (25.8 ± 1.1 m.y.) age of crystallization which accords with other radiometric dates for the area.

Dikes and Sills

Dikes and sills are abundant within the map area. No attempt was made to differentiate among the different mafic rock types found in the field. Twenty-one thin sections were studied to describe the rock types. Elston and Snider (1964, p. 140) have distinguished seven major types of dikes in the Capitan swarm northeast of Nogal: 1) labradorite-olivine diabase porphyry, 2) olivine diabase porphyry, 3) diabase, 4) homblende-biotite diabase, 5) rhyolite, 6) latite (grading into trachyte), and 7) phonolite. Patton (1951) briefly discussed olivine-free diabases of the area while Sidwell (1946, p. 66) stated that approximately 75 percent of the dikes in the Capitan quadrangle consist of medium-grained diorite porphyry.

In the vicinity of Nogal, at the southern end of the exposures of the Capitan swarm, dikes are exceedingly numerous. Most of the dikes here trend N. 20° E. The presence of a dike swarm and volcanic rocks with associated dike feeders suggests that an intrusive magma, or magma chamber, existed beneath the dike swarm. The N. 20° E. trend of dikes is common down to Bonito Canyon. South of here, trends of N. 40.70° E. are found radiating from the large stocks. Exposures are particularly poor and can be traced no more than a few hundred feet.

Where individual dikes could not be mapped because of poor exposures or intensities of intrusion, the area was designated on the map (fig. 2) as "dike-sill complex."

Mineral Deposits

HISTORY AND PRODUCTION

The Nogal and Bonito mining districts are not covered in their entirety in this report, and only that portion of the districts within the area of Fig. 2 is considered. No boundary is herein given to areally define the two districts, but there has been some confusion in the past on their limits.

The first record of mining in the district was for placer gold in the 1860's along Dry Gulch in sections 6 and 7, T. 9 N., R. 13 E. (Griswold, 1959, p. **41).** Sporadic placer mining on a small scale continues to the present time. This early activity eventually led, in 1868, to the lode source in the Helen Rae-American vein system. The deposit was sporadically exploited from the 1880's to the early 1930's. Production records have been lost, but an old undated map found recently by Mr. Ralph Forsythe of Nogal gives production figures for the mines in T. 9 S., R. 11, 12, and 13 E. Ten mines produced a total of $212,000 at the prices of the time. A study of claim records in the Lincoln County courthouse indicates the date to be about 1920.

The Parsons mine (sec. 34 and 35, T. 9 S., R. 11 E.), produced an estimated 85,000 tons from 1900 to the 1920's. During 1908 the ore averaged $3.50 per ton based on a gold price of S20.00 per ounce (Lindgren and others, 1910), indicating S300,000 of gold may have been produced.

No other production records are available for the Nogal district, but probably no other mine produced more than a few thousand dollars of ore judging from dump sizes and extent of workings. The total production of the district probably amounts to something near $1,000,000 at present value, a rather small figure. There is potential for considerably increasing this total by present-day low-grade, high-tonnage mining.

TYPES OF DEPOSITS

Four types of mineral deposits are in the Sierra Blanca area: 1) fissure veins, 2) breccia pipe deposits, 3) disseminated "porphyry" deposits, and 4) placer accumulations.

Except for the placer accumulations, the deposits were hydrothermally emplaced and are considered mesothermal to epithermal. Silicification, pyritization, and/or argillization of the country rock are common adjacent to the deposits.

MINE DESCRIPTIONS

These descriptions include most of the major workings, but not all the mines and prospects.

Fulmer (Rialto Group) Mine

The Rialto Group lies in the northern half of the Rialto stock (secs. 26, 27, 34, and 35, T. 9 S., R. 11 E.) and was located by M. D. Gaylord in 1894. The workings consist of the Fulmer tunnel and the Upper adit above the Fulmer level (figs. 2, 7, and 8). The Rialto Group is a series of 39 claims owned by the Rialto Exploration and Development Company, Inc., of Nogal, New Mexico. Mr. Ralph Forsythe of Nogal oversees the property.

The northern half of the Rialto stock (fig. 7) has been extensively affected by hydrothermal alteration. An earlier study (Griswold and Missaghi, 1964) indicated four irregularly distributed types of alteration. The present author feels that Griswold and Missaghi failed to distinguish between hydrothermal and supergene alteration. This is substantiated by a drilling project in which many of the drill holes in their zones of intense alteration encountered unaltered rock at shallow depths. Many hand specimens were collected over the surface of the Rialto stock to help outline the hydrothermally altered areas (Appendix A).

Drilling of the Rialto Group in 1964 by the Cleveland-Cliffs Iron Co. consisted of 18 holes done by rotary hammer-tool with forced-air circulation. These holes were logged by the author (Appendix B) and helped define the alteration zones. Griswold and Missaghi (1964, p. 12) showed that the molybdenite mineralization was concentrated in areas in which silicification, sericitization, kaolinization, and pyritization of the monzonite had occurred. One exception was reported at the mouth of Indian Creek near the site of **DH** 4-26. The present author did not observe molybdenite at this locality; assays of DH 4-26 show nothing more than a trace of MoS_2 common throughout the entire stock.

The present study (fig. 7) shows the maximum extent of argillic alteration. Rocks of this type alteration are composed mostly of clays minerals with minor amounts of quartz, sericite, and pyrite. The original rock textures are destroyed except near the outermost argillic alteration. The opaque minerals consist generally of sulfides below the zone of oxidation. The outermost boundary of the argillic zone is not distinct; limited outcrops make the contact on the map only approximate. Peripheral to this zone is a zone of propylitization in which the feldspars are normally unaffected and the ferromagnesian minerals are replaced by chlorite and magnetite. Within the propylitic zone the monzonite is crosscut by numerous magnetite veinlets and veins. Often actinolite and sphenc are found with the magnetite. The magnetic fraction both in hand samples and from the drill hole cuttings is commonly 10 to 12 percent (by weight). Plagioclase containing acicular rutile is partly replaced by alunite or epidote in a few places.

The most intense alteration of the monzonite consists entirely of fine-grained quartz and sericite with traces of opaques. The extent of this type alteration is quite limited, occurring as small patches throughout the argillic zone. The quartz-sericite alteration is controlled by brecciated portions of the monzonite; although not all the breccias are altered as extensively as at DH1-27 or at the breccia zone in the vicinity of Parsons mine. The quartz-sericite alteration results in resistant masses forming distinct topographic knobs.

The distribution of molybdenite appears to be closely related to the small breccia pipe found in the vicinity of the Fulmer tunnel and Upper adit (figs. 7 and 8). A core-drilling project by American Metals Climax, Inc. in 1957 showed mineralization becomes more spotty away from the breccia. Molybdenum content is also greatest around the brecciated zone (Griswold and Missaghi, 1964, p. 11). The brecciated zone appears to have nearly vertical contacts and probably formed by explosive pneumatolytic action.

Tentative interpretations from logging of Cleveland-Cliffs drill holes suggest that all brecciated zones are found in the periphery of the biotite monzonite phase of the Rialto stock.

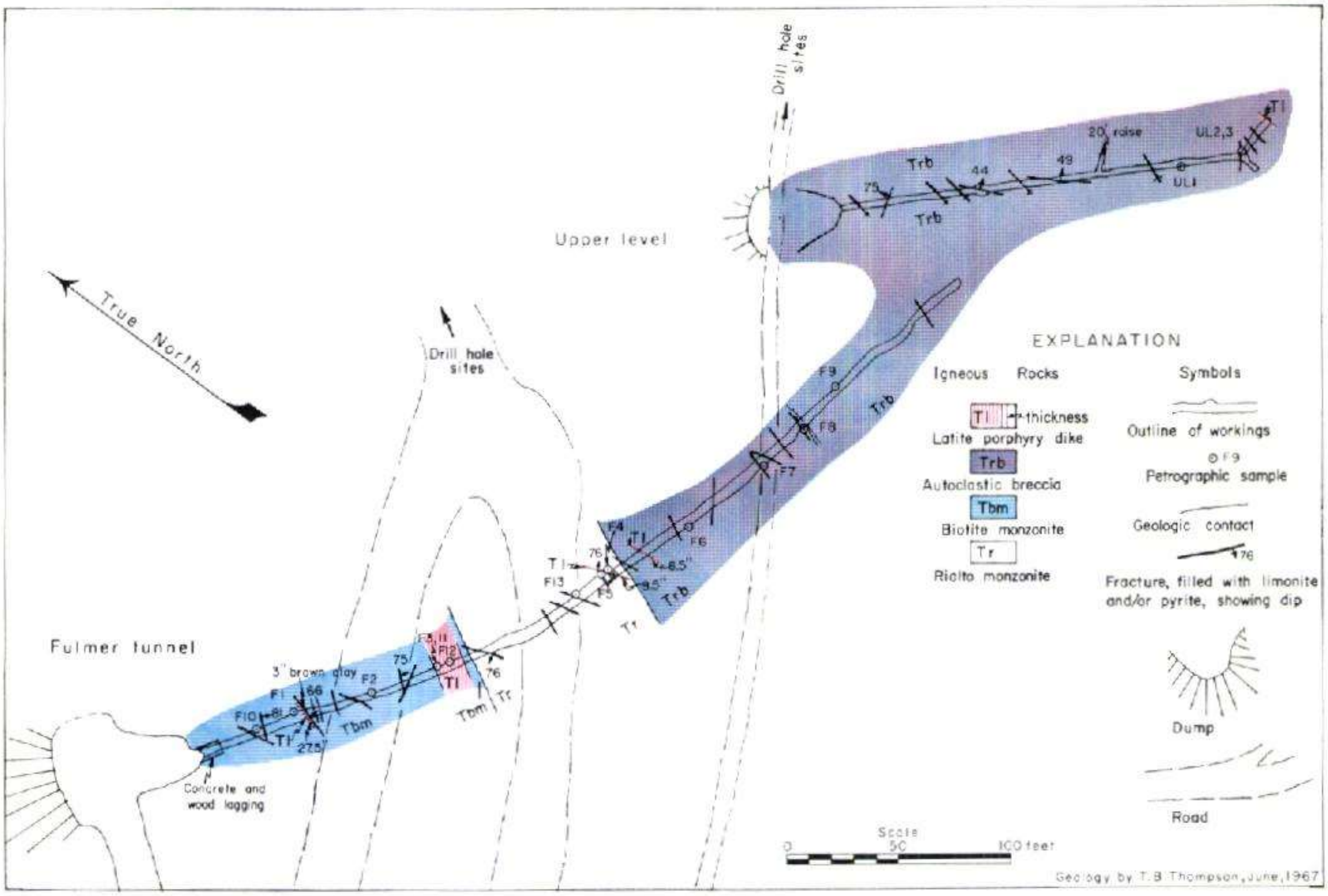


Figure 8
FULMER TUNNEL AND UPPER LEVELS.

The breccia pipes and their associated alteration appear to be at intersections of joint and fracture systems near contacts of the biotite monzonite and the hornblende-biotite monzonite. Mapping of fractures (fig. 8) in the Fulmer tunnel and Upper level shows two distinct trends. One trends N. 7° E. and is found within the breccia pipe on both levels. The other trend, found only on the Fulmer level in the biotite monzonite and Rialto monzonite (hornblende-biotite monzonite), is N. 15° W. The N. 7° E. aligns with an elongate silicified breccia pipe north-northeast of the Upper level. The same trend is found in vein quartz on the surface south of the workings. Fractures and vein quartz mapped on the road northwest of DH5.27 trend N. 60° W. and, when extended southeasterly, trend through three of the breccia pipes. Thus, fractures, as well as contacts between the biotite monzonite and hornblendebiotite monzonite, apparently controlled the location of the breccia pipes.

Hydrothermal alteration extends outward from the breccia pipes much like an anastomosing series of inverted cones. This interpretation is supported by logging of DH2-27 which shows a quartz-sericite zone (fig. 7, section A-A') at depths of 35 to 165 feet. The same quartz-sericite zone crops out just south of the drill hole. This zone of alteration may have originated from a small silicified breccia pipe northeast of the drill hole.

During the summer of 1967 the author collected 29 rock samples (fig. 7) which were analyzed for copper by the New Mexico State Bureau of Mines and Mineral Resources (Appendix C). The analyses (fig. 9) show an anomalous area in the vicinity of the Parsons mine and extending northward for approximately 2,000 feet. The east-west dimension of the anomaly is about 800 feet. The mean copper content of the monzonite outside of this anomalous area is 30 ppm. The bedrock copper content within the anomaly ranges from 3 to 26 times that of the mean. Secondary copper mineralization is found at the surface over much of this area. X-ray diffraction indicates the copper mineral is turquoise. In addition, DH3-27 contains abundant chalcocite-coated pyrite and bomite which average 0.22 percent copper over a 240-foot interval. Minor chalcocite-coated pyrite occurs in DH2-34. Minor amounts of chalcopyrite were noted in the cuttings of other drill holes on this property (Appendix B).

A study of heavy minerals from the cuttings of the Cleveland-Cliffs drilling project resulted in some interesting observations. The dominant heavy mineral in drill holes located in the propylitic zone is magnetite while within the argillic and quartz-sericite zones sulfides are the characteristic opaques. The opaque minerals noted in this study include magnetite, pyrite, molybdenite, native copper, bornite, and chalcocite.

Two magnetite veins in the Rialto stock (fig. 7) have been prospected, but not mined. Gold can be panned from some of the magnetite samples (Ralph Forsythe, personal communication).

To date, drilling results in the Rialto Group have been discouraging. This condition may be due, in part, to poor drill

Figure 9

GEOCHEMICAL ROCK-SAMPLING OVERLAY, RIALTO STOCK.

(whole rock copper content in ppm)

hole locations and to poor sampling techniques. American Metals Climax, Inc. did not catch sludge samples, and core recovery was poor in the molybdenite-bearing zones (Ralph Forsythe, personal communication). The Cleveland-Cliffs drill holes were so randomly and widely spaced that several ore deposits could have been missed. Also their drilling rates (524 feet per day on D111-27) were so great that samples were inadequately handled. No fines were collected from the air drilling, and assay samples were not split (Ralph Forsythe, personal communication). Presumably systematic drilling around the Upper adit or from the Fulmer tunnel level would test the extent of molybdenum mineralization. Possibly some additional drifting at the Fulmer tunnel level would be warranted.

Although the Rialto has been considered only a molybdenum prospect, the bedrock copper geochemical anomaly as well as the high copper content of DH3-27 marks this area as a copper prospect. In fact the copper-bearing zone at the surface is more extensive than the molybdenum-bearing zone. Although the copper could be the result of weathering and leaching from a small source area, further drilling is needed to adequately test the anomaly.

Parsons Mine

The Parsons breccia pipe in the central part of the Rialto stock is an elliptical body with the long axis trending northeasterly (fig. 2). The breccia consists of fragments of various volcanic rock types and monzonite in a matrix of monzonite. The ratio of monzonite to volcanic fragments is on the order of 10:1. Portions of the breccia pipe have been subjected to hydrothermal alteration which has obliterated most of the original rock textures. The breccia pipe was exploited for gold in the early 1900's by glory-hole methods (fig. 10). The initial discovery was made in 1888 by R. C. Parsons. The present owners are Ruth L. Penfield of Roswell, New Mexico, and J. H. Fulmer of Carrizozo, New Mexico.

One large glory hole and two smaller holes constitute the main workings. Underground stoping was done from an adit in the northeastern corner of the main glory hole. Access to the underground draw ways of the main glory hole was through a shaft, southwest of the glory hole, now caved.

Minerals within the breccia pipe appear to be gold-bearing limonite and two turquoise caps. The turquoise is not found in underground workings. There are two post-breccia, pre-mineralization dikes whose compositions cannot be determined due to hydrothermal alteration. Post-dike faulting within the breccia pipe is common. In the two larger underground workings off the main glory hole, the breccia pipe boundary with the Rialto stock is intersected. The unbrecciated rock is monzonite containing pyrite, chalcopyrite, and molybdenite.

Two holes were drilled in the breccia pipe during Cleveland-Cliffs exploration of the Rialto stock (fig. 10, DH3-34 and DH4-34). Below the oxidized zone the pipe contains abundant sulfides; however, the drilling encountered old workings which halted further drilling.

A reconstruction of topography and determinations of rock volume removed from the accessible workings indicates that 70,000 to 85,000 tons of rock have been mined. These figures do not include inaccessible draw ways beneath the glory holes.

The ruins of an old mill are present south of the mine.

During the summer of 1971, an extensive drilling program was conducted in the area of the Parsons mine through a partnership of several interests.

Renowned O.K. and Crow Mines

The Renowned O.K. and Crow (a patented claim) mines are on the Crow vein in Tanbark Canyon. The vein is tangent to the southern part of the Rialto stock on the west side of Tanbark Canyon. It diverges from the contact to the east (fig. 2). The vein trends roughly east-west, dips steeply south in the Renowned O.K. mine and is vertical in the Crow mine (fig. 11). Mineralization is localized along a fault zone and is discontinuous along strike as well as along dip. Postmineral shearing has given rise to some gouge ore. Secondary copper minerals are also localized along the shear zones. Pyritized wall rock is present throughout the workings.

At the time of mapping (November 10, 1964) the Renowned mine did not show any signs of recent activity. Signs indicate New Mexico Copper Corporation owns the property. A comparison with Griswold's map (1959, pl. 7) indicates that the Renowned O.K. workings are slightly more extensive than were accessible during the present study. These workings are now either caved or full of broken rock. The vein disappears where it comes in contact with Griswold's "gray latite porphyry," probably the southern margin of the Rialto stock. Sulfides of lead and zinc were noted in three localities in the Renowned O.K.: 1) near the portal, 2) in a stoped area 210 feet from the portal, and 3) in the wine and stope area indicated in section B-B' (11g. I 1). Elsewhere the vein is barren and consists of quartz-pyrite stringers.

To the east across Tanbark Canyon the Crow (Silver Bar)

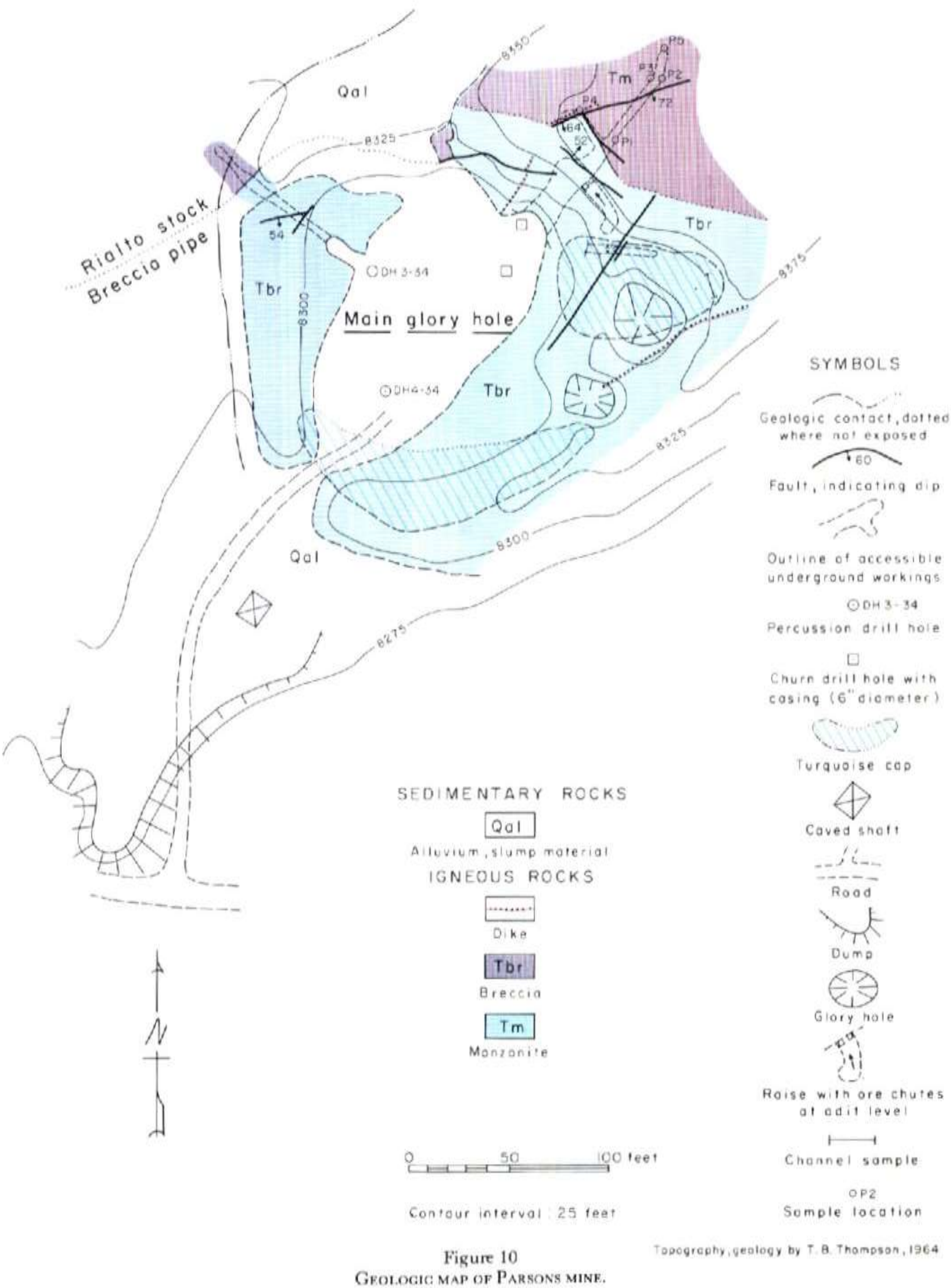


Figure 10
GEOLOGIC MAP OF PARSONS MINE.

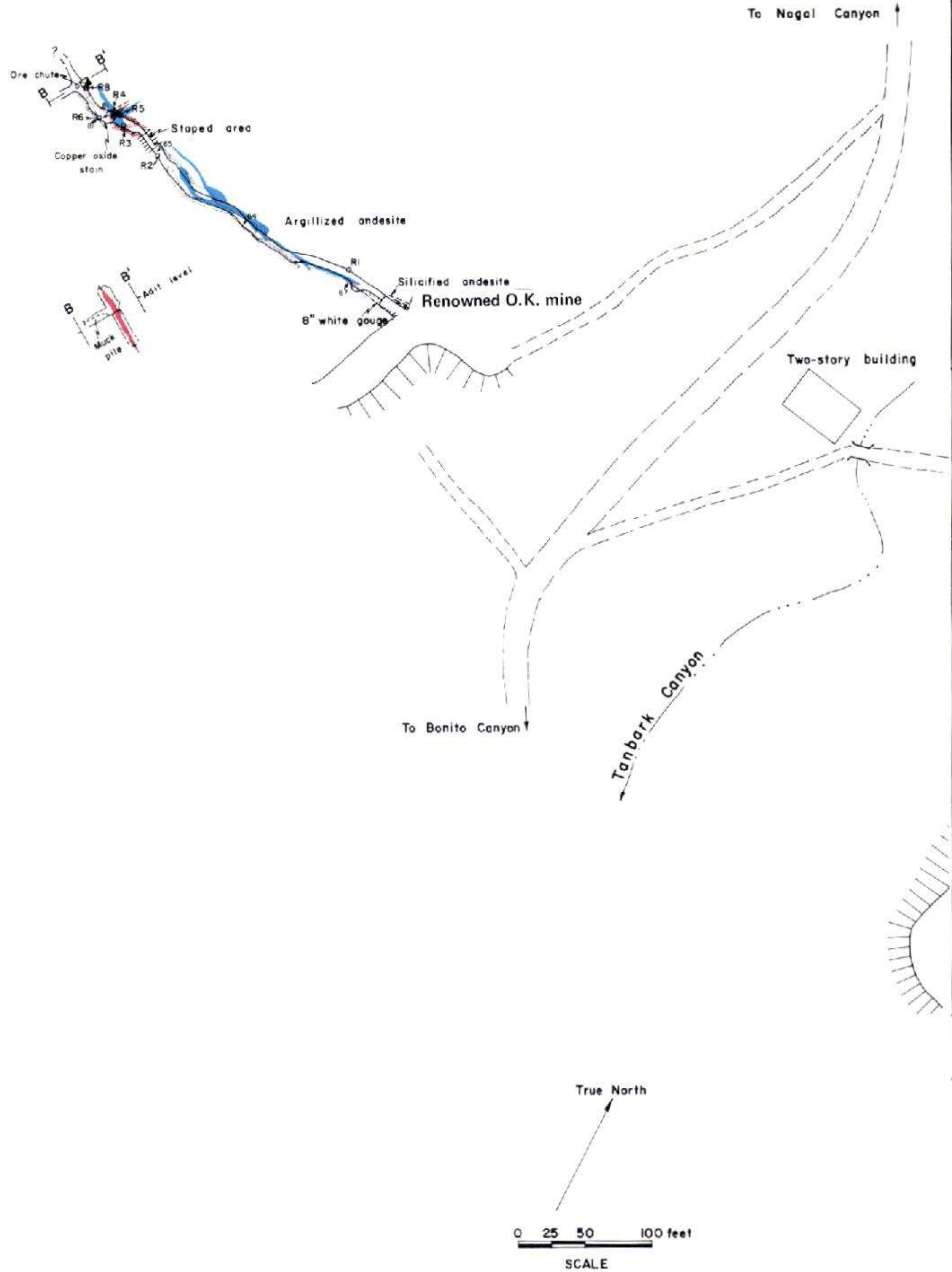
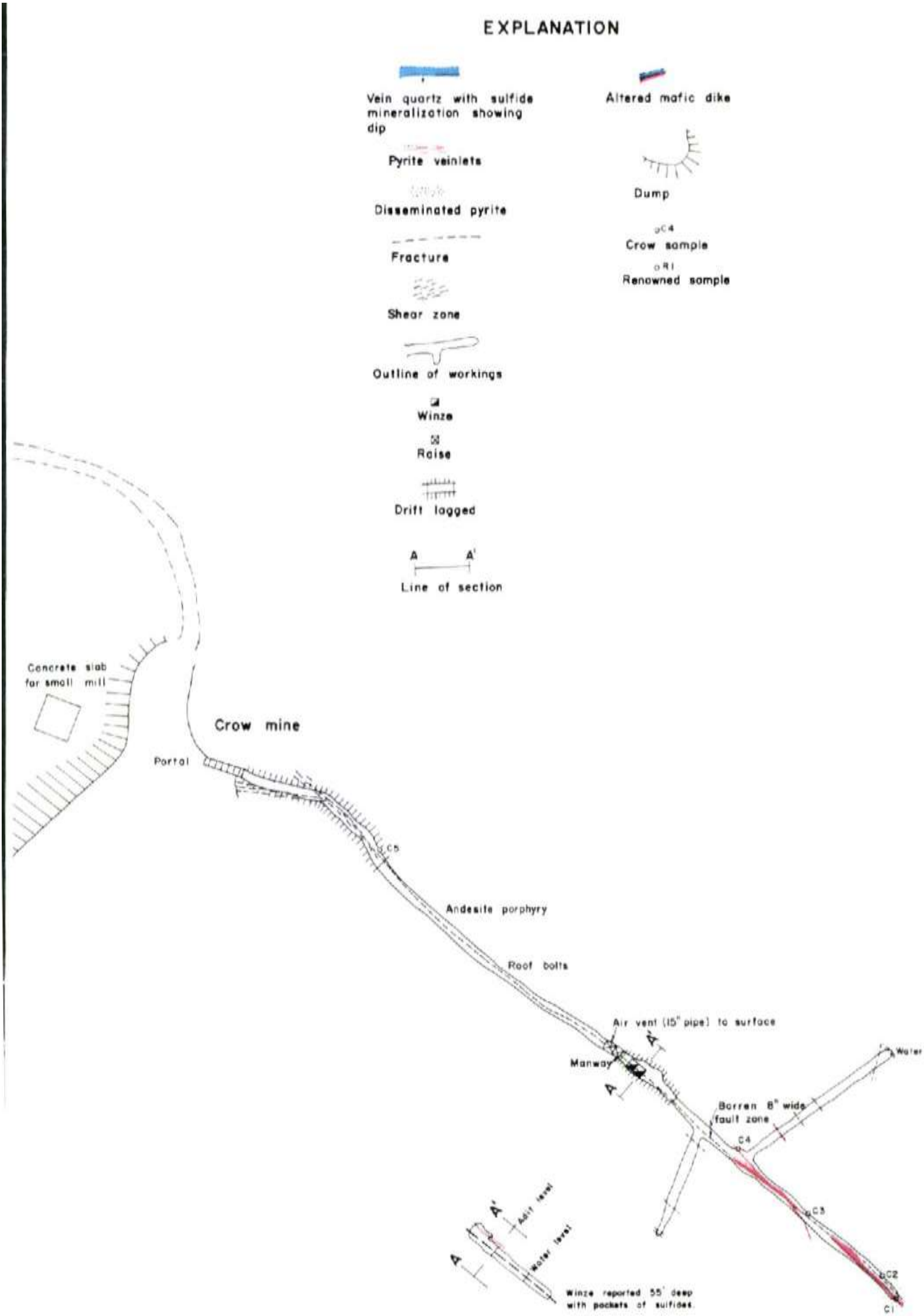


Figure 11
GEOLOGIC MAP OF CROW VEIN AND WORKINGS.



T. B. Thompson, 1964

mine has extensive workings but little mineralization. On October 1, 1963, East Utah Mining Company leased 552 acres from Southern Pacific Company, the owner of the Crow, to do exploration. At that time the workings extended back to the line of the section A-A' (fig. 11). East Utah developed the workings to their present extent. The company sunk a winze to a reported depth of 55 feet and did core drilling from the surface. Monzonite was encountered with depth in drilling beneath the workings, but no vein was intersected (Glenn King, personal communication). Base-metal mineralization within the vein is everywhere less than two feet wide. East Utah Mining Company's lease expired July 14, 1964.

To the cast, along the same vein, is the Martha Washington mine, but workings are inaccessible.

Polished sections of the ore minerals from the Crow vein show galena rimmed with chalcopyrite, in turn, rimmed and replaced by sphalerite. Sphalerite cuts across galena. In the Renowned O.K. the ore is banded, and sphalerite is the more common constituent. In the Crow vein disseminated sulfides in quartz are common. Late barite is found in the Crow mine, also. Some rhodochrosite was reported by the East Utah Company. These mines were all reported to have high silver content, but the lenticular nature as well as narrowness of the vein is not conducive to economic production.

Maud Mine

The Maud mine, a patented claim, is in Big Bear Canyon, south of the Rialto stock. It is owned by D. E. White and family. On July 10, 1963, the mine was leased to R. R. Ringwald and Guy B. Hilton. On October 22, 1964, the author completed mapping of the mine. It was inactive due to litigation, but some work had been done during the summer of 1964. The vein trends approximately east-west and dips 75° S. It has been mined at two levels on the west side of Big Bear Canyon (fig. 12) and attempts have *been* made to locate the same vein on the east side of the canyon. The prospect on the cast side of the canyon is approximately 25 feet north of the projected vein, and no vein has been intersected.

The main workings are separated 54 feet vertically. The lower level was driven in 1963 and 1964. Reportedly, a shaft was sunk 38 feet east of the lower portal to a depth of 200 feet. Mineralization is reported to have been continuous to that depth, but the owner later filled the shaft with waste. Serious water problems were encountered during the sinking of the shaft. Vein widths vary in the lower adit from 16 to 82 inches.

The upper working was driven in the 1890's. Its age along with oxidation and leaching in the upper portions of the vein, made mapping difficult. A stope (fig. 12, sec. A-A') is inclined 37° to the horizontal. The vein intersects a pre-mineral biotite syenite dike similar to the Rialto monzonite less than half a mile to the north. Elsewhere in both levels the wall rock is hydrothermally altered andesite. Pyritization of the footwall is present throughout the workings. Nine hundred tons of vein material were stockpiled at the road at the time of the study.

The vein is composed primarily of quartz, sphalerite, galena, and subordinate amounts of pyrite, chalcopyrite, and barite. A chip sample over 6 feet 10 inches of the face in the lower adit was assayed with the following results: 7.10% lead, 0.39% zinc, 0.017% molybdenum, 0.32 ounces gold, and 1.28 ounces silver. Copper was not detected. Using values of 12 cents per pound for lead and zinc, $43.00 per ounce for gold, and $1.40 per ounce for silver, the assay value is $33.55 per ton. The ore minerals occur either as disseminations in colorless to dark-gray quartz or as sulfide-rich incrustations giving the vein a banded appearance. Quartz veinlets cut euhedral barite crystals. Several stages of quartz are evident by the content variation of disseminated pyrite and by differences of color seen in various crosscutting relationships.

Helen Rae and American Mines

The Helen Rae and American mines are in the NW 1/4 sec. 13, T. 9 S., R. 12 E., about 3 miles southwest of Nogal. The mines were discovered in the late 1800's and produced intermittently from 1880 to the early 1930's (Griswold, 1959, p. 45). Production records including tonnage and grade figures have been lost but these were the most extensively developed lead-zincsilver mines in the district. The workings are not accessible, but open stopes show that the deposit was in a north-trending vein worked by both mines. Griswold (1959, p. 47-49) showed a sketch map and composite plan map of the Helen Rae workings as well as a vertical longitudinal section of the Helen Rae and American workings. The American mine was worked down to the 360-foot level while the Helen Rae was worked to the 150-foot level.

A polished section of a dump sample from the Helen Rae contains galena, sphalerite, pyrite, quartz, and barite. Considerable silver was produced from the mines (Ralph Forsythe, personal communication).

Other Lead-zinc Vein Deposits

With few exceptions other vein deposits strike east-west along the trend of the Bonito fault (fig. 13). Most of the veins have been prospected only to a limited extent; in many cases, these workings are inaccessible.

Old Red Fox vein in the NW 1/4 sec. 34, T. 9 S., R. 11 E. has been prospected by a shaft and drift on the vein. The vein strikes N. 26 W. and is vertical, except near the portal where it swings to the cast with a low southward dip. The vein is not traceable southward from the portal. Mineralization consists of lenticular sulfide stringers (two inches maximum width) on both sides of a vertical fault zone in andesite porphyry. Galena, sphalerite, pyrite, and quartz were noted. During the summer of 1965 the adit was cleared and widened back to the shaft. Sixteen tons of hand-sorted lead-zinc ore were reportedly shipped to El Paso, but nothing is known about the grade.

Silver King vein, a patented claim, in the SE% sec. 34, T. 9 S., R. 11 E. has been prospected by an inclined shaft 70 feet deep with drifts off the bottom. Vein quartz, approximately eight inches wide, carries some sulfide minerals at the surface. Minerals noted are sphalerite, galena, chalcopyrite, pyrite, quartz, and euhedral barite. The wall rock is pyritized Rialto monzonite. An adit several hundred feet to the east is reported to intersect the vein, but this adit is caved around the portal.

Old Abe mine, a patented claim, is located in the NW% sec. 3, T. 10 S., R. 11 E. (fig. 13). According to records in the county courthouse, the Old Abe was patented (Survey 1307) on January 21, 1908, by A. R. Byrd. The workings were not accessible during mapping (July 6, 1967) due to caving above the portals. The workings consist of two adits and a shaft. The upper adit was driven along the vein while the lower level was driven below the outcrop and is reported to intersect the vein. Dump samples at the lower adit contain vein quartz and sulfide mineralization. From the appearance of the mine workings and the size of trees on the dumps, many years have lapsed since any activity has occurred.

The mineralization is found along two east-west veins that dip steeply to the south at 68° to 75°. Prospect pits up slope to the northwest encounter the same veins about five to ten feet apart. Sulfides found on the dump include galena, sphalerite, and pyrite. Minor amounts of barite were also found. The wall rock is argillized andesite porphyry. About 50 feet due north of the workings is the southern contact of the Rialto stock. The monzonite of the stock apparently was encountered in the lower adit as much of this rock is in the dump material and quite fresh. The vein may be considerably weaker in the monzonite—thus curtailing the mining—as noted in the upper Maud adit and in the Renowned O.K. workings.

The Old Abe vein appears to be the westward continuation of the Martha Washington-Crow-Renowned O.K. vein, but poor outcrops prevented actual tracing of the vein.

Argentine (Cricket) *mine* is on the ridge between Turkey and Argentina Canyons (fig. 1 and 13). The mine is owned by Mr. Arvel Runnels. In 1948 the adit was driven by Runnels back to the shaft which had been sunk earlier. The shaft was sunk at the intersection of a pair of veins trending east and N. 10° W. The cast-trending vein is a wide pyritic quartz vein with galena and sphalerite stringers. The N. 10° W. vein is in a shear zone stained by malachite and limonite. The workings extend northward from the shaft but were not accessible due to bad air. A large sloped area is reported to have yielded considerable amounts of gold at the intersection of the veins.

On the surface the N. 10° W. vein is a massive bullquartz and has been prospected for several hundred feet along the trend.

Polished sections of mineral specimens from the shaft dump show sphalerite, galena, chalcopyrite, pyrite, and quartz. Sphalerite is dominant.

Bailey prospect lies in Turkey Canyon in the southern portion of the Rialto stock (fig. 13). The wall rock is kaolinized, pyritic monzonite. The adit is sinuous and shows much shearing. An andesite porphyry dike crosses back and forth along the adit level for about 100 feet. Quartz stringers with pyrite follow a shear zone which parallels the dike. Two narrow east-southeast-trending sulfide stringers were encountered 263 feet from the portal. Beyond this point the adit level is inaccessible due to a large pool of water. Small prospects on the surface indicate that the shear zone continues some 800 to 900 feet eastward. Minerals noted in polished section include galena, sphalerite, chalcopyrite, pyrite, and quartz.

White Swan prospect, a patented claim, is on an east-trending vein in the NE 1/4 SE 1/4 sec. 3, T. 10 S., R. 11 E., just north of Bonito Canyon (fig. 13). The vein dips approximately 65°-71° north. Accessible workings include a shaft and northwesterly adit intersecting the vein. The sulfide zones are lenticular with widths of two to six inches. The vein consists of quartz and pyrite with stringers of galena and sphalerite. Numerous pyrite veinlets extend into the andesite wall rock. Post-mineral faulting is evident.

Another adit, approximately 100 feet beneath the White Swan vein, is inaccessible. It supposedly intersected the White Swan vein, but sulfides were not found on the dump.

The White Swan vein may be a westward extension of the Spur vein (fig. 13), but poor outcrops prevented tracing of either.

The White Swan prospect is owned by Mr. Arvel Runnels who lives at Parsons Hotel three miles west of Bonito Reservoir.

Spur vein (fig. 13) near the center of sec. 3, T. 10 S., R. 11 E., has been prospected along an inclined shaft to 38 feet vertically, as well as along a short drift west of the shaft. To the south of the vein two adits have been driven northerly to intercept the vein. The lower of these two adits is 292 feet short of the projected position of the vein at that level. The upper adit intercepts the vein as well as three others at a level 78 feet vertically below the collar of the inclined shaft. The maximum vein thickness observed was 28 inches, and a chip sample across this interval assayed 2.8% lead, 2.9% zinc, 0.055% molybdenum, and 1.38 ounces silver. No gold or copper were detected. The host rock throughout the workings is strongly argillized and pyritized andesite.

Washington mine is near the center of sec. 2, T. 10 S., R. 11 E., and within the Bonito Lake stock (fig. 13). An east-north-east-trending vein has been prospected by an adit, now caved, and two shafts, 300 to 400 feet deep. Because none of the workings is accessible, mineral specimens were collected on the dumps. Sphalerite is dominant, with subordinate amounts of galena, chalcopyrite, pyrite, quartz, and barite. Sphalerite replaces galena, and both are cut by euhedral barite.

Greenville prospect, a patented claim, is in the NE% sec. 10, T. 10 S., R. 11 E., on the ridge southeast of the Maud mine (fig. 13). It explores a northeast-trending vein which dips 57° E. The vein occurs adjacent to a diorite dike in andesitic volcanic breccia. Post-mineral shearing has occurred with later deposition of secondary copper minerals along the zone. The main development on the Greenville is an inclined shaft which extends downdip 90 feet before a maze of timbers is encountered. The incline is reported to be 150 feet long. A polished section indicates that galena, the major sulfide, is replaced by sphalerite along fractures and cleavage planes.

Great Western mine can be reached from Big Bear Canyon by a steep road leading eastward (fig. 13). Two minor adits are driven along an east-trending shear zone in altered andesite. Pyrite and quartz were the only minerals noted. A small open pit in an extensively silicified zone has also been prospected. The pit is cut by cast-west shears dipping 75° S. The product of this mine is reported to be gold which averaged about 25 cents per ton (Glenn King, personal communication). A small mill is located near the open pit. Recent operations are not apparent.

Mineral Farms Canyon (Applejack No. 1) *prospect* is about half a mile east-northeast of the Bonito Reservoir (figs. 1 and 13), on the eastern contact of the Bonito Lake stock. It appears to be located on an east-southeast shear zone; but the workings, which are on a shaft entry, were not accessible. Dump samples indicate galena, sphalerite, chalcopyrite, covellite, pyrite, quartz, and barite. Galena is serrated and rimmed by sphalerite or covellite. Pyritization of the wall rock is extensive.

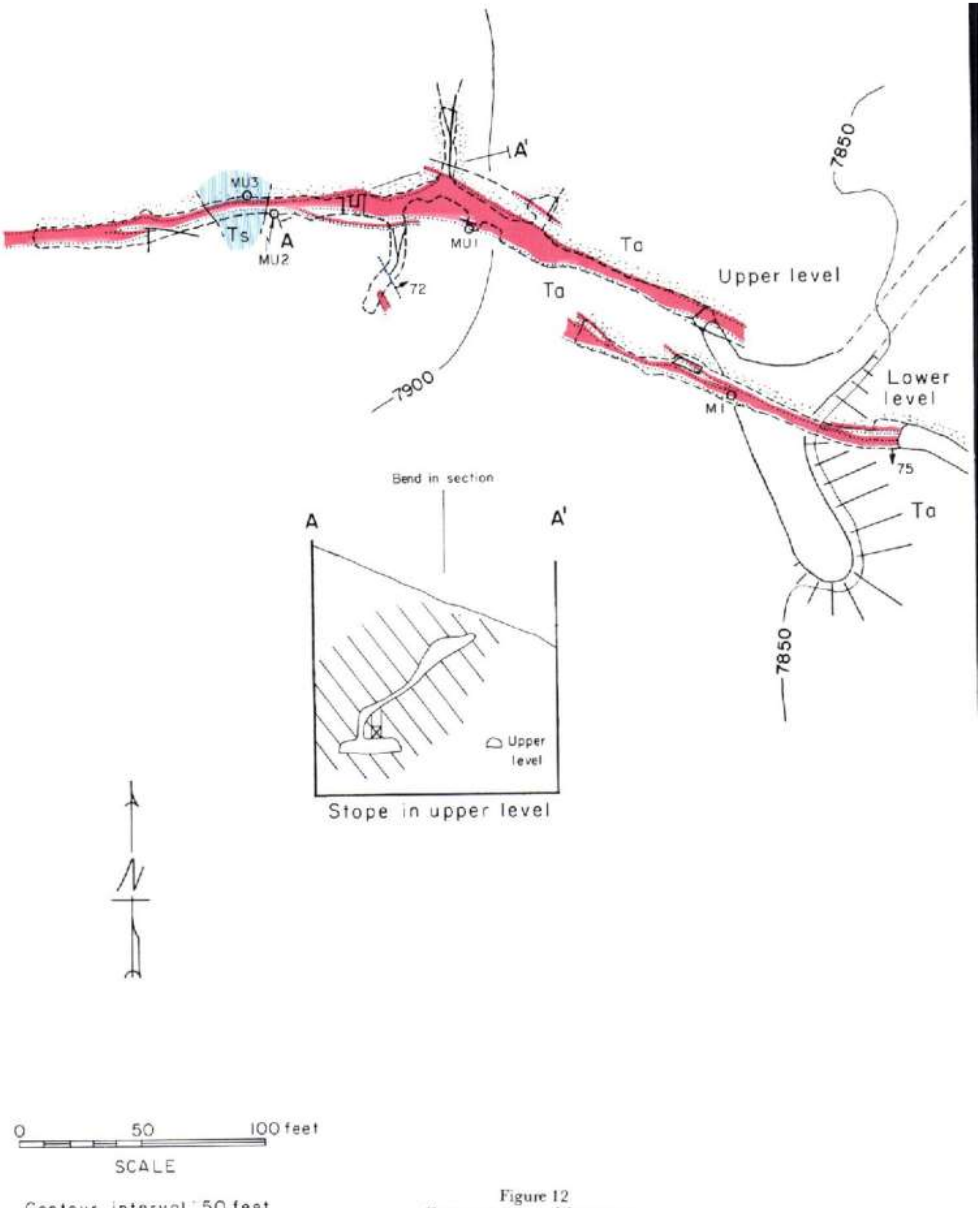
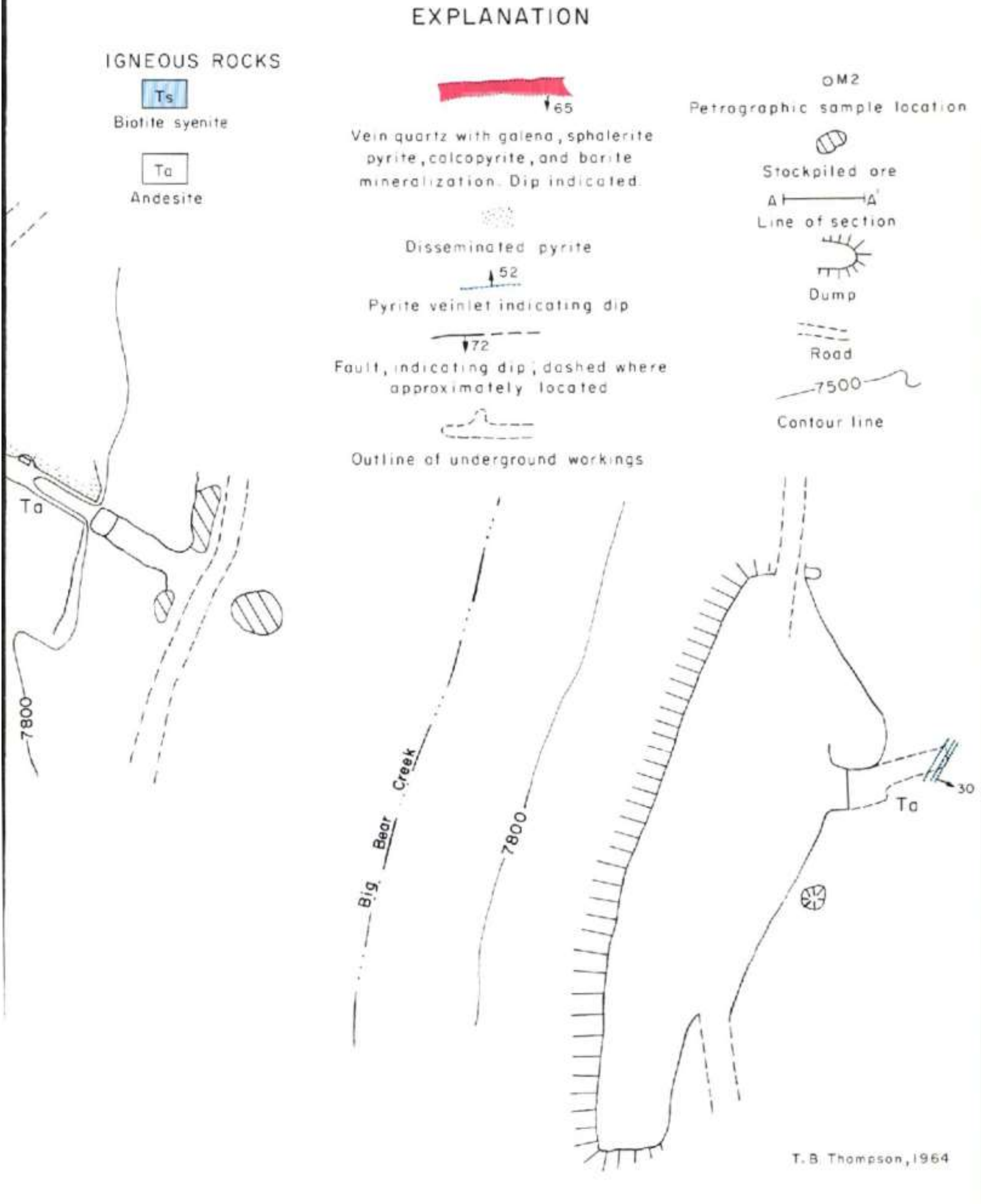
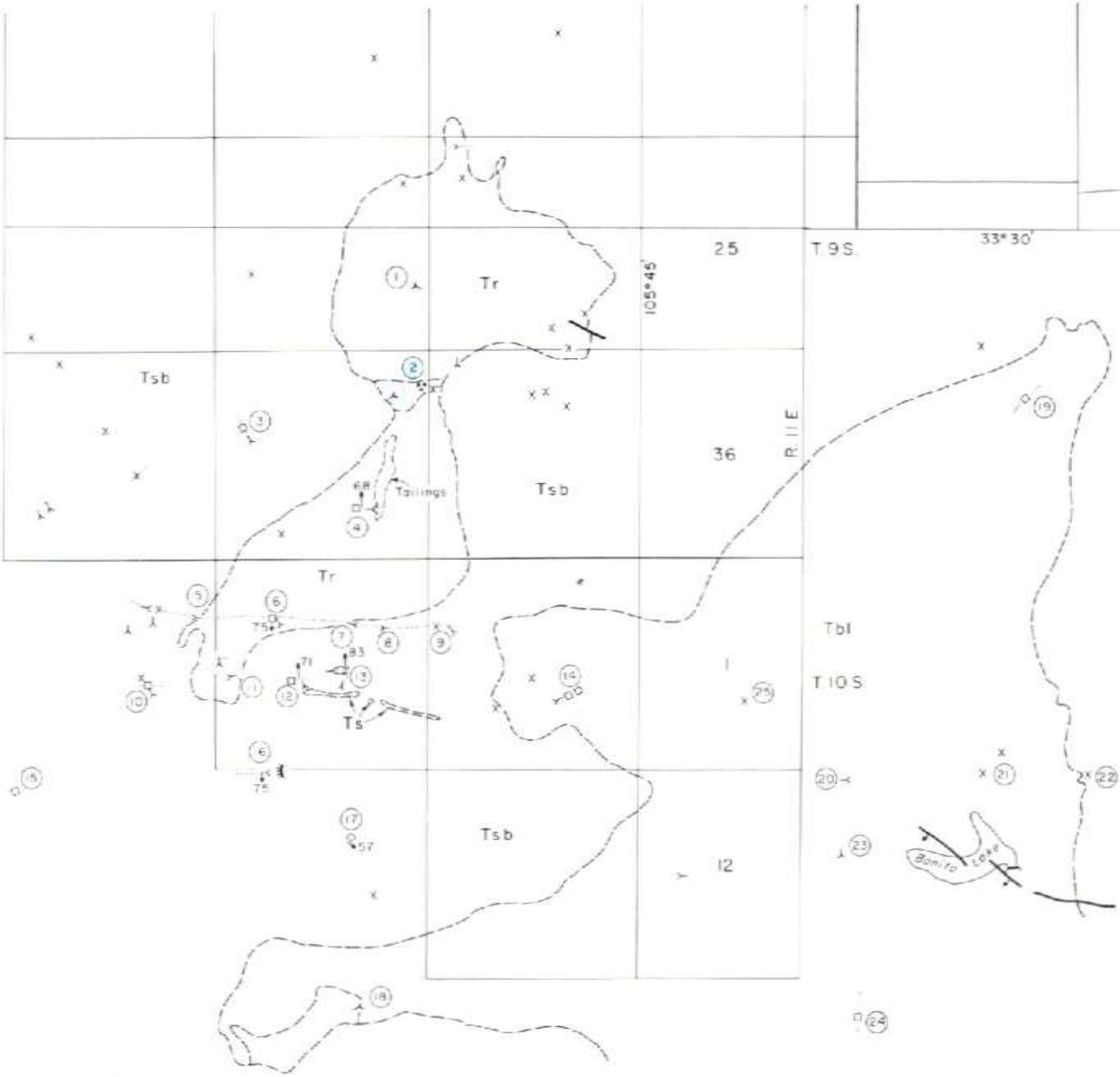


Figure 12
GEOLOGIC MAP OF MAUD MINE.


EXPLANATION
IGNEOUS ROCKS
Ts
Biotite syenite
Ta
Andesite
65
Vein quartz with galena, sphalerite pyrite, calcopyrite, and barite mineralization. Dip indicated.
Disseminated pyrite
52
Pyrite veinlet indicating dip
72
Fault, indicating dip, dashed where approximately located
Outline of underground workings
OM2
Petrographic sample location
Stockpiled ore
A A'
Line of section
Dump
Road
7500
Contour line
Ta
7800
Big Bear Creek
7800
Ta
30
T. B. Thompson, 1964



EXPLANATION

INDEX TO MINES

1. Fulmer (Rialto Group)
2. Parsons (Hopeful)
3. Old Red Fox
4. Silver King
5. Willis
6. Old Abe
7. Renowned O.K.
8. Crow
9. Martha Washington
10. Argentine
11. Bailey
12. White Swan
13. Spur
14. Washington
15. Silver Spoon
16. Maud
17. Greenville
18. Great Western
19. Water Dog No. 1
20. Soldier
21. Hope
22. Mineral Farms Canyon
23. Christmas
24. Rock No. 1
25. Silver Nugget

Adit Prospect Shaft

Vein quartz with sulfide Mineralization

Figure 13
INDEX OF MINES IN NOGAL AND BONITO MINING DISTRICTS.

Hope prospect is a few hundred yards north of Bonito Reservoir (fig. 13), probably on a westward extension of the shear zone of the Mineral Farms Canyon prospect. The workings arc adits which enter in a northeasterly direction and then turn along the shear zone. Water in the workings as well as extensive alteration of the wall rock prevented a detailed study. Dump samples contain galena, sphalerite, chalcopyrite, pyrite, quartz, and barite. Griswold (1959, p. 62) reported that some silver was produced from this prospect.

Water Dog No. 1 mine lies in the northeastern part of the Bonito Lake stock (fig. 13). The owners listed on a claim notice are F. G. McCrory and F. T. LaMay. It is accessible only by a shaft. Several pits are present along the northeasterly trend of the Water Dog vein. A polished section of a dump sample shows galena, sphalerite, pyrite, quartz, and barite.

Rock No. 1, Christmas, and Soldier mines are along a north-trending shear zone just west of Bonito Reservoir (fig. 13). The Rock No. 1 was prospected by a short adit and a vertical shaft reported to be 102 feet deep. The owner, Mr. Arvel Runnels, reports that a selected sample ran 17 ounces silver and 0.08 percent copper. Specularite and malachite were noted on the dump, and native copper, malachite, and galena were found on a small dump a few hundred feet to the north.

Christmas mine in the bottom of Bonito Canyon (fig. 13), is developed by an adit trending N. 6° W. The fault zone is approximately three feet wide and dips 70° W. Silver is re• ported to have been produced from the hanging wall. Local people give the length of the adit as 725 to 925 feet. The Soldier mine is a quarter mile north of the Christmas mine and is reported to have been a silver producer.

Silver Nugget is three-quarters of a mile northwest of the Soldier mine (fig. 13). It was owned by Tom Bragg (deceased). Copper oxide staining was noted in a quartz vein which trends N. 50° E. with a vertical dip.

Blue Jay prospect is in the southeastern prong of the Bonito Lake stock. It is reached by taking the road toward Mon Jeau from Alto. After traveling approximately one and a half miles a faint road bearing west leads to the prospect. Mineralization appears to be localized in a northeasterly-trending shear. Malachite and melaconite with pyrite cores are disseminated in altered syenite.

Willis mine, a patented claim, is east of Turkey Canyon and adjacent to the Rialto stock. It is reported to be a gold producer from a vein localized along an east-trending fault. The workings are adits some of which have filled with water behind slump material at the portals.

Mayberry mine is in Philadelphia Canyon one and a half miles from Bonito Canyon. It is localized along an altered mafic dike. Access to the workings is by a shaft which was flooded at the time of the study. R. T. LaMay, who lives there, is the owner. Griswold (1959, p. 56) showed a map of the workings. Vein material on the dump contained galena, pale-green sphalerite, pyrite, quartz, and minor barite.

Silver Spoon prospect lies in upper Bonito Canyon at the end of the road (fig. 13). It is prospected by a shaft that is now flooded. Dump samples contained galena, pyrite, quartz, and barite.

Ore genesis and zoning of mineral deposits

Thirty-four polished ore sections from the fissure veins were examined during the present study. In addition, 26 polished sections of panned concentrates from cuttings of the Cleveland-Cliffs project were studied.

The mineral assemblage of the fissure veins is simple. The ore minerals are sphalerite and galena with subordinate amounts of chalcopyrite, pyrite, barite, and quartz. Gold, silver, and molybdenum occur in varying amounts as shown by assays; however, minerals with these elements in the Nogal District veins have not been recognized under the microscope.

Textures of the vein minerals indicate that the sequence of mineral deposition was quite consistent throughout the district. A paragenetic diagram (fig. 14) indicates galena to be the earliest-formed ore mineral. Replacement of wall rock is minor although hydrothermal alteration is extensive. The ore minerals were deposited in fractures that were repeatedly opened. Banding of ore minerals is common and comb texture is frequently exhibited. The last hypogene mineral formed, barite, is normally in the center of the vein. The Spur veins exhibit fracturing during the barite crystallization. Fractures in early-formed quartz host galena veinlets in the Old Abe veins, and crushing and fracturing of other minerals, indicate repeated opening of the faults.

The ores commonly are vuggy; colloform chalcedony around the vugs is not unusual. In the Renowned vein, which is typical, the minerals from the wall rock occur in the following order:

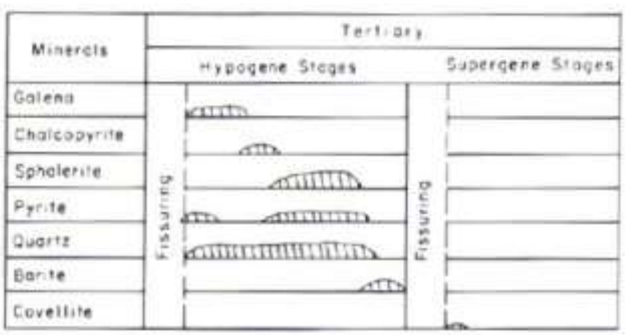


Figure 14

Paragenetic relationships of fissure-vein deposits of Nogal and Bonito mining districts.

1) quartz, massive to euhedral with disseminated euhedral pyrite which may occur in several bands controlled by opening of fault,
2) massive galena which slightly corrodes some of the quartz crystals,
3) chalcopyrite and sphalerite with the chalcopyrite concentrated along the boundary with galena, and
4) barite as distinct bladed crystals along the center of the vein, crushed by repeated faulting.

The chalcopyrite-sphalerite textures suggest that the chalcopyrite exsolved from a homogeneous phase and diffused out of the unfavorable structure and concentrated at the grain boundaries of its former host. Laboratory studies (Edwards, 1954, p. 92) indicate that unmixing of chalcopyrite from a sphalerite host occurs in the range of 350° to 400° C. Because all of the chalcopyrite has migrated to the edge of the sphalerite and adjacent to galena, the temperature of crystallization must have been lower than 350° C. The last product of crystallization, barite, is normally accepted as a mesothermal to epithermal mineral. The depth of formation for the veins can be shown by a reconstruction of the Sierra Blanca Volcanics to be on the order of 6,000 feet. All these data support the classifying of the Nogal District mineral deposits as mesothermal of the Lindgren classification. Certainly the assemblage indicates an expected cooling of hydrothermal fluids with successive stages of crystallization.

Although the assemblage of minerals is the same within the district, percentages vary. A good example is the zinc to lead ratios. Fig. 15 shows a decrease in this ratio with increase in distance from the Rialto stock. Within the vein deposits molybdenum and copper mineralization is more prominent nearer or within the Rialto stock (Silver King mine). Neither of these elements is present in economic amounts, however.

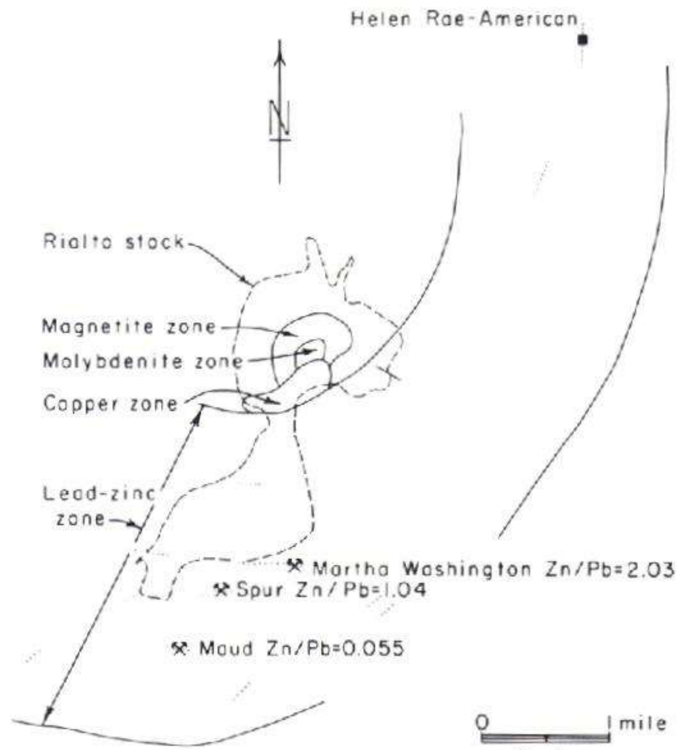


Figure 15

Mineral zoning around Rialto stock.

Within the Rialto stock disseminated mineralization occurs in zones that are nearly concentric with the lead-zinc zoning to the south. The magnetite, molybdenite, and copper zones are also closely related to the type of hydrothermal alteration, and, as a result, do not form complete circular zones rimming each other. Nevertheless, many of the deposits are apparently closely related to the Rialto intrusive, although some influence from the Bonito Lake stock might be expected.

STRUCTURAL CONTROLS

The vein systems of the area south of the Parsons mine rend generally cast-west, parallel to the Bonito fault found both east and west of the district. The Washington vein (fig. 2) splays northward, as does the fault, and adjoins the Bonito Lake stock on the east. Faulting occurred after intrusion of the stock. Elsewhere vein deposits either parallel or radiate outward from the hypabyssal intrusive boundaries. The amount of dip appears to be a factor on the presence of sulfide mineralization. If the vein dip is greater than 70°, sulfide mineralization is usually found. Sulfides in veins with dips less than 70° are limited to those systems in which strike deviates from east-west.

Disseminated mineralization within the Rialto stock appears to be related to fractures and breccia pipes whereas the disseminated mineralization of the two other large intrusives is closely related to intrusive borders or late-stage intrusive phases. More data are *needed* on the latter deposits.

CONCLUSIONS

The Nogal district appears to have considerable potential for low-grade high-tonnage deposits. Possibly one or more of this type deposit may exist, but exploration will require a company with sufficient capital to finance an extensive program.

The vein deposits are discouraging, due to their lenticularity and narrow widths. Transportation expenses to milling facilities are excessive. Small operations which have their own mills appear to be the only solution for this type of deposit in the Nogal district.

Availability of Water

In 1907 the Rio Bonito was partly diverted into a pipeline system by the El Paso and Southwestern Railroad (later the Southern Pacific Railroad). Today water is still diverted through a pipeline from Bonito Reservoir, owned by the City of Alamogordo. The pipeline also furnishes Carrizozo and Holloman Air Base from the 5 cfs-diversion from Bonito Reservoir. The story of the development of the mountain waters of the Sierra Blanca is realistically portrayed by Neal (1961).

In the Sierra Blanca many springs issue from perched water tables on top of massive andesitic flows. Many of these springs have been improved and water is collected in metal tanks for wildlife and stock. The flow of these springs is less than 1 gpm. Unit 34 of the Nogal Peak section is a particularly impermeable volcanic unit which localizes water flow from a perched water table. The springs issue in the re-entrants of the cliff-forming unit. Ground and surface waters have been studied in parts of the map area (Mourant, 1963).

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Appendix A

Petrologic Descriptions of Rialto Samples
(See *fig.* 7 for locations; * petrographic description)

No. Description

74 Monzonite, fresh feldspar, hornblende, biotite, and magnetite

75 Monzonite, fresh feldspar, hornblende, biotite

76 Monzonite, fresh feldspar, hornblende

77 Monzonite, fresh feldspar, chlorite replacement of hornblende, magnetite veinlets

79 Monzonite, feldspar slightly altered; chlorite replaces hornblende

80 Monzonite, as above (79); magnetite-quartz veinlets

81 Fine-grained quartz-sericite alteration

82A Monzonite porphyry, argillized feldspar phenocrysts; minor amounts of clay, sericite, and fine-grained quartz

82B Monzonite, slightly argillized, feldspar, no ferromagnesian minerals, abundant magnetite

83 Magnetite vein, euhedral to massive with traces of actinolite and sphene

84 Monzonite, unaltered feldspar, ferromagnesian minerals destroyed, siliceous

85 Monzonite, fresh feldspar, chlorine replacement of hornblende, quartz-magnetite veinlets

86* Fine-grained quartz (dominant mineral approx. 60%), sericite (approx. 40%), traces of sphene and pyrite; all of the original textures have been obliterated

87 Fine-grained quartz, sericite

88 Fine-grained quartz with some euhedral quartz in vugs, sericite

89 Monzonite, fresh orthoclase with some argillization of plagioclase, chlorite replacement of hornblende and biotite

90* Monzonite, fresh feldspar, 15-20% hornblende, traces of apatite, magnetite, biotite, and sphene; veinlets of magnetite-sphene-actinolite

91 Monzonite, feldspar slightly altered, ferromagnesian minerals replaced by chlorite and magnetite

92 Monzonite, unaltered feldspar, chloritic hornblende, minor silicification

93* Monzonite, argillized feldspar, quartz, trace of magnetite and sphene

94* Monzonite, orthoclase slightly more abundant than plagioclase, biotite replacement of hornblende, trace of magnetite and sphene

Monzonite, argillized and silicified, no ferromagnesian minerals or magnetite present

100* Monzonite, orthoclase and plagioclase (An„ to An„) dominant minerals, biotite and hornblende constitute 15% of the rock, accessories are apatite, sphene, rutile, and magnetite

101* Monzonite, orthoclase and plagioclase (An„) dominant minerals, biotite forms at expense of hornblende, accessories are apatite, sphene, quartz, and magnetite

102 Vein quartz with "limonite" staining

104 Andesite, argillized

105 (as 104)

109 Monzonite, unaltered feldspar, chlorite replacement of ferromagnesian minerals

Appendix B

Logs of Rialto drill holes
(See fig. 7 for locations, * polished section of heavy minerals)

Interval	Description
DH1-26	
0-65	Monzonite; very slightly altered; euhedral biotite (1-2%); magnetite is abundant (3-5%); limonitic; trace epidote (pale yellow-green); hornblende (pale blue-green).
65-85	Monzonite; high limonite content; magnetite (1-2%); quartzose; trace chlorite; trace epidote and biotite; feldspar relatively fresh; vitreous ruby-red "limonite." At 75, trace pyrite; magnetite quite massive 7-9%+); chlorite (pale bluish-green) abundant.
85-105	Monzonite; limonitic; trace sericite; loss of epidote and chlorite; magnetite content decreased (± 2%); pyritic (1-3%); siliceous; argillic. At 90, chlorite and epidote abundant; magnetite (3-4%). 100-105 single grain with epidote, quartz, and magnetite in aggregate. 105, bottom oxidized zone.
105-205 (105-110*) (200-205*)	Monzonite composed of plagioclase-epidote-quartz with approximately 2-4% magnetite; trace pyrite, limonite, chlorite, biotite, and hornblende; pyrite, biotite, hornblende, and chlorite increase with depth. 165-175, trace chalcopyrite. From 165 downward biotite as much as 5%.
205-225	Monzonite; only slightly altered; quartzose; feldspar unaltered; trace epidote, chlorite, pyrite, chalcopyrite; biotite abundant (3-4%); hornblende present in trace amounts; magnetite (3-4%+).
225-255	Monzonite; siliceous; feldspar fresh; trace chlorite, epidote, hornblende; magnetite (2-3%); pyrite abundant (~2%). At 250, magnetite <1%; very fine-grained quartz, as much as 50%.
255-345 (340-345*)	Monzonite, only slightly altered; feldspar fresh; trace quartz; biotite; chlorite and hornblende abundant; magnetite 3-4%; pyritic. At 275, hornblende abundant.
345 Total depth	
DH1-27	
0-15	Abundant sericite, "limonite," quartz, biotite (trace), gypsum; feldspar remnants, minor magnetite; trace chlorite (?).
15-55	Sericitic feldspar dominant; quartz with magnetite veinlets or disseminations; trace chlorite, "limonite," trace biotite only ferromagnesian; trace gypsum (sometimes pink); slight increase chlorite (25-30); trace pyrite begins 45-50; 50-55 interval: magnetite ~3.5% (by weight); trace clay minerals.
55-148	Sericitic feldspar; 5-10% quartz; limonitic; argillic alteration; few opaques; trace gypsum; (100-105 only) increase in opaques: magnetite, pyrite (trace).
148-153	Intersected material with abundant magnetite (~5-10%); "dike" is highly altered.
153-173	Sericitic-kaolinitic feldspar; quartz (<10%); limonitic; trace magnetite and pyrite; gypsum (trace); trace chlorite; no ferromagnesians.
173-179	Intersection with material containing abundant magnetite (5-10%); some coarse pyrite; slightly chloritic; silicic; dark-colored compared to stock rock; (may not be dike but rather a silicified fracture zone with magnetite and pyrite in veinlets in quartzose material; trace sericite.)
179-185	Sericitic feldspar; magnetite (trace) and pyrite (trace); quartzose; limonitic; (most abundant sericite so far in #1-27).
185-200	Sericite; trace magnetite; trace quartz; limonite (trace); noticeable increase in sulfides; from 195-205: trace molybdenite.
200-230	Sericite; increase in "limonite"; sericite less striking but still dominant; quartz ~5%; pyrite (trace); molybdenite (trace); 210-220, trace molybdenite; some euhedral, acicular quartz; pyrite much finer grained. 220-225: 0.15% magnetite. 220-225: molybdenite approximately 0.3%; 225-230: trace molybdenite, sericite decreasing from 225 downward.
230-245	230: increase in magnetite (possibly total of 1%), trace molybdenite; pyrite relatively abundant; sericite decreasing. 235: Abundant feldspar; quartz <10%; trace molybdenite, abundant magnetite and pyrite.
245-255*	Approximately 245 top of un-oxidized zone; no molybdenite noted; magnetite more abundant than pyrite; alteration less intense; feldspar only slightly sericitized; quartz ~10%. 245-250: 14% magnetite; Mag: py=50: 14. 250-255: biotite approx. 1%; trace chlorite; otherwise as 245-250.
255-270	As 245-255: increase in biotite and chlorite: combined <5%. 255-260: trace molybdenite and chalcopyrite; abundant magnetite and moderate pyrite. 260-265: trace molybdenite and chalcopyrite. 265-270: trace molybdenite and chalcopyrite.
270-275	Chloritized; sericite abundant; noticeable increase in sulfides though magnetite still abundant; trace molybdenite and chalcopyrite; biotite (trace); quartz <5%.
275-280	Sericitized; trace chlorite; approx. 0.1% molybdenite; abundant pyrite; moderate magnetite and quartz; trace biotite.
280-325	Sericitized; chlorite abundant; trace molybdenite and chalcopyrite; pyrite and magnetite abundant; chlorite content increasing from 300 downward; sericite decreasing.
325-345*	Chloritic alteration; abundant magnetite and pyrite; trace molybdenite and chalcopyrite.
340-345	Chlorite decreases from 330 downward.
345-350	Sericitized (very fine-grained); trace chrlorite; sulfides more abundant than magnetite (very marked change); pyrite most abundant with trace molybdenite and chalcopyrite.
350-370	Chloritized; trace sericite; sulfides more abundant than magnetite, but magnetite increases at 345-350.
370-415	Sericitized; trace chlorite; pyrite and magnetite abundant; trace molybdenite; quartz greater than 5%. (385-390: quartz may be as much as 10% of total sample.) (395 downward: trace magnetite; pyrite dominant opaque.) Pyrite more massive and found as veinlets in quartz and sericite.
415-515	Chloritic alteration; magnetite more abundant and equal to pyrite abundance; feldspar unaltered; vein quartz; trace molybdenite and chalcopyrite (?). 425-430: as above, trace biotite; magnetite more abundant than pyrite. Trace biotite 450 downward. Biotite 2-3% from 465-470.
515-550	Chloritic alteration; noted decrease in magnetite approx. one-half as abundant as in 510-515; trace clear euhedral quartz crystals approx. 1 mm. in length; fresh feldspar; trace biotite; pyrite unchanged in abundance; some silicification. (525-530: chlorite decreasing; more siliceous.) (530-535: noted increase in opaques, possibly 5-7% of total; pyrite, magnetite; 0.1% molybdenite (quite siliceous, trace sericite although chloritic alteration still present.) (535-540: as above with molybdenite (trace).) (540-550: increase chlorite and magnetite; magnetite as abundant as pyrite.)
550-640	Chloritic alteration; fresh feldspar; abundant magnetite and pyrite.
635-640*	12.3% magnetite; trace chalcopyrite and molybdenite; quartz less than 5%. (610-615: trace biotite.) (615-620: 2-3% biotite.)
640 Total depth	

DH2-27

0-35 Monzonite; silicified; sericitic; trace magnetite (less than 1%); limonitic (slight decrease in alteration with magnetite increase).

35-55 Monzonite; no magnetite; silicified; sericitic; limonitic; trace kaolinite (?).

55-60 Monzonite; silicified (quartz as great as 50%); trace sericite; limonitic.

60-140 Monzonite; silicified; sericitic; pyrite 2-3%; trace magnetite to no magnetite; minor limonite staining on some fragments (probably along fractures); pyrite disseminated and as veinlets. (75-80: sharp limonite increase; gradual decrease lower.) (115-120*: trace molybdenite.) (140: bottom oxidized zone.)

140-160 Monzonite; silicified and sericitized; quartz and sericite constitute 85% of total rock with quartz dominant; pyrite abundant; clay mineral(s); trace molybdenite. 155-160.

160-165 Monzonite; silicified; sericitized; kaolinite; trace feldspar; pyrite abundant.

165-260 (170-175*) Monzonite (dark-gray color); abundant quartz and trace sericite; biotite less than 1%; trace chlorite; magnetite 2-3%; trace chalcopyrite; pyrite abundant; (magnetite content increasing with depth); alteration becomes less with depth; sulfides less than 1% at 200'; biotite 1-2%, 250-255; trace hornblende, 255-260.

260-285 Monzonite; trace quartz; biotite and magnetite abundant; trace chalcopyrite; pyrite abundant; chloritic alteration with trace of remnant hornblende.

285-324 (320-324*) Monzonite; trace quartz; biotite, magnetite, hornblende, pyrite abundant; trace chlorite; feldspar fresh. (305 down, pyrite less than 1%.)

324 Total depth

DH3-27

0-10 Monzonite; oxidized; trace biotite and magnetite; limonitic.

10-30 Monzonite; limonitic; trace pyrite; trace magnetite; no biotite; more clay alteration; trace quartz.

30-70 As above; less than 0.1% molybdenite; chalcocite-coating on pyrite; traces of ruby-red "limonite"; trace chalcopyrite and bornite(?); trace to approximately 0.5% black sooty chalcocite; no magnetite at 65-70; trace sericite.

70-120 (70-75*) Monzonite; siliceous; sericitic; bottom of oxidized zone at 70'; pyrite is coated with chalcocite; no magnetite; trace chalcopyrite. (115-120: trace biotite, sooty chalcocite abundant.)

120-325 (165-170*) Monzonite; siliceous; sericitic; biotite abundant; abundant pyrite coated with chalcocite; trace chalcopyrite. (Loss of biotite at 135–with trace of chlorite appearing.) (At 145, trace magnetite with gradual increase copper staining and pyrite decrease.) (At 155, biotite abundant [approx. 1%+] with chlorite abundant [approx. 1%].) Biotite increases with depth to approximately 3%. (210-215: abundant pyrite coated with chalcocite and trace chalcopyrite.) (225-230 [only]: sudden sericite increase; biotite, chlorite, pyrite with chalcocite coat, chalcopyrite [trace] are present.) (230-240: biotite increases to 5-10%.) (255: sulfides increase with abundant chalcocite stains.) (260-275: chalcocite coating of pyrite only in trace amounts; abundant pyrite.) At 290, sudden increase magnetite (approx. 1-2%). (295-300: very abundant chalcocite-coated pyrite, trace molybdenite.)

325-350 Monzonite; siliceous; trace sericite; chloritic; abundant biotite; magnetite (1-2%); abundant pyrite with minor chalcocite coating; trace chalcopyrite. (345-350: magnetite increases (4-5%).) Trace rutile.

350 Total depth

DH4-27

0-4 Overburden: organic debris in soil; rock fragments.

4-60 Monzonite; hornblende; biotite approx. 5%; trace pyrite; limonite; abundant magnetite as disseminations and veinlets in quartz and feldspar; quartz approximately 5%; trace epidote. (55-60:* magnetite also replaces amphibole.)

60 Total depth

DH5-27

0-6 Soil with mixed rock fragments.

6-60 Monzonite, hornblende; disseminated magnetite; pseudohexagonal biotite plates; feldspar fresh; quartz less than 5%; "limonite" staining (hornblende: pale green and fibrous). No sample: 20-30. Decrease in hornblende with appearance of chlorite. 55-60: first trace of pyrite.

60-75 Monzonite; chloritic alteration of hornblende; biotite, 1-3%; magnetite and pyrite abundant; quartz, 5-10%; feldspar argillic; trace molybdenite and chalcopyrite.

75-90 (75-80*) Monzonite; chloritized; silicification minor; trace sericite; feldspar altered to clay; trace molybdenite and chalcopyrite; abundant magnetite and pyrite; trace biotite.

90-125 Monzonite; argillization strong; trace chlorite only; trace magnetite; abundant pyrite (euhedral); trace chalcopyrite and molybdenite; trace sericite; quartz approximately 10%.

125-135 (130-135*) Silicified; trace magnetite; abundant pyrite; quartzose; trace sericite and clay; trace molybdenite and chalcopyrite.

140 Total depth No sample 135-140.

DH6-27

0-3 Soil

3-25 Monzonite; light green hornblende; trace biotite, abundant magnetite; limonite stained; trace epidote. 5-10: no sample.

25-50 Monzonite; hornblende; biotite, 3-5%; abundant magnetite; limonite stained; trace epidote; trace quartz; 45-50: no sample.

50-65 Monzonite; siliceous; sericitic; small acicular quartz to massive quartz; trace pyrite (euhedral to massive); limonitic; decrease magnetite (less than 1%); trace biotite.

65-75 Monzonite; siliceous; unoxidized; light green hornblende; magnetite, approx. 5%; pyrite abundant; trace biotite; trace molybdenite and chalcopyrite. (65-75: silicification not as intense as 50-65 interval.)

75 Total depth

DH1-34

0-43 Monzonite; quartz (approx. 5%); feldspars fresh; biotite; magnetite (2%-); limonite-stained; ruby-red "limonite"; hornblende at 10'.

43-55 Monzonite; silicified; sericitic; limonite-stained; trace magnetite and biotite.

55-85 Monzonite; silicified; abundant biotite; magnetite (2%); limonite-stained; feldspar fresh; ruby-red limonite (geothite); trace sericite.

85-100 Quartz-sericite-biotite alteration; trace magnetite; limonite-stained.

100-135 Monzonite; siliceous; abundant biotite (slightly chloritized); magnetite increased (3-4%); pyrite present from 105 downward; limonite-stained; trace hornblende. (Bottom oxidized zone: 105'); 105-110*.

135-265 Monzonite; chloritized hornblende; abundant biotite; magnetite (3-4%); pyrite abundant (1-3%); hornblende gradually increases at expense of chlorite; 155-160*, 260-265*.

265 Total depth

DH2-34

0-80 Monzonite; argillized; trace sericite; trace biotite; trace molybdenite; pyritic down to 20'; trace pyrite below 20'; limonite-stained; quartz (less than 5%); sericite more abundant (5-10%) at 20 downward; sooty magnetite veinlets appear at 45' downward; argillization decreases from 65' downward with pyrite increase (1-2%); biotite content up (1-2%).

80-85* Monzonite; siliceous; biotite abundant; magnetite 5%+; (80': bottom oxidized zone); pyritic.

85-105 Monzonite; siliceous; no biotite; trace magnetite; pyrite abundant (3-5%); trace sericite; trace chalcocite coating on pyrite, 90-105; magnetite increasing 95' downward.

105-115 Quartz-sericite-pyrite zone; at 110, pyrite partly chalcocite-coated.

115-120 Monzonite; fresh feldspar; abundant biotite; magnetite (3-5%); pyrite abundant; quartz (3-7%).

120-135 Monzonite; silicified; sericitic; abundant pyrite; magnetite (2-3%).

135 Total depth

DH3-34

0-30 Monzonite; argillized; limonite-stained; pyritic; biotite (trace); magnetite (2-4%); siliceous at 15' downward; sericite (trace) at 20' downward; 25-30*

30 Total depth

DH4-34

0-64 Monzonite; quartzose, sericitic; magnetite (3-5%); trace turquoise (0-5'); biotite (trace); at 5': magnetite (7-8%); oxidized zone bottoms at 45'.

64-80 Andesite; chloritized; magnetite (8-10%); trace pyrite; 65-70*.

80-95 Monzonite; silicified; abundant magnetite; pyritic; 90-95*.

95 Total depth

DH1-35

0-4 Soil (organic) and weathered monzonite with disseminated magnetite.

4-60 Monzonite with silicified andesite(?) inclusions; argillized; trace chlorite and magnetite; limonite-stained; trace biotite at 40 feet downward; pyrite at 50' downward; 50-55*.

60 Total depth

DH3-35

0-4 Soil (organic) and weathered monzonite; limonite-stained vuggy quartz.

4-10 Monzonite; siliceous; limonite-stained; trace magnetite.

10 Total depth

Appendix C

Geochemical Sample Descriptions
(See fig. 7 for locations)

Number	Description	Copper Content (ppm)
RS-1	Hornblende monzonite, minor biotite and quartz, abundant magnetite	34
RS-2	Monzonite, fresh feldspar, no ferromagnesian minerals, trace "limonite" and magnetite	29
RS-3	Monzonite, feldspar kaolinized and sercitized, approx. 5% quartz, no ferromagnesian minerals, trace "limonite" and magnetite.	13
RS-4	(Same as RS-3)	23
RS-5	Hornblende monzonite, trace biotite, chlorite, and epidote, abundant magnetite	14
RS-6	Hornblende-biotite monzonite, abundant magnetite	38
RS-7	Syenite, pink feldspar, less than 10% ferromagnesian minerals, occurs as dike and cross-cuts hornblende-biotite monzonite and biotite monzonite	22
RS-8	Quartz-sericite alteration of monzonite	25
RS-9	Hornblende monzonite, silicified along fractures, argillized	20
RS-10	Biotite monzonite	26
RS-11	Argillic alteration of monzonite, abundant very fine-grained quartz and sericite.	150
RS-12	Andesite, argillized, less than 5% quartz, no ferromagnesian minerals or magnetite	19
RS-13	Hornblende monzonite, abundant magnetite, trace geothite	35
RS-14	Quartz-sericite alteration of monzonite, trace "limonite"	21
RS-15	Monzonite, fresh feldspar, less than 5% quartz, no ferromagnesian minerals, abundant magnetite	30
RS-16	Monzonite, argillized, abundant fine-grained quartz, moderate amount of magnetite	13
RS-17	Sericite-clay alteration of monzonite, abundant quartz, trace biotite but otherwise no ferromagnesian minerals or magnetite	29
RS-18	Biotite monzonite, quartz less than 5%, abundant to moderate magnetite	31
RS-19	Argillic alteration of monzonite, approx. 10% quartz; trace fresh feldspar and magnetite	32
RS-20	Argillic alteration of monzonite, sericite (5-10%), trace turgite and pale green fluorite(?)	685
RS-21	Argillic alteration of monzonite, fine-grained quartz (5%), deep red goethite, sericite (5-10%)	90
RS-22	Argillic alteration of monzonite, fine-grained quartz (5-10%), trace sericite	108
RS-23	Argillic alteration of monzonite, fine-grained quartz (5-10%)	25
RS-24	Monzonite, 2-3% hornblende, abundant magnetite, vein quartz	47
RS-25	Biotite monzonite, trace hornblende, moderate magnetite	25
RS-26	Monzonite, feldspar slightly argillized, quartz less than 5%, trace biotite and hornblende, moderate magnetite and goethite	63
RS-27	Monzonite, argillized, trace quartz, magnetite and goethite	60
RS-28	Hornblende-biotite monzonite, moderate to low magnetite content	49

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