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Copper Mountain Drilling
1960? — Presen

(M) holes (1 to 28 & 30-39) All copper mountain
Trigg's air holes
100' x 200' pattern 1st drilling
stored in paper sacks, cups, envelopes
and distributed in various locations
in property. Now being organized
bx USNR staff.
Assayed by ~~Hawley & Hawley~~ 1966 Southwestern Assayers & Chemists
Records in warehouse in brown binder.
No geology
~~Copper range~~
No assay checks.
Most in old warehouse
Check assays by H & H & Jacobs consistently
lower by .05 to .15% Cu. on M. series

Field Notes
Elmer

Copper Range

XM series (1 - 14) holes (All Copper Mountain)
diamond drilled (small outfit) 1968
NX - BX

— Locations for 1 to 8
Core for 1 through 14 Part ~~Sea~~ in core shed Part outsid.
Logs & assays for 1 through 14
" " " in Engineering office
Logs by CR. (D. E. Hopkins & Ray Leon)
Assays by Hawley & Hawley with
occasional checks by Jacobs.

CD - Copper Range churn drills
(for both copper Mtn & Copper Leach)

Samples in area?
Assays on sheet in Engineering Dept
Assayer ??
CD 1 through 5 at copper Mtn.
No logs.

No log forms

USNR

2 core holes

101 and 201

Drilled by Thatcher,

Recovery 90% ±

Bx

Core in shed by dam ?

Logged and partial assayed (H & H)

Part not split.

All qtz. monzonite porphyry

Logged 101 0'-218' > simple description

201 0 - 403'

Air drill holes by USNR

300 & 400 series (Mayhew drill #100)

$1.50 per foot. 4½ diameter

200 series Ingersoll Rand 5½" diameter

down the hole hammer

Notes on work sheets describing

basic petrology.

Assays. - H & H. & Southwest & "in house"

Essentially no checks

Samples in attic (Eng. Bld) & old warehouse

& core shed.

Samples in paper sacks and envelopes

Mixed up properly !

All assay weighted the same whether core, air or churn

No channel samples of benches.
Some grab sampling (for leach column testing) underway at present.
No truck samples.

118 holes in CM ore body
8 million tons.

$$118 \overline{)8{,}000{,}000} = 90{,}000$$

Copper Leach Mineralization
Drilling

CL Series
Trigg air holes
S.W. assays
no geological logs
Samples all over property
No check assays
L 1 through 50
No ~~data~~ location on 50

100' x 200' pattern.

Copper Range
XL Series 1 through 15
Diamond Drill
1-15 drilled & assayed
1-12 & 14 located
1-15 geological logs. Ray & Leon
Data in Engineering Don Hopkins
Core scattered throughout property
(some covered by plastic on
open ground)

C.L.

Copper Range (continued)

LA series Air drill holes

LA 1 through 14

Assays by H & H.

no check assays

No geology

Churn Drill holes

CD 1 & CD

Assays - unknown assays

No geology

USNR

X Diamond Drill holes

Drilled by Thatcher

Core recovery 99% ± BX

AMAX will assay them. Amax has split them and give them to USNR.

16 Logged (Basic)

22

25 "

31 "

50 "

63 "

69 "

75 "

Core in core shed & on front porch.

USNR air drilling - Ingersoll Rand 5½"

- 1 - 74 - Assayed by Southwest
- 1000 - 1047 Assayed "in house"

Samples in attic & old warehouse and core shed.

Blast holes assayed in mined area.

Samples Kept on last few holes

1 - 74 - Silver City testing
1000 - 1047 assayed "in house"

Aerial Photographs

1. Color set

2 or 3 B & W sets

Flown for mining calculation
Photos cover CM & CL areas.

RING-FRACTURE INTRUSION AND MINERALIZATION AT CLIMAX, COLORADO: A PRELIMINARY REPORT

V. 68, p. 1809.

GSA '57 A-M.

Stewart R. Wallace, David C. Jonson, Robert A. Navias, and Stanley A. Skapinsky
Climax Molybdenum Company, Climax, Colo.

p. 139-140

[redacted]

F.
Paul

MEMO TO FILE

September 17, 1971

SUBJECT: COPPER LEACH ORE RESERVES
USNR PROPERTIES
TYRONE, NEW MEXICO

EVERYONE KNOWS THIS

Because of the geometry and the erratic nature of mineralization in the Copper Leach area at the USNR properties which is demonstrated by drilling to date, the Essex geologic staff feels that no positive ore reserves can presently be attributed to the Copper Leach area without additional study and possible drilling. The copper mineralization shown on the ore reserve sections at Copper Leach by USNR may or may not produce mineable ore reserves. Such eratic mineralization demands close spaced drilling to prove ore reserves.

Paul I. Eimon

PIE:td

cc: H. Lanier
G. Jackson

WHY THIS ?
ARE YOU TELLING ME THAT WE SHOULD DO IT OR SHOULD NOT.
WE HAVE TO MAKE A DECISION.
WHAT IS YOUR RECOMMENDATION.

On Guerdon's request after my comments at copper Leach last week.
Paul

Recorded 15th May 1970
9 o'clock - Recorded 172 Deed Records
Page 176 - County Clerk, Grant County.

5-15-70

STATUTORY WARRANTY DEED

MARY JANE TURNER, formerly known as Mary Jane Steinwender, for consideration paid, grants to USNR MINING & MINERALS, INC., a Delaware corporation, the following described real estate situate in Grant County, New Mexico:

Township 19 South, Range 15 West

Sec. 28: Lot 2

Sec. 21: All that part of Lot 17 lying in the NW¼ of said Section, being more particularly described as follows:

Begin at the SE corner of the NW¼ of Sec. 21 and run Westerly along the South line of said NW¼ to a point on the SE line of the Signal Mountain patented lode mining claim, Mineral Survey No. 221; thence N. 45°30' E. along said SE line of said claim to a point on the East line of said NW¼ of Sec. 21; thence South along the East line of said NW¼ to the place of beginning;

with warranty covenants, subject to patent reservations.

WITNESS my hand and seal this 8th day of May, 1970.

Mary Jane Turner (SEAL)

STATE OF NEW MEXICO,)
: SS.
COUNTY OF GRANT.)

The foregoing instrument was acknowledged before me this 8th day of May, 1970, by Mary Jane Turner, formerly known as Mary Jane Steinwender.

Notary Public

My Commission expires:
10-2-70

Kind regards of R. E. Somers

D. H. McLAUGHLIN
ROTCH BUILDING
CAMBRIDGE, MASS., U. S. A.

FROM THE
GEOLOGICAL DEPARTMENT
CORNELL UNIVERSITY
ITHACA, N. Y.

Geology of the Burro Mountains Copper District, New Mexico

BY
RANSOM EVARTS SOMERS
~~Utica, N. Y.~~
ITHACA N. Y.

PRESENTED AS A THESIS TO THE FACULTY OF THE GRADUATE SCHOOL OF CORNELL UNIVERSITY FOR THE DEGREE OF DOCTOR OF PHILOSOPHY

Reprinted from *Bulletin* No. 101, May, 1915, American Institute of Mining Engineers

(San Francisco Meeting, September, 1915)

NEW YORK, N Y.
1915

Burro Mts, N.M

So

which were developed after the principal period of mineral formation. The latter is sometimes well shown in the hand specimen, as in Fig. 20.

Chloritization, sericitization, and silicification represent the action of hydrothermal solutions. The zonal arrangement of the first two corresponds in a general way with the alteration at Butte, as described by Kirk.[17]

Kaolinization.—Meteoric waters have developed near the surface large amounts of kaolinite which give the rock a soft, chalky appearance. As with the secondary metallic minerals, kaolinite extends to varying depths, depending upon the permeability of the rocks.

6. *Genesis of the Ores*

The location of the Burro Mountains deposit on the contact of a post-Cretaceous intrusion of monzonite, its formation after that intrusion and yet previous to a Tertiary volcanic breccia, and a mineralizing activity which is generally considered to-day to be due to hot solutions, point to the monzonite as the prime factor in its existence. In this respect it corresponds with the many deposits of the southwestern part of the United States which are closely connected in origin with monzonite intrusions.

A fractured zone helped to determine the location of the deposit by furnishing channels for the easy circulation of the hot ascending solutions that were given off by the congealing monzonite magma. These hot solutions chloritized the ferro-magnesian minerals and sericitized the feldspars of the country rocks; they deposited quartz and pyrite in the walls of the fissures wherever minor fractures would allow them to penetrate; and they filled the fractures themselves with an aggregate of quartz, pyrite, chalcopyrite, and sphalerite, probably because of a decrease in pressure and temperature as the solutions rose. Chalcopyrite was scarce in the original aggregate, and hence copper very low, but since the fractures were first exposed at the surface by erosion, meteoric waters have been effecting a concentration. This has been brought about by oxidation of the copper to soluble salts, downward percolation, and precipitation as chalcocite upon reaching the reducing environment of the underground water.

Both primary mineralization and downward enrichment were given the most favorable opportunity for their activity where the fracturing was most open, a condition which seems characteristic of the central part of the fractured zone, and hence the best orebodies are found in that portion.

The district is still comparatively undeveloped. Many new orebodies will undoubtedly be disclosed as mining is carried on, and the future of the district seems bright.

[17] Kirk, C. T.: Conditions of Mineralization in the Copper Veins at Butte, Mont., *Economic Geology*, vol. vii, No. 1, p. 35 (Jan., 1912).

TRANSACTIONS OF THE AMERICAN INSTITUTE OF MINING ENGINEERS
[SUBJECT TO REVISION]

DISCUSSION OF THIS PAPER IS INVITED. It should preferably be presented in person at the San Francisco meeting, September, 1915, when an abstract of the paper will be read. If this is impossible, then discussion in writing may be sent to the Editor, American Institute of Mining Engineers, 29 West 39th Street, New York, N. Y., for presentation by the Secretary or other representative of its author. Unless special arrangement is made, the discussion of this paper will close Nov. 1, 1915. Any discussion offered thereafter should preferably be in the form of a new paper.

Geology of the Burro Mountains Copper District, New Mexico

BY R. E. SOMERS, ITHACA, N. Y.

(San Francisco meeting, September, 1915)

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I. INTRODUCTION

1. *Location, Topography, and Climate*

The Burro Mountains are located in the southwestern part of New Mexico, in Grant County. The group is made up of two distinct mountain masses, known as the Little Burros and the Big Burros, the former lying about 6 miles southwest of Silver City, and the latter about 9 miles farther in the same direction.

They are separated by the valley of the Mangas River, a tributary of the Gila, and a stream only in name, except after a heavy downpour of rain. The Little Burros attain an elevation of 6,625 ft. above sea level, and the Big Burros 8,054 ft., with the surrounding country averaging about 6,000 ft. To the south of these mountains stretches the desert plain, while to the north are the more frequent elevations of the mountainous country.

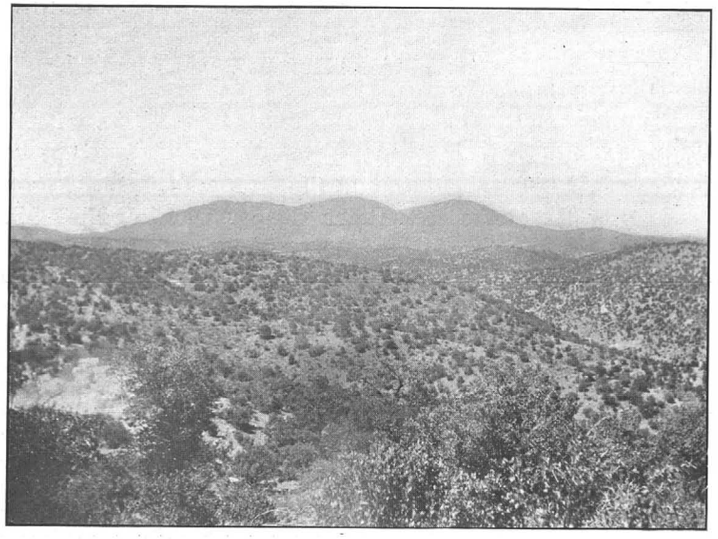

FIG. 1.—BIG BURRO MOUNTAINS FROM LEOPOLD, N. M. SHOWS A PORTION OF THE DISSECTED SLOPE WHICH EXTENDS FROM THE BIG BURROS TO THE MANGAS VALLEY.

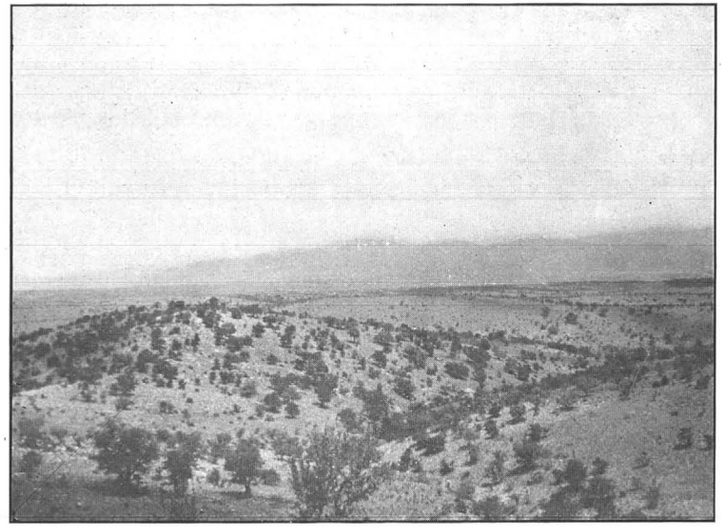

FIG. 2.—MANGAS VALLEY, SHOWING RIDGES OF PLEISTOCENE AND RECENT GRAVELS IN THE FOREGROUND.

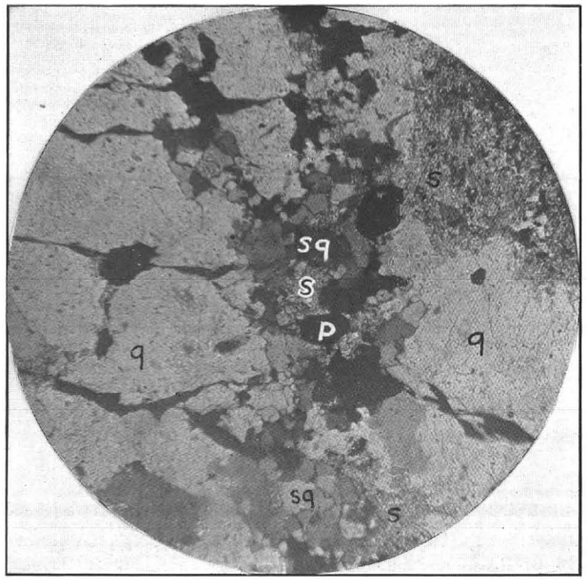

FIG. 24.—VEINLET OF SECONDARY QUARTZ (sq) AND PYRITE (p) IN PRIMARY QUARTZ (q) OF THE GRANITE. SHOWS REPLACEMENT. SERICITE (s) FROM ALTERATION OF FELDSPAR AND ALSO IN VEINLET. CROSSED NICOLS. × 50.

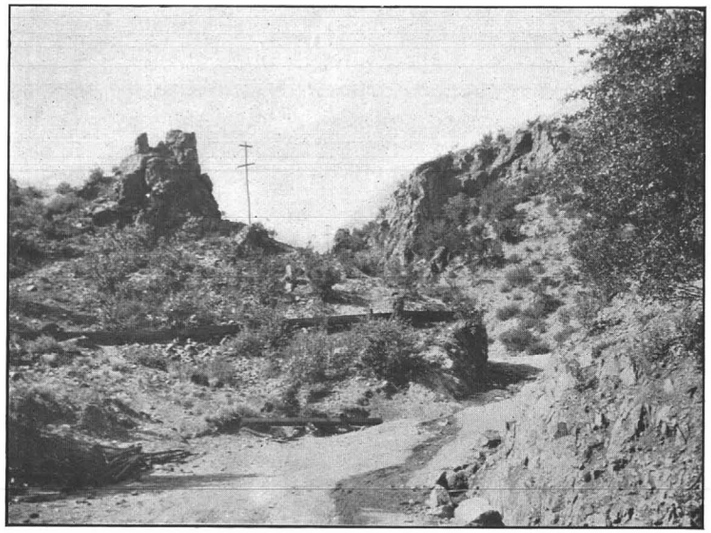

FIG. 25.—ON THE ROAD FROM TYRONE TO SHAFT NO. 2, SHOWING GOSSAN OUTCROPS.

fault gouge. This clay-like material is probably made up of sericite, secondary quartz, and kaolinite, and the intrusive character of its parent rock is proved beyond a doubt by the fact that it often shoots off tongues or branches from the main stringers.

Silicification.—Silicification of the wall rocks has taken place in the Burro Mountains to varying degrees (Figs. 23 and 24). In many places the rock on each side of the fractures is saturated for short distances with secondary silica, which replaces the original minerals, and, at times, may completely obliterate its texture. In some places, however, there is practically no such saturation, the secondary quartz being confined

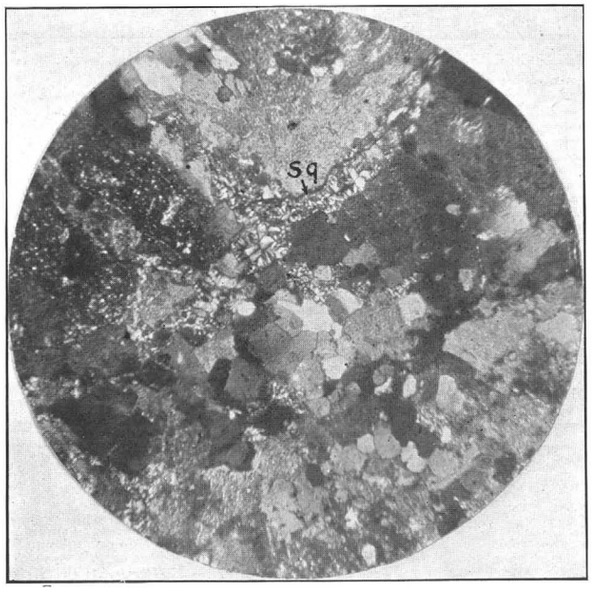

FIG. 23.—VERY FINE SECONDARY QUARTZ (sq) IN MONZONITE. CROSSED NICOLS. × 50.

to the small fractures, with perhaps an occasional replacement grain. On the whole, silicification has not been nearly as abundant as in many deposits of similar type.

When present in large amounts, secondary silica, with the accompanying iron oxide, gives a strong gossan-like character to the outcrops. These may be noted in any part of the area (Fig. 25). Although these seem rather common in a survey of the district, nevertheless they do not represent any very large proportion of the total number of fissures.

Study with the microscope suggests that there were at least two generations of secondary silica, one of which accompanied the primary sulphides, while the other followed at a later time and filled fractures

The Little Burros are about 8 miles long, and ½ to 1½ miles wide, with a northwest-southeast trend. To the southwest they drop off rather abruptly into the Mangas Valley, but to the northeast their slope is gradual. The continental divide passes through the southeasterly end of this group, as well as through the summit of the Big Burros.

The Big Burros are more rounded in plan. They descend rather rapidly on the north and east from their maximum elevation of 8,054 ft. above sea level, down to about 7,000 ft. altitude, from which there is a rather gentle slope for about 5 miles until the surface drops off into the Mangas Valley on the northeast. This slope is made up of ridges separated by sharp gulches, or *arroyos* (Fig. 1), which are tributary to the Mangas. Near the foot of this slope is situated the camp of Tyrone, with Leopold about 2 miles farther up in a southwesterly direction.

The climate is arid, and hence the ridges are barren except for the sage brush, cactus, and mesquite, which detract little from the yellowish brown, or, in the mineralized section, rusty and jagged, appearance of the surface. In some of the gulches, however, a few evergreens and other trees may be found, especially about Tyrone, where in places the desert-like appearance is wholly lacking.

The accompanying map (Fig. 3) shows the relative location of the different points of interest in the district.

2. *Scope of Work and Acknowledgments*

The Burro Mountains, as a whole, contain two classes of ore deposits: (1) quartz veins with gold and silver; and (2) copper deposits in fracture zones with more or less disseminated replacement of the walls. The former have not been very extensively worked, but the latter have attracted considerable attention, and the richest of them, so far as shown by present development, lie in the vicinity of the two camps, Tyrone and Leopold. The object of this paper is to set forth the results of a rather detailed study upon this section of the Burro Mountains area.

The field work was done during the summer of 1913, and was made possible through the kindness of Dr. James Douglas and Walter Douglas of the Phelps-Dodge Co. To E. M. Sawyer, Superintendent of the Phelps-Dodge properties at the Burro Mountains, and to his staff, the writer wishes to extend his thanks for their hospitality and the facilities which they so willingly placed at his disposal. To Prof. Heinrich Ries the writer is particularly indebted for generous and thoughtful guidance and patient criticism throughout the work.

3. *History and Mining*

Copper was first discovered in 1871, and in the following years the district passed through various periods of activity and idleness

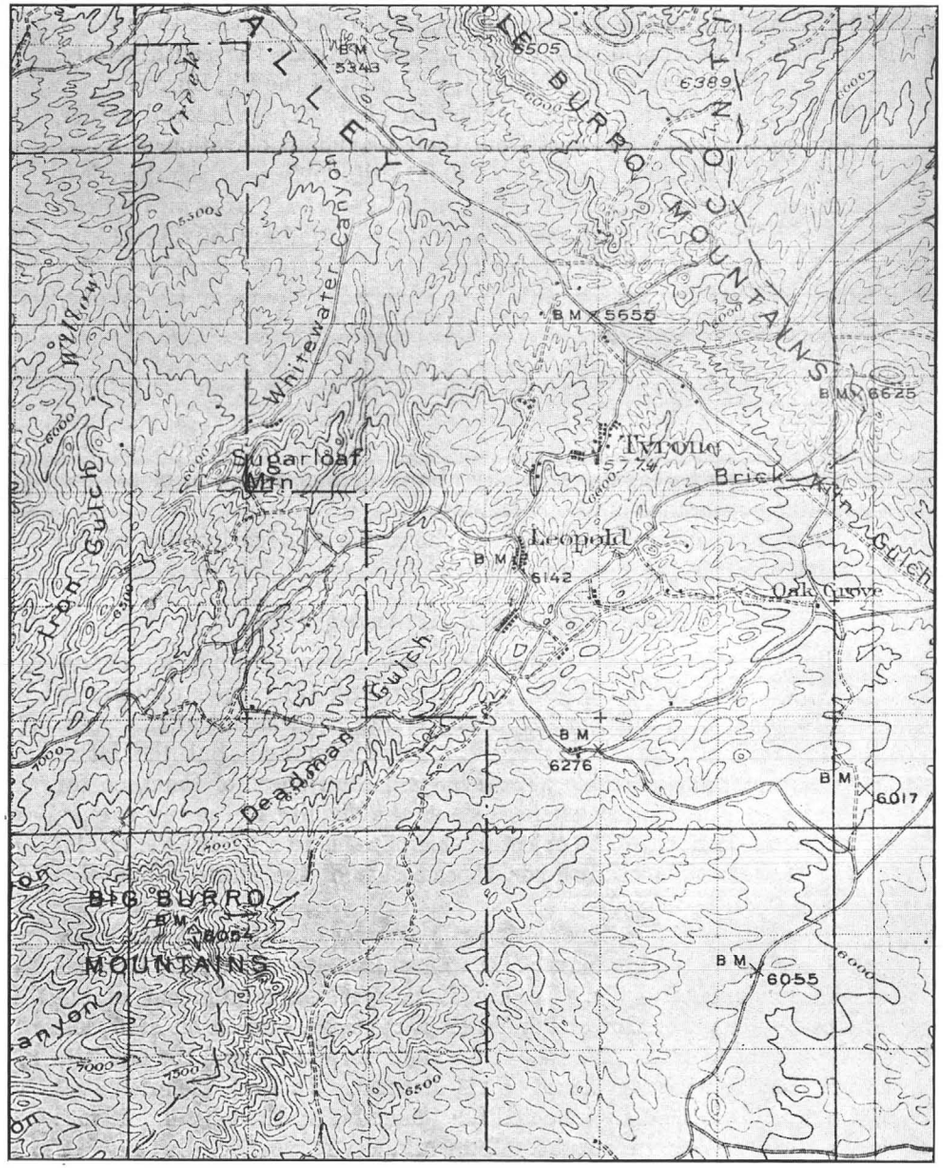

FIG. 3.—MAP OF THE BURRO MOUNTAINS REGION, NEW MEXICO.

share the same alteration, but they are present in such very small amounts that consideration of them is unnecessary.

As seen in the hand specimen, the biotite thus altered may show merely a greenish color and a lack of elasticity in its plates where the change has not proceeded far, but the final product is a greenish powder, without semblance to micaceous form.

Under the microscope all stages may be observed, from the earlier, where cores of fresh biotite are abundant, through those in which no biotite remains but the outline of the original grain is still clearly defined, to the stages where the chlorite seems to have diffused into neighboring cracks as well as occupying the volume of the primary mica. This last stage produces a very irregular mass of alteration products, which shows only an indistinct resemblance in form to the original biotite.

Rocks which are altered in this manner contain small amounts of sericite.

Sericitization.—In the fractured area, however, sericite is very abundant. It replaces the feldspars in very minute flakes and may possibly develop in quartz in extreme cases.

Plagioclase changes to sericite earlier than orthoclase. The alteration proceeds gradually from the first stage, where a few scattering flakes of sericite appear in the feldspar, to the final product, which is a densely packed aggregate of sericite flakes with occasional grains of the secondary quartz which results from this alteration.

As seen in the hand specimen, the effect is a whitening of the feldspars with the destruction of their luster and cleavage planes. The silky character of the sericite is frequently evident, but it is not general, due to the fineness of the sericite flakes.

Not only has sericite been formed at the expense of the feldspars, but also it has replaced the chlorite of the earlier stage of alteration. In both slides and hand specimens may be observed the large flakes of sericite which occupy the positions once held by the chlorite. The flakes of sericite thus developed are much larger than those formed in the feldspars.

Sericitization is most pronounced immediately adjoining the ore-bearing fractures, and gradually diminishes as the distance from these fissures increases. It is also found intermingled with the quartz-pyrite filling of the fissures, where it has been carried by solutions from the walls.

Sericitization affects all the intrusive rocks of the district. It is perhaps most strikingly developed in some of the fine-grained monzonites which occur as dikes in the northern part of the district. Those phases of this rock which contained very little primary quartz have been converted by this process, combined probably with some kaolinization, into clay-like masses which soften when wet and in many ways resemble

outcropping fissure would hardly indicate a zone of fissuring, and it is the latter in which orebodies are found in the Burro Mountains. The requirement that cross fissures should be present is perhaps open to question, but nevertheless it is doubtful if the solutions which deposited the primary minerals, and the meteoric waters which converted them into ores, were able to work effectively except in zones where a free circulation was promoted by the general breaking up caused by fissures in more than one direction. As noted above, the good orebodies of the district have been found in places where cross fracturing is common. Some ore may be found where cross fracturing is absent, but it will probably not be very plentiful.

In some places, especially about Tyrone, the presence of large fissures is proved, not by the outcrops, but by fragments of vein filling, mixed in with other surface débris, in such locations that it could not have been transported very far.

(2) Exceptional Rust.—Especially large amounts of limonite or hematite at the surface show indirectly that mineralization has been more extensive than usual. This indicates ore, provided that chalcopyrite was a constituent of the primary minerals, and that there has been sufficient fracturing to allow surface waters to form an enriched zone. The former could not be proved from any surface evidence, and if chalcopyrite is unevenly distributed, as seems probable from a study of the district, herein lies a difficulty in locating ore from the surface showing. It is not an all-important difficulty, however, because the cases where chalcopyrite seems lacking are the exceptions rather than the rule.

Nearly all the orebodies of the district show exceptional rust in their outcrops. The new Bison orebody is well indicated by a rusted area which is very noticeable from any of the surrounding hills.

(3) Pyrite Replacement Cavities.—Cavities which, from their size and shape, must have formerly contained pyrite, are also valuable indicators of ore. They are subject to the same qualifications, however, as given above in reference to the presence of limonite and hematite.

They are to be found above most of the orebodies, and are of special importance over the shaft No. 3 workings, where they seem to be about the only signs that show the location of the ore.

5. *Rock Alteration*

Chloritization.—At a distance from the fractures, beyond the sphere of intense mineralizing action, and where pyrite is very seldom developed, the biotite of the rocks has been changed to chlorite, epidote, and magnetite. This is equally true of monzonite, granite, and quartz porphyry, but results in small quantities of these secondary minerals because of the relative scarcity of original biotite. Other ferro-magnesian minerals

until, in 1905, the Phelps-Dodge Co. secured the Burro Mountain Copper Co., which was organized in 1904 by the Leopold Brothers, of Chicago, to work a group of claims around the camp which is now called Leopold. In the vicinity of Tyrone there was another group of claims which was operated by the Chemung Copper Co., and in 1913 the Phelps-Dodge Co. purchased these also.[1]

Since 1904, development in the Burro Mountains has been going on steadily and with excellent results. Tyrone is being made the

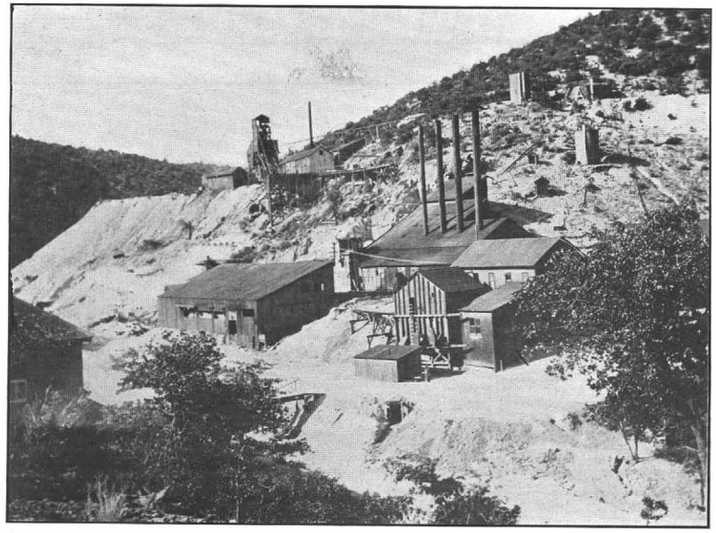

FIG. 4.—SAMPSON SHAFT AT LEOPOLD.

center of activity and it is reached by the recently completed Burro Mountains R. R., which runs from Whitewater on the Deming to Silver City spur of the Santa Fé.

At Leopold the principal shaft is the Sampson (Fig. 4), and through it a number of orebodies, such as the East and West Sampson, and the Protection, have been worked in the past. A short distance northeast of the Sampson shaft is a large deposit of developed ore, called the East orebody. There is also at Leopold the St. Louis shaft, an incline which is on the so-called "St. Louis slip," or fissure. South of the St. Louis is the McKinley shaft, which, however, has not been extensively worked. About ½ mile northeast of Leopold are the Boston and Niagara shafts,

[1] For more details, see Wade, W. Rogers: Burro Mountain Copper District, *Engineering and Mining Journal*, vol. xcviii, No. 7, pp. 287 to 289 (Aug. 15, 1914); also Bush, F. V.: Burro Mountain Porphyry Copper Developments, *Mining Press*, vol. cx, No. 6, pp. 222 to 224 (Feb. 6, 1915).

neither of which has shown very much ore. The former connects with the Sampson workings. At Tyrone there are three shafts, called No. 1, No. 2, and No. 3. The first, which is separate from the other two, lies to the northwest and is not yet very important. Nos. 2 and 3 (Fig. 5) lie close together in the same gulch in which Tyrone is situated and open extensive deposits. Between the 300 and 400 ft. levels in No. 3 is a rich deposit in breccia, which is known as the "breccia orebody." Between No. 2 and No. 3 is the portal of the Niagara tunnel, a 7,000-ft. opening, running southwest, and extending to the East orebody at Leopold. It is connected by a crosscut with the Niagara shaft, and is

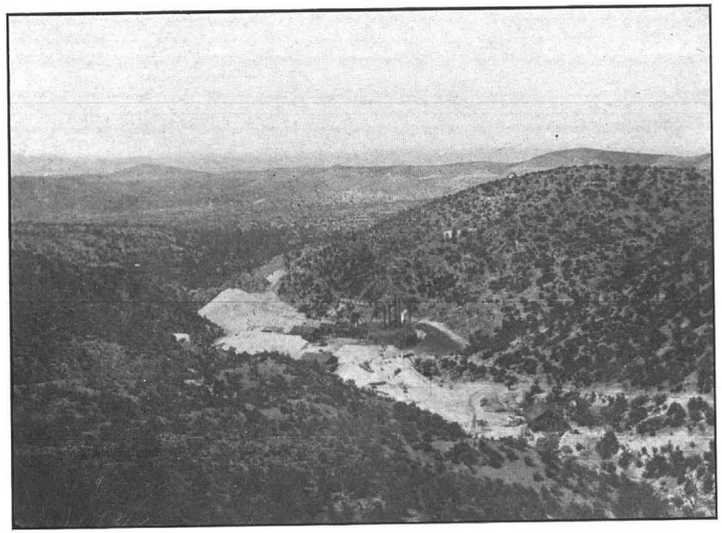

Fig. 5.—Shaft No. 2. Entrance to Niagara Tunnel is near House in Lower Right-hand Corner.

to be used to deliver the ore from the Leopold workings to the railroad, which is to enter it on grade. About 1,400 ft. from the portal, the Niagara tunnel has opened up a mass of ore called the "Bison orebody."

Besides the larger interests mentioned above, the Savannah Copper Co., Mangas Development Co., and others, are doing some work in the district.

II. General Geology

1. *Introduction*

The Big Burros, considered broadly, consist of a pre-Cambrian granite complex into which has been intruded a mass of quartz monzonite of post-Cretaceous age. The summit of the Big Burros is of

indicators of ore, viz.: (1) the presence of fissures; (2) exceptional rust, either in the outcrops or in the rock débris; and (3) pyrite replacement cavities.

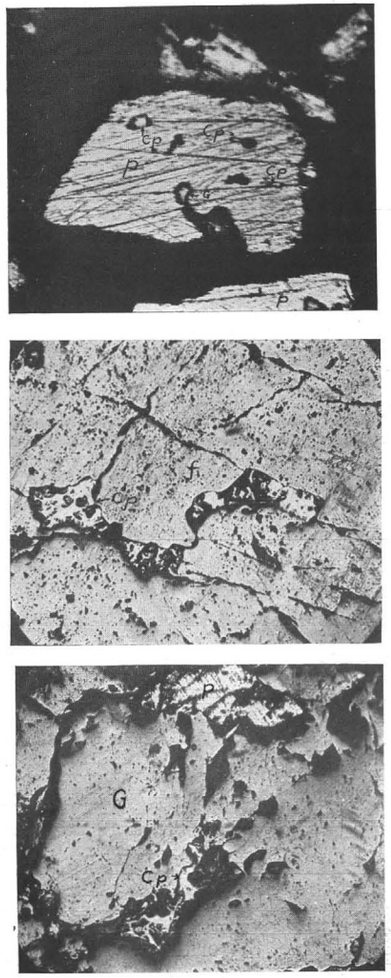

Fig. 22.—Chalcopyrite (cp) in Pyrite (p), Feldspar (f), and Quartz. Gangue (G). Reflected Light. × 40.

(1) Fissures.—The ore-bearing fissures outcrop occasionally at the surface, although silicification has been hardly strong enough to enable the majority of them to withstand the weathering agents. When, however, fissures do appear at the surface, they may indicate ore if they are persistent, of sufficient width, and of more than one direction of strike. Without persistence, or a fair width or openness, an occasional

reach about 300 ft. at Leopold and 720 ft. at Tyrone, probably represent the lowest limit of any possible enriched zone.

Source of Copper.—The primary sulphides contain copper, although in very small quantities, and from the standpoint of a few years ago it would have been sufficient to say that the original pyrite was "cupriferous," without further qualification.

More recently, however, the work of Simpson at Butte[15] and the broader studies of Graton and Murdoch[16] indicate that, chemically, cupriferous pyrite does not exist, but that the copper in lean pyrite masses is present as a copper mineral scattered in very small amounts through the other sulphides.

The primary copper of the Burro Mountains furnishes an example of this. Chalcopyrite is found in polished sections of primary sulphides taken from the Bison orebody and from the workings of the Sampson, No. 1, No. 2, and No. 3 shafts. It is generally very scarce, is usually too small to detect even with a hand lens, and undoubtedly represents the source of the copper.

It occurs in small irregular grains, in veinlets, and in more or less rounded patches (Fig. 22). It is believed to be approximately contemporaneous with pyrite. When in grains, chalcopyrite and pyrite may occur as neighbors, with interlocking contacts, and neither mineral impressing its form upon the other. When in veinlets they may occur together in a similar manner, or they may be found in different parts of what appears to be one fracture. While the patches of chalcopyrite in pyrite at first seem to be quite rounded and drop-like, upon further examination they show irregular outlines that indicate contemporaneous formation. Very similar patches are found in the quartz.

Specimens from some orebodies will show much more chalcopyrite in the primary sulphides than others, although there seems to be no regularity to this variation. It is safe to conclude, however, that an extensive examination of primary sulphide specimens would disclose regional differences in the primary copper content, which in some cases might well account even for the presence or absence of chalcocite.

Surface Ore-Indicators.—The surface of the mineralized area, as a whole, differs from that of the rest of the Burro Mountains region in color and form of outcrops. The limonite and hematite, which have leached out on to the surfaces of the outcrops and rock débris, stain them red-brown, and thereby give the area a generally rusty appearance. Furthermore, the outcrops are more rough and jagged than in the unaffected parts of the district.

Considered in more detail, there are three fairly reliable surface

[15] Simpson, J. F.: Relation of Copper to Pyrite in the Lean Copper Ores of Butte, Mont., *Economic Geology*, vol. iii, No. 7, p. 628 (Oct.-Nov., 1908).

[16] Graton, L. C., and Murdoch, Joseph: *Trans.*, xlv, 42 (1913).

granite, and the flanks are either granite or monzonite down to the level where both are covered by the gravels of Pleistocene and Recent age. These gravels represent the débris worn from the earlier rocks and washed into the valleys or out on to the plain.[2]

The vicinity of Tyrone and Leopold includes a corner of this monzonite mass, and some of the granite into which it has been intruded. In detail, the rocks may be enumerated as follows: (1) pre-Cambrian granites; (2) quartz porphyry, of uncertain age; (3) post-Cretaceous quartz monzonites; (4) volcanic breccia of Tertiary age; (5) Pleistocene and Recent gravels.

2. *Granite*

Megascopic Characters.—The granites are medium- to coarse-grained rocks, containing rather large grains of feldspar when fresh, and abundant irregularly shaped grains of quartz. Biotite is occasionally seen but it is not common. The feldspars are of two kinds, a pink orthoclase, and a white plagioclase, and their colors may be easily distinguished in the hand specimen when the rock is not badly altered. Sometimes the feldspars are enough larger than the other minerals to give a slightly porphyritic texture.

The granite, in whatever condition it may be found, can be recognized megascopically by its abundant, irregularly shaped quartz grains, and by the lack of small feldspar phenocrysts. The first feature distinguishes it from the quartz porphyries, in that their quartz is in the form of rounded hexagonal phenocrysts and is not as abundant as in the granite; and also from the monzonite, which seldom contains quartz in large enough grains to be visible in the hand specimen. The granite is not sufficiently silicified to furnish any obstacle to this method of recognizing it. The lack of small feldspar phenocrysts in the granite distinguishes it from the porphyritic varieties of the monzonite as well as the quartz porphyry. The granite is never porphyritic with the exception of the very coarse phase already mentioned.

Microscopic Characters.—Under the microscope, the plagioclase proves to be an albite or oligoclase (Fig. 7). The orthoclase usually shows an exceedingly fine perthitic intergrowth with a plagioclase, which is too minute to be identified. In the granite as a whole, plagioclase is usually more abundant than orthoclase. Zircon, titanite, and apatite are present as accessories.

Structure, Distribution, and Age.—The granite is the original country rock of the district. It is found chiefly in the northern part of the area studied (see Fig. 6), where, however, it contains numerous and

[2] For a very good description of the Burro Mountains region, see Paige, Sidney: Ore Deposits near the Burro Mountains, New Mexico, *Bulletin* No. 470, *U. S. Geological Survey*, pp. 131 to 150 (1911).

irregular dikes of monzonite, which gradually diminish in size and number beyond the lateral limits of the map. These dikes are so irregular that they were not mapped in detail, but they are so numerous that this section of the area cannot be called granite without qualification.

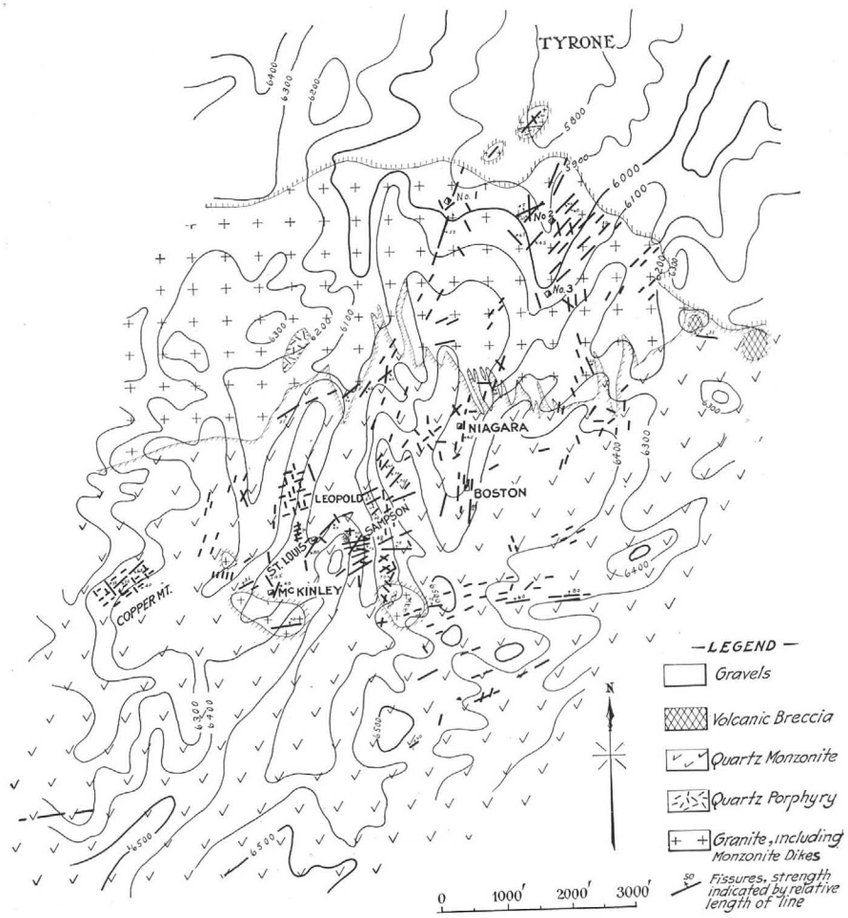

FIG. 6.—GEOLOGICAL MAP OF THE BURRO MOUNTAINS COPPER DISTRICT.

The granite included in this study of the Tyrone-Leopold district is but a very small part of the main mass. It is covered on the north by the Pleistocene and Recent gravels which fill the Mangas Valley, and does not appear directly opposite on the other side of the Mangas because of an intrusion of rhyolite porphyry which has cut through at that

been wearing away constantly without any part of them remaining long enough at the surface for chalcedony to develop.

Likewise, hematite stains this crypto-crystalline silica, but limonite is the surface form of the iron to the southward, which indicates that the northern outcrops have been longer exposed to the influence of the dry, hot climate than the more southern ones. These facts serve as additional evidence in favor of the second profile of Fig. 21.

Finally, the dotted line, *D*, represents the water table of such a former surface as that shown by the line *C*.

The important feature of the diagram is that the former water table crosses the present surface profile about at Leopold, but gradually diverges from it toward Tyrone. In a similar manner, any other former water level would pass comparatively near to the surface under Leopold, but at a considerably greater depth under Tyrone, and only recently has the water table been depressed below Leopold, while it has been as far below Tyrone as it is at present, during this whole stage of erosion. Hence, if the secondary zone is formed at or near the water level, it should be found at a depth of several hundred feet below Tyrone, because the water table has been at that depth for a long time. But at Leopold conditions have been different. Although the secondary zone tended to form at the water level, the latter has been sinking so fast that the former has been unable to keep up with it. This is because, in an arid climate, run off, with its accompanying erosion, is large, but absorption, and consequently alteration and enrichment, are small, so that erosion and the lowering of the water table go ahead of the downward migration of the secondary zone. In this way the chalcocite zone at Leopold has been left marooned above the water table and very near to the present surface. Going from Leopold to Tyrone, the water table has been considerably below the surface for an increasingly longer time, so that a better opportunity for leaching has been given and the depth of the chalcocite zone below the present surface gradually increases, while the amount of downward migration of this zone becomes less.

In the above discussion it is considered that the secondary sulphides could not have been precipitated consistently above the water level, because, on the whole, the fracturing of the Burro Mountains district is open and abundant, and there must have been a free enough access of oxygen and air to prevent any such precipitation.

Primary Zone.—The secondary sulphide at depth gives way to unaltered primary minerals. The line of separation between the two is neither regular nor sharp, and the depth at which it is reached depends on the permeability of the rocks. Locally, primary sulphides are found within a few feet of the surface, and unaltered cores are quite common throughout the deposit. On the other hand, the deepest workings, which

the Mangas Valley, and on it are indicated the locations of Leopold and Tyrone. The broken line, *C*, represents the general profile of some former surface before erosion had worn the land down to its present level.

The location of this second profile is based on the tendency of erosion to wear down hills or mountains faster than valleys, especially in an arid region where so much of the work of erosion is done by infrequent but torrential rains that wash débris from the heights down into the larger valleys, but do not maintain constant flowing streams to erode these valleys very rapidly.

The Mangas Valley itself was probably initiated during a former period of erosion when the climate was less arid than it is now, or perhaps in the early part of the present period, under somewhat different conditions than those which prevail to-day. But for a large part

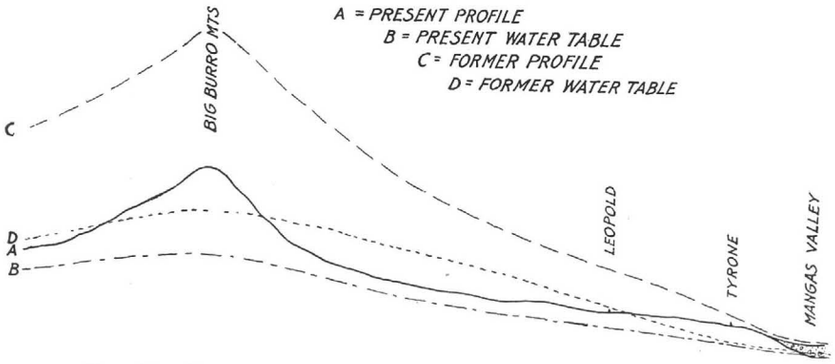

FIG. 21.—PROFILE OF BIG BURRO MOUNTAINS COPPER DISTRICT.

of the present stage of erosion the climate has been arid, as is proved by the angular form and undecomposed condition of the gravels, and the Big Burros have been worn down relatively fast, while the Mangas Valley has remained about where it was.

In this connection it is notable that the outcrops of many fissures about Tyrone contain, in place of the limonite and granular quartz which are found in the southern part of the area, a chalcedonic or crypto-crystalline variety of silica stained deep red with hematite. Chalcedony[14] is a mineral that, under these conditions, would form very slowly, at or near the surface, and its presence in the more northerly veins indicates that their outcrops have been nearly stationary for a long time, whereas its absence to the southward indicates that in this section the veins have

[14] *Bulletin No. 529, U. S. Geological Survey*, pp. 156 to 157 (1913).

point. It is found, however, about 4 miles north-northwest in the Little Burros.

In addition to this northerly extension of granite, there are several smaller areas in the central and southern parts of the district. About ⅓ mile southwest of Leopold there are outcrops which extend 1,200 ft. in an east-west direction and 600 ft. north and south. Just south of Leopold is another area of about the same size. To the west of Leopold at a distance of a little less than ½ mile is a third one of these "islands," but this occurrence is very much smaller than the first two mentioned, its greatest dimension being not more than 250 ft. Besides these, a single small outcrop appears 300 ft. northwest of the Sampson shaft, on the hill back of the old Burro Mountain Co. office.

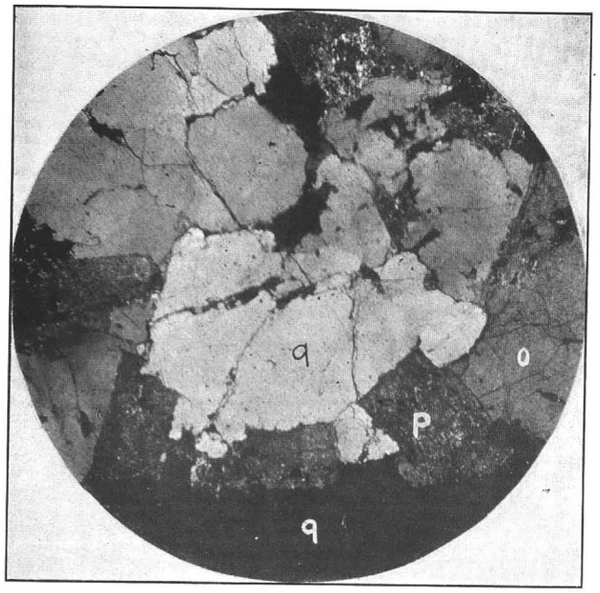

FIG. 7.—QUARTZ (q), ORTHOCLASE (o), AND PLAGIOCLASE (p) IN GRANITE. CROSSED NICOLS. × 20.

While slight textural and mineralogical variations are to be noted in the granite, there is no regularity in the distribution of the different phases. The age of the granite is pre-Cambrian, since it is found overlain by Cambrian sediments in some parts of the Silver City quadrangle.

3. *Quartz Porphyry*

Megascopic Characters.—The quartz porphyry is a light-colored porphyritic rock which always contains hexagonal phenocrysts of quartz,

varying in size up to 1 cm. in diameter of cross-section, and usually very striking phenocrysts of pink feldspar which are sometimes as much as 4 cm. long. The quartz phenocrysts show clearly their double-ended hexagonal pyramids, with edges somewhat rounded, and the pink feldspars have very well defined crystal outlines. In addition to these, smaller phenocrysts of a whitish feldspar are very common, and a few greenish grains of chloritized biotite were noted. In some places the white feldspars make up the background for the phenocrysts, but in others there is an aphanitic, blue-gray to white groundmass.

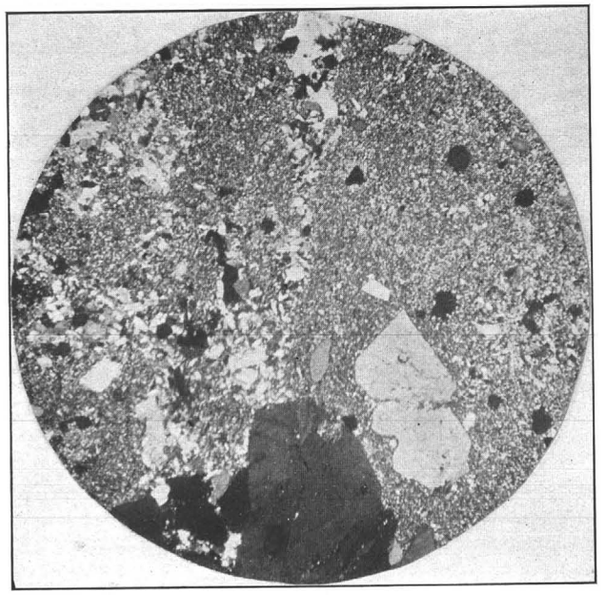

FIG. 8.—QUARTZ PHENOCRYSTS IN SILICIFIED QUARTZ PORPHYRY. TYPICAL UNALTERED SECTIONS SHOW MUCH MORE FELDSPAR. CROSSED NICOLS. × 20.

Microscopic Characters.—Examined in thin section, the pink feldspar proves to be orthoclase, and the white, oligoclase. The notably rounded outlines of the quartz phenocrysts are clearly shown (Fig. 8). The groundmass is an aggregate of oligoclase, orthoclase, and an occasional grain of quartz. Apatite, zircon, and magnetite are the accessories present.

Structure, Distribution, and Age.—The quartz porphyry is intrusive into the granite. A large dike of it outcrops about 1 mile west of Leopold, just beyond Copper Mountain, and another one is found on the hill about ¾ mile northwest of Leopold, above the Leopold-Tyrone road. A few smaller dikes are found both underground and on the surface

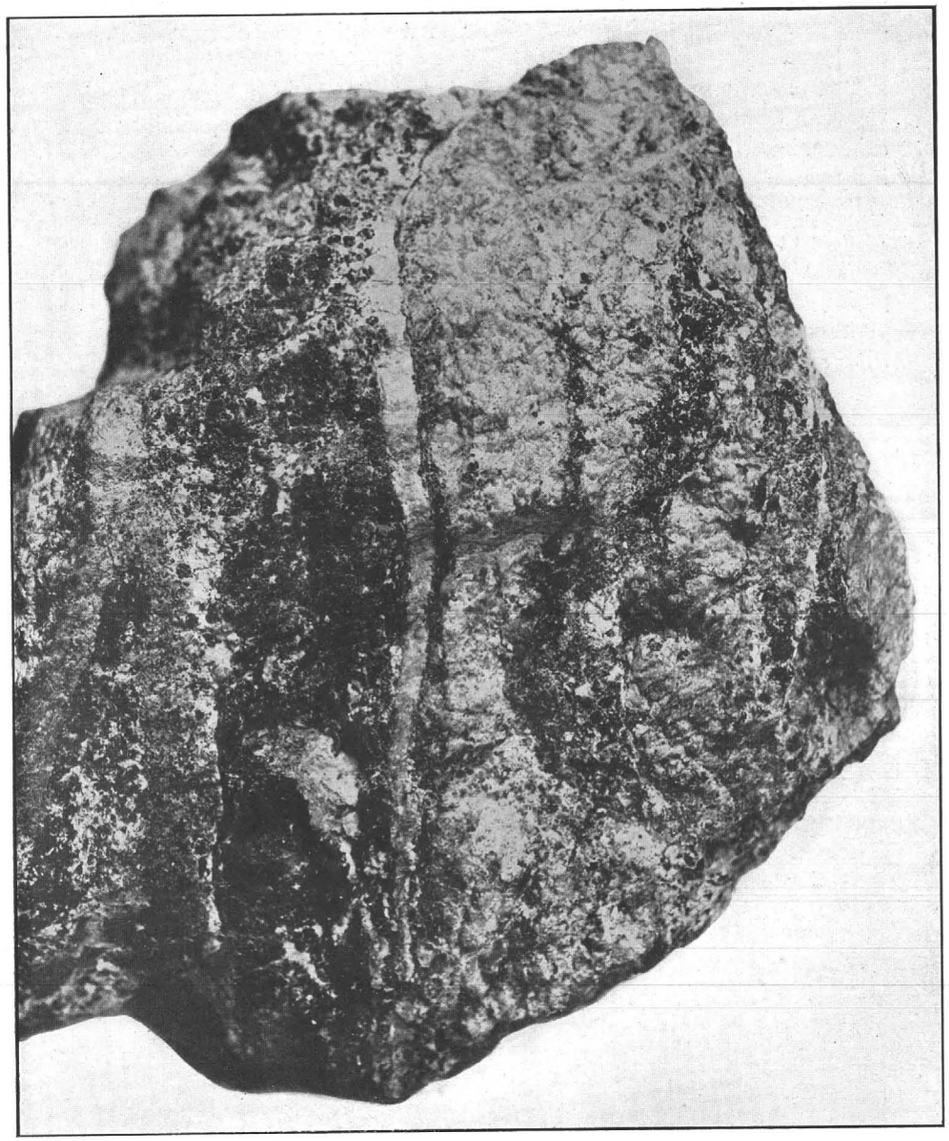

FIG. 20.—SPECIMEN OF ORE FROM SAMPSON SHAFT. SHOWS "SLIP" WITH LATER VEINLET OF QUARTZ. BLACK IS CHALCOCITE, WHITE IS QUARTZ. NATURAL SIZE.

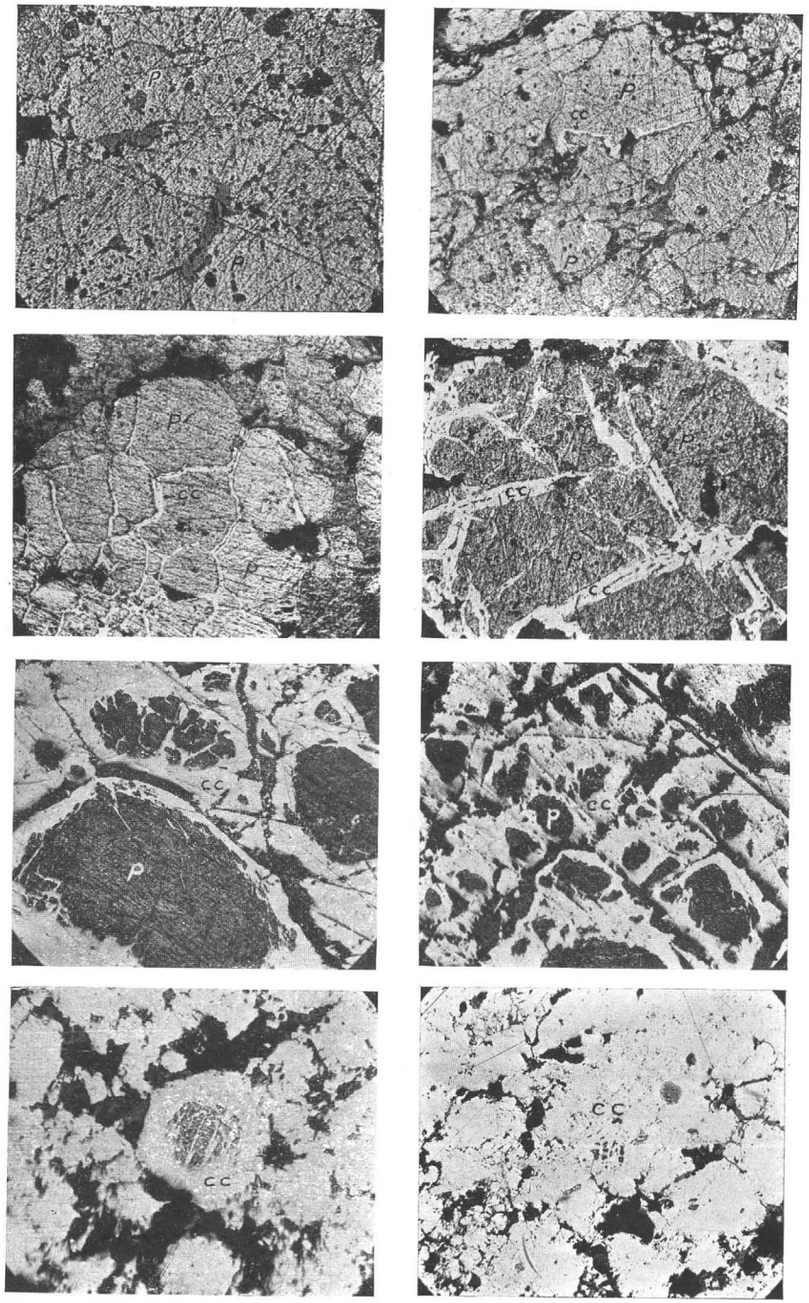

FIG. 19.—PHOTOMICROGRAPHS OF POLISHED SPECIMENS, ARRANGED TO SHOW PROGRESSIVE STAGES IN THE REPLACEMENT OF PYRITE (p) BY CHALCOCITE (cc). REFLECTED LIGHT. × 40.

in the vicinity of Tyrone, and in connection with the "islands" of granite to the south and east of Leopold.

The quartz porphyry is considered to be an earlier intrusion than the monzonite, since, while it is found in the granite, no occurrences have as yet been discovered where it cuts the monzonite. Furthermore, it is often mineralized. Its exact age is indeterminate, but the similarities in composition, structure, and texture between the quartz porphyry and the monzonite suggest the likelihood that the former did not precede the latter by a very long time, geologically, and that it was probably an earlier intrusion from the same magma.

4. *Quartz Monzonite*

Megascopic Characters.—The monzonites are extremely variable in texture. The most common phase about Tyrone and Leopold is a light-colored porphyritic rock of medium grain, containing abundant phenocrysts of white feldspar, and rarely a grain of quartz or biotite, in a dense whitish groundmass.

Some of the monzonite outcrops are of fine-grained porphyry rather than medium grained, and consist of a dense gray groundmass through which are sprinkled a few indistinct phenocrysts of feldspar.

Occasionally, however, there is found a phase which is almost granitic in texture. This contains an abundant whitish feldspar that shows striations and averages about 0.5 cm. in diameter, rather common grains of biotite which often show chloritization distinctly even in the hand specimen, some small grains of pinkish feldspar, and a little quartz which has the dull luster of an almost cryptocrystalline aggregate rather than the clear glassy luster of a single crystal. Whenever the texture of this rock tends toward porphyritic, the pink feldspar and the quartz make up the groundmass.

Different from any of these varieties is a rock which is found in narrow dikes in the granite in the northern part of the area. This rock is fine grained and dense, and wholly lacking in phenocrysts of any size. In the altered condition in which it is found, it is so quartzose and brittle in some occurrences that its resemblance to quartzite is marked. In other outcrops the quartzitic appearance may be less prominent, and at the opposite extreme are very dense phases which are so soft and smooth that they seem to be almost wholly lacking in quartz.

Microscopic Characters.—Under the microscope, the porphyritic varieties of the monzonite show large amounts of orthoclase and plagioclase, the latter, if anything, being slightly in excess. It does not predominate sufficiently, however, to change the identity of the rock. The plagioclase varies from oligoclase to andesine, the more basic phases being found to the south, away from the contact with the granite, which may

possibly be due to assimilation by the monzonite of blocks of the slightly more acid granite near the contact of the intrusive.

Quartz is present in practically all the monzonite, classifying it, therefore, as a quartz monzonite. It is very seldom present, however, in phenocrysts, but is rather to be found in small grains in the groundmass. Even when the texture of the monzonite is so coarse that it appears granitic in the hand specimen, the quartz is shown by the microscope to maintain its fine texture, filling in the interstices between the idiomorphic crystals of feldspar in the form of a fine aggregate, rather than in single grains that are nearly the same size as the feldspars. This feature is shown in Fig. 9 and is responsible for the rather dull luster of the

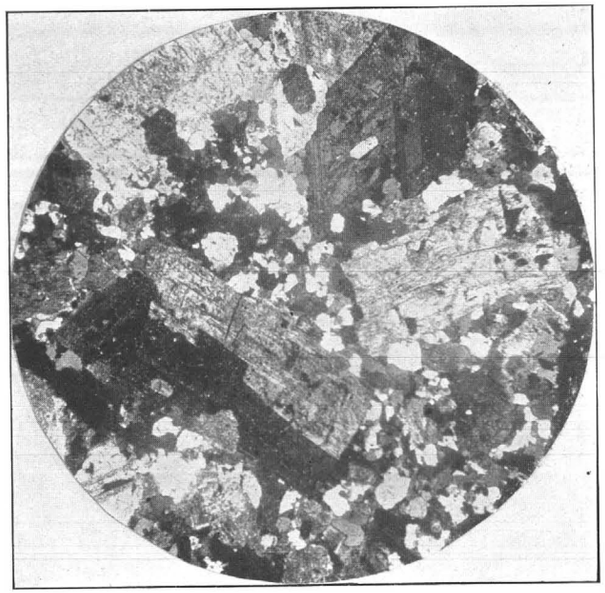

Fig. 9.—Quartz (Small Grains) and Feldspar in Monzonite. Crossed Nicols. × 20.

quartz as it shows in the hand specimen in these coarse varieties. It also furnishes a very good means of distinguishing the coarse monzonites from granite (Fig. 7).

The porphyritic monzonites contain apatite, zircon, and perhaps magnetite as common accessories. One section shows a small cluster of rutile needles.

The fine-grained dike rocks are found in thin section to be made up of quartz and secondary sericite (Fig. 10), no unaltered specimens having been obtainable. The phases which resemble quartzite in the hand specimen, show clearly in thin section an abundance of quartz in irregular

at Tyrone. The slips are much richer than this, but the poorer rock between brings down the value of the portion to be mined.

The chalcocite zone is irregular in thickness, with a maximum of 200 to 300 ft. It is found throughout the horizontal range of the mineralized area with the exception of one or two places where imperviousness of the rocks has caused a diffusion of the copper-bearing waters and consequent lack of a secondary zone.[13] About 175 ft. southeast of shaft No. 2 is an instance.

The zone of enrichment does not show a close relation to the present water table. At the time of the writer's visit, this level was at a depth of from 275 to 400 ft., with the Leopold orebodies to a considerable extent above the ground-water level; while at Tyrone large masses of chalcocite are both above and below it.

Taken as a whole, however, the secondary zone shows a very regular

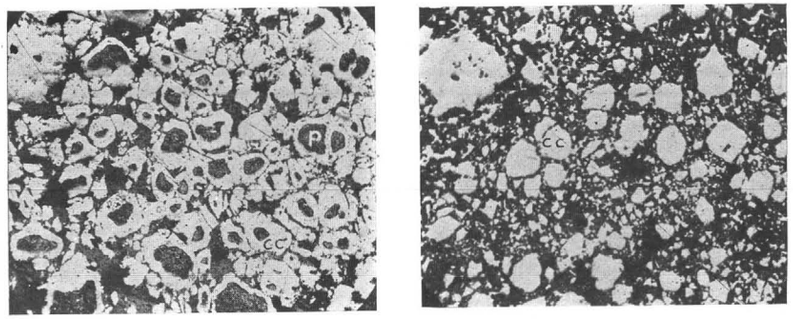

Fig. 18.—Replacement of Pyrite (p) by Chalcocite (cc). Outlines of Original Pyrite Grains Indicated by Hollows and Gangue Minerals, which Appear Black. Reflected Light. × 40.

arrangement in the matter of depth from the present surface. It is quite near to the surface in the southern part of the area, as, for example, at Leopold, but becomes gradually deeper toward the northeast. When the Sampson shaft was sunk, chalcocite was found within a very few feet of the surface, and even along the larger fissures oxidation has not extended very deep. At Tyrone, however, the secondary zone is found at a considerable depth, and leaching has gone as deep as 700 ft. in places. Observations at intermediate points prove a gradually increasing depth from Leopold to Tyrone.

This tendency of the secondary zone, and its lack of correspondence with the present water table are due to the changes which have taken place in the relief, and consequently the water level, of the district.

In Fig. 21 the heavy line represents a profile from the Big Burros to

[13] Penrose, R. A. F.: *Economic Geology*, vol. ix, No. 1, p. 20 (Jan., 1914); also Emmons, W. H.: *Bulletin No.* 529, *U. S. Geological Survey*, p. 20 (1913).

Enriched Zone.—Below the oxidized zone is a zone of secondary enrichment in which the mineral developed is chalcocite.

The chalcocite is metallic or dull in luster in most cases, though occasionally sooty where recent changes in water level have allowed oxidizing waters to come in contact with it and by partial solution convert the massive chalcocite into the porous, sooty form.[11] Although the ores have been thoroughly examined under the microscope by means of reflected light, no secondary copper sulphides, other than chalcocite, have been disclosed.

The chalcocite has been developed by replacement of primary pyrite, chalcopyrite, and sphalerite. Sphalerite is rare, but nevertheless, as shown in Fig. 17, it is easily replaced by chalcocite. Although this has not been as generally observed in the studies of other ore deposits as has the replacement of pyrite and chalcopyrite, it is not at all unknown, and is clearly shown in the Burro Mountain specimens.

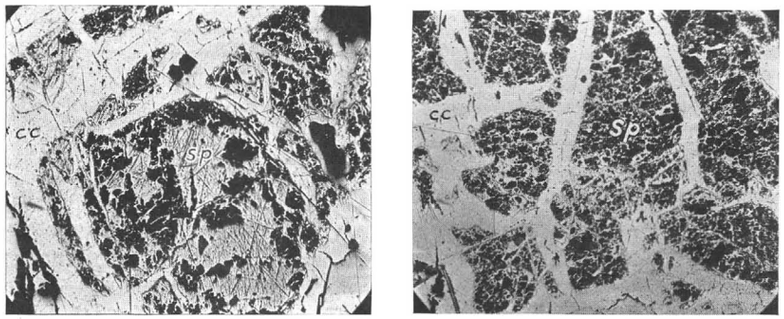

FIG. 17.—SPHALERITE (sp) BEING REPLACED BY CHALCOCITE (cc). BLACK SPOTS ARE PITS IN THE SURFACE. REFLECTED LIGHT. × 40.

A complete gradation may be observed, from the first formation of a film about the original sulphide grain, with a thin veinlet or two running through it, to the point where there is nothing left but an occasional small residual core in a matrix of chalcocite, which indicates with shadowy outlines the size and shape of the replaced pyrite grains (see Figs. 18 and 19). No sulphides intermediate between pyrite and chalcocite have been noted.[12]

Since it therefore occupies the position of the primary sulphides, the chalcocite is found in fissures and fractures intergrown with quartz, and in disseminated grains in the adjacent walls (see Fig. 20). The ore as it is blocked out will average about 2 per cent. at Leopold and 3 per cent.

[11] Sales, Reno H.: *Trans.*, xlvi, 49 (1913).

[12] Graton, L. C., and Murdoch, Joseph: The Sulphide Ores of Copper, *Trans.*, xlv, 40 (1913).

grains, together with many flakes of sericite. The quartz grains are intergrown with each other wherever they lie in contact. When they are not in contact, the spaces between them are filled with flakes of sericite, which form definite patches whenever the sericite is plentiful enough, and represent feldspars that have been altered. Quartz is relatively more abundant than the space occupied by the original feldspar, and even though some of it may be secondary, the rock as a whole was much more acid in character then the porphyritic monzonites.

The smoother phases are also made up of quartz and secondary sericite, but the patches of sericite are predominant and in extreme cases there is probably little or no primary quartz present. On the whole, their composition must have been more like that of the porphyritic monzonites.

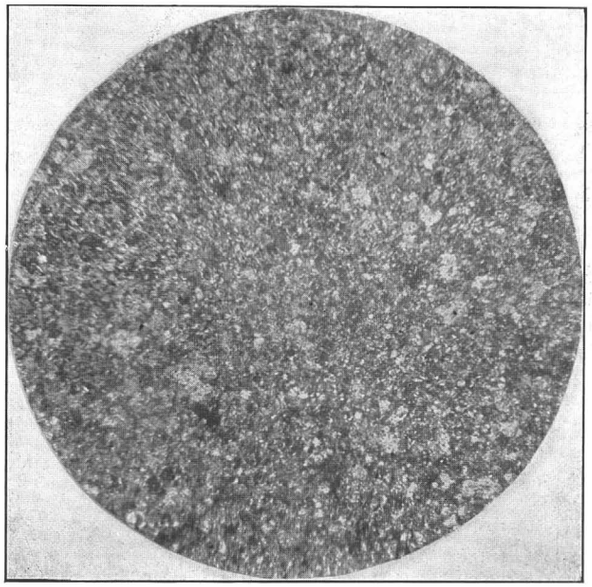

FIG. 10.—FINE-GRAINED MONZONITE. GRAINS OF QUARTZ AND FLAKES OF SERICITE. CROSSED NICOLS. × 50.

The texture of these dike rocks is exceedingly fine. In the quartzitic phases, about 0.13 mm. is the maximum diameter noted for a quartz grain, and the average piece of quartz is about 0.05 mm. in diameter. One section, with quartz very predominant, showed a flow structure, and an average size of grain of about 0.006 mm.

Structure, Distribution, and Age.—The quartz monzonite is the main intrusive in the granite. The exposure of it in the area mapped in Fig. 6 is, however, but a corner of the larger mass, which stretches away to the

southwest for about 6 miles, with an average width of about 3 miles. The intrusive nature of the monzonite mass is clearly shown by the dike-like character of some of its offshoots, the increasing fineness of texture in the monzonite as the contact is approached, and the slight baking which has been effected in the granite directly at the contact.

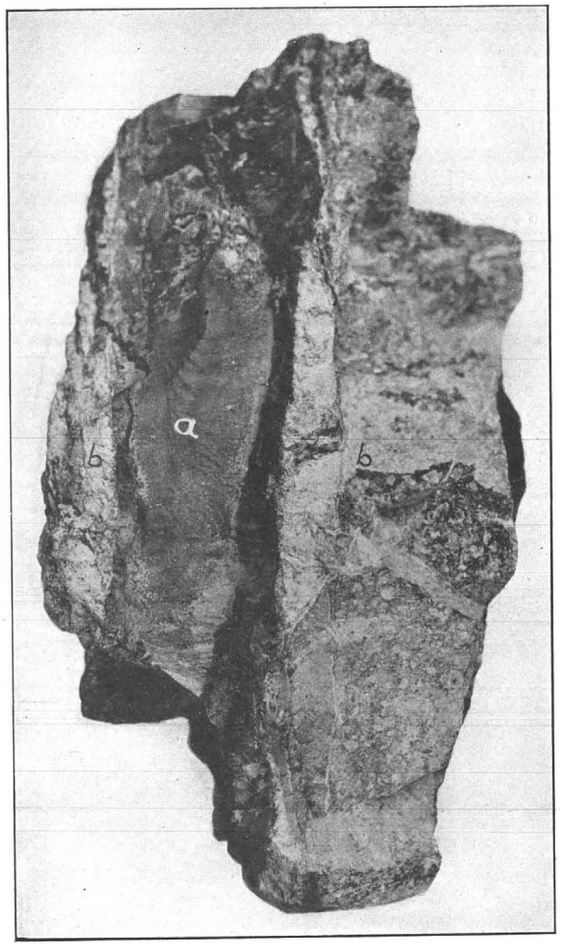

FIG. 11.—FINE-GRAINED MONZONITE DIKE (a) IN BADLY ALTERED QUARTZ PORPHYRY (b). NATURAL SIZE.

A part of the contact between the granite and this larger monzonite intrusion crosses the mineralized area (Fig. 6). It is characterized by tongues of the monzonite extending irregularly into the granite. Although the islands of granite about Leopold are mapped with rather

4. *Oxidation and Downward Enrichment*

The value of these deposits as a source of copper is due to the presence of a definite, though irregular, zone of secondary chalcocite of sufficient extent and richness to work.

Oxidized Zone.—Between the secondary chalcocite and the surface there is a zone of oxidation which is irregular in depth, and from which the copper has been very thoroughly leached over most of the area. The pyrite which formerly existed in the fractures and disseminations has been changed to limonite, and the rock itself has a bleached appearance.

The depth to which leaching has extended is extremely variable. The fissures are leached much deeper than the less pervious rock between them, indicating that the freedom with which surface waters may reach considerable depths is a big factor in determining the vertical distribution of the different zones. It is not at all uncommon to find the slips thoroughly leached while the disseminations in their walls are enriched.

Furthermore, steep fissures are apt to be leached deeper than the flat ones. It is occasionally found that where a flat slip crosses a steep one, the latter is leached, whereas the former is enriched, which the writer would attribute, not to any difference in age between the two, but rather to the fact that a steep fissure would allow freer and deeper circulation of surface waters than would a flat one, with consequent deeper leaching.

In a few places some copper remains in the oxidized zone. It is in the form of chrysocolla and malachite, with some azurite and rare occurrences of cuprite and native copper in very small amounts. Such is the case at shaft No. 1, at the Boston, St. Louis, and McKinley shafts, and at Copper Mountain, as well as in a few other scattered areas. With the possible exception of Copper Mountain, there is hardly enough oxidized copper at any place to be workable.

The occasional presence of copper minerals in the oxidized zone is probably due to the impermeability of the rocks in these localities, which has hindered a free downward circulation of meteoric waters, and thus forced the precipitation of copper within the zone of oxidation, chrysocolla having been the result to a much greater extent than malachite or azurite because of the scarcity of carbonic acid, and the presence of silica under conditions suited to the formation of the silicate.[10] The cause of this impermeability is not always clear. It may be due to the tightness of the original fracturing, or to an unusual amount of silicification. In a few cases it would appear that dikes of the more impermeable quartz porphyry have been responsible.

[10] Kemp, J. F.: Secondary Enrichment in Ore-Deposits of Copper, *Economic Geology*, vol. i, No. 1, pp. 24 to 25 (Oct.–Nov., 1905).

zonites, but with the quartz more subordinate the fractures are more evenly distributed through the rock.

Secondary quartz is often present with the pyrite, and thin sections show all stages of gradation, from the smallest fractures with only one or two grains in them to the more distinct veinlets, where the filling is a granular aggregate of quartz and pyrite.

The second class of disseminations, however, have been formed strictly by metasomatic substitution, and they appear under the microscope to be for the most part replacements of the feldspars (Fig. 15). Clearly

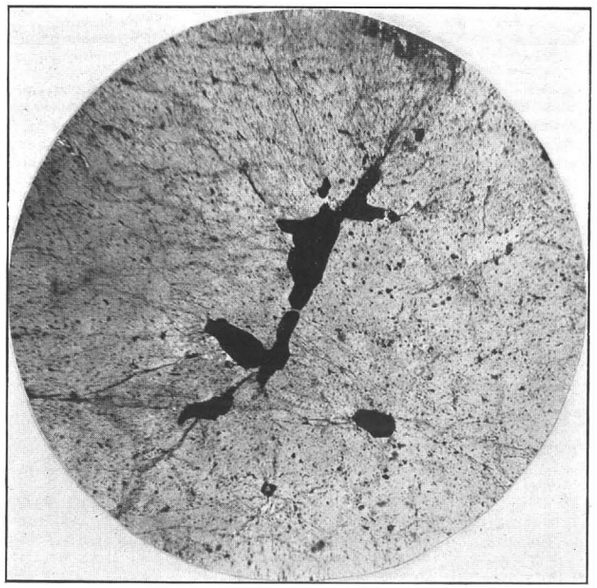

FIG. 16.—PYRITE (BLACK) REPLACING QUARTZ OF THE GRANITE. SHOWS FRACTURES THAT SERVED AS CHANNELS OF ACCESS. CROSSED NICOLS. × 50.

pefined cubes of pyrite are often developed, and some grains show a connection with small fractures which have served as channels of access.

Many grains show the characteristics of both types, in that they are fracture fillings extended by replacement. Each of these occasionally appears to replace the quartz as well as the feldspars (Fig. 16).

The disseminations are scattered through the walls of the fissures for varying distances, depending upon the openness of the fracturing and therefore the freedom with which circulating waters could penetrate the rock. The walls are usually more or less impregnated from one slip to the next, and therefore the actual distance can seldom be measured.

even contacts, it is probable that much more irregularity would be shown if the surface débris were sufficiently stripped to show bedrock. This is strongly suggested by such exposures as there are.

With the exception of the very fine-grained phase, the differently textured varieties of the monzonite show little regularity of distribution. The medium-grained porphyritic monzonite is the most abundant. A very coarse monzonite has been found in the Old Virginia shaft, about ½ mile east of Leopold. At a similar distance south of Leopold the coarse unmineralized phase of the main mass first begins to appear. As any contact with the granite is approached, the finer variety of the porphyritic monzonite is usually found.

The dikes of aphanitic texture, which are found cutting the granite in the northern part of the area, require separate consideration. While these also intrude the quartz porphyry (Fig. 11), they seldom, if ever, cut the porphyritic or granitic monzonites. The writer believes that they represent that part of the monzonite magma which intruded the granite country rock in small dikes, either at the time of the main intrusion, or perhaps soon after, probably accompanied more or less by water vapor, and hence much after the fashion of the aplitic intrusions of a granite batholith.[3] The name "aplite," however, is hardly applicable to all of these rocks. Many of them must, when fresh, have a composition very similar to that of the coarser monzonites, and they should therefore be called fine-grained monzonites. A few of the more quartzitic varieties may have the composition of true aplites, and they may be properly given the name aplite.

The age of the quartz monzonite is post-Cretaceous, as determined by Paige in his study of the Silver City quadrangle.[4]

5. *Volcanic Breccia*

Description.—This rock is a red porous clastic, consisting of fragments of varying sizes with 10 cm. as the maximum diameter. The fragments are quite angular and are composed mostly of red porous lava with occasional pieces of granite or monzonite. The breccia owes its red color to the fact that it is very thoroughly soaked with hematite and limonite which have been diffused by weathering of the lava fragments.

Structure, Distribution, and Age.—A few small outcrops of breccia are found about 1 mile south-southeast of Tyrone, near the road to the Savannah property. They are only a few feet thick and are the remnants of a formation which was once much more extensive than it is now. Other outcrops are to be found in the Little Burros. The outcrops observed to the south of the Mangas are stratified and have a north-east

[3] Daly, R. A.: *Igneous Rocks and Their Origin*, p. 368 (1914).
[4] *Bulletin* No. 470, *U. S. Geological Survey*, p. 133 (1911).

strike with a dip of 15° to the northwest. The pronounced red color in the vicinity is due to the large amount of iron oxides which the breccia contains.

The age of the breccia is presumably Tertiary.

6. *Gravels*

Description.—The gravels are made up of varying-sized fragments of all the older rocks of the district. The grains and pebbles are slightly rounded.

Structure, Distribution, and Age.—The gravels represent the débris worn from the other rocks of the area in Pleistocene and Recent times and washed into the valleys. Their distribution and rather angular form indicate their transportation and deposition by the few, but torrential, rains of an arid region, and this process is still going on.

They are sufficiently definite in form and composition to be a geologic formation, and they occupy the lower levels in the region, chiefly the Mangas Valley. Their southerly boundary is quite distinct and is shown on the map.

III. Economic Geology

1. *Introduction*

The copper of the Burro Mountains occurs in the mineral chalcocite, which has been produced by downward secondary enrichment. Chalcocite replaces primary pyrite, for the most part, and hence it is found, like the latter, as vein material, along with quartz, and as disseminated replacements in those portions of the rock bordering the fissures. The fractures, both large and small, which these minerals have filled, occur in a well-defined zone. Vertically, the three zones, of oxidation, downward secondary enrichment, and primary sulphides, are well marked, but their thicknesses and depths below the surface are very irregular.

2. *Mineralogy*

The primary vein and replacement minerals of the district are quartz, pyrite, chalcopyrite, and sphalerite. The secondary minerals resulting from (*a*) the processes of superficial alteration and downward enrichment are chrysocolla, malachite, azurite, cuprite, native copper, limonite, hematite, and chalcocite; (*b*) from hydrothermal action upon the rocks, sericite, chlorite, and epidote; and (*c*) from the action of descending meteoric waters on the rocks, kaolinite.

Quartz.—This mineral is not only present in the district as an original constituent of the igneous rocks, but it also occurs as a secondary mineral in three different forms, viz.:

Mineralization of the Fractures.—In these fractures, solutions have deposited quartz, pyrite, chalcopyrite, and sphalerite, and secondary processes have enriched portions of them to an extent sufficient to make their mining profitable. But in addition to the ore which is found in this multitude of fractures, there is an important amount found disseminated in their walls.

(2) *Disseminations.*—Primary pyrite has been deposited in the walls of the visible fractures in grains which range in size from exceedingly small particles up to those which are perhaps 5 mm. in diameter, with about 1 mm. as the average.

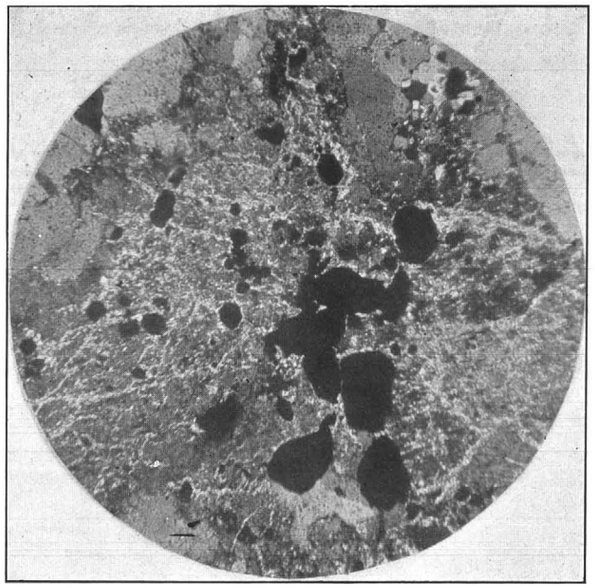

Fig. 15.—Pyrite (black) Replacing Sericitized Feldspar. Light Streaks are Sericite. Quartz Grains around the Edges. Crossed Nicols. × 50.

Upon examination of thin sections of the ores, it is found that these grains were deposited in two ways: (1) as filling of minute open spaces; and (2) as metasomatic replacements.

The former occupy the irregular fracture spaces of microscopic size that exist in the rocks, and are of course similar in mode of origin to the more evident open-space fillings, the distinction between them being simply an arbitrary difference in size.

These micro-fractures develop commonly between the mineral grains, and also throughout the feldspars, as in the case of the granites, but to a much less degree in the quartz. The same is true in the mon-

A diagrammatic cross-section of such an area is shown in Fig. 14. In the first place, the fractures along both sides of the area would not be vertical, but would dip toward each other, since caving involves an area of surface larger than that of the cavity into which the rocks have fallen. In mining operations it has been found that in hard rocks the outermost fractures dip at angles of from 60° to 75°, and these correspond with the angles of dip noted in the vicinity of Leopold and Tyrone. The central fractures would show more nearly vertical dips.

While the majority of the larger fissures might dip as described above, there would, nevertheless, be many cross fractures and fracture zones, which would break the rock into blocks, especially in the center of the caved area. Along the edges the tendency might be to develop fissures in a single direction, but toward the center a generally broken condition

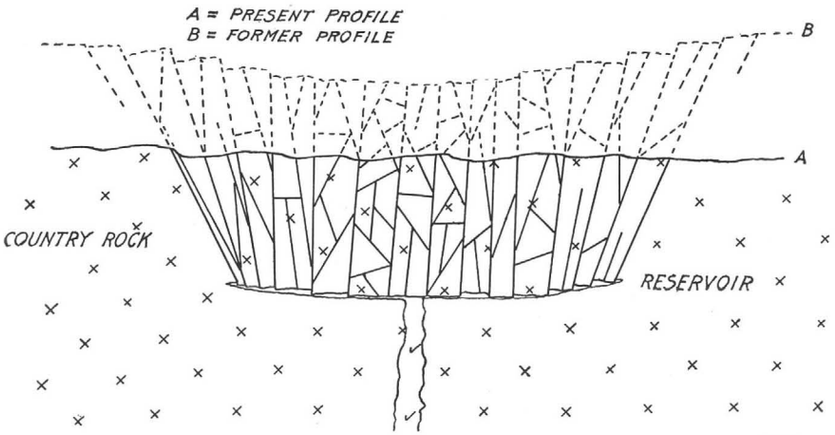

Fig. 14.—Diagrammatic Cross-Section of Fractured Zone.

of the rocks, with more fractures, and more directions of fracture, would be produced.

Furthermore, innumerable smaller fractures would be developed, increasing in number with greater brittleness of the rock, until in extreme cases a breccia might result. This is the explanation of the breccia found at Tyrone, and the brittle rock is the granite, while in the tougher monzonite breccias are seldom, if ever, found.

Finally, the actual caving would consist of a settling of the blocks formed by these breaks and a readjustment to the new conditions, which would cause a small amount of displacement along nearly all the fissures, without relatively great movement in any case. And while all the fractures would not be of exactly the same age, on the other hand, no consistent differences in age between different systems of fractures would be expected.

(1) As a gangue mineral of the ores, where it is found in crystalline grains of moderate or small size in fractures, or saturating the country rock (Figs. 23 and 24). In this form it is either glassy or milky white, is found throughout the area, and has been deposited from ascending solutions.

(2) As a precipitate, separated out during the sericitization of the feldspars. This variety is not very abundant and is much less distinct than gangue quartz, but may occasionally be noted in thin section.

(3) As a weathering product, descending meteoric waters having reworked the earlier quartz more or less, and in some cases left it deposited in the upper portions of veins, as a crypto-crystalline aggregate, or chalcedony. This is often stained deep red with hematite, and in such condition may resemble jasper. It is found in the northern part of the district. The presence of hematite instead of limonite is interesting and corresponds with the observations of Emmons[5] and others that hematite is apt to be the ultimate result of oxidation in place of a hydrous oxide, where the climate is arid.

Pyrite.—Pyrite is by far the most abundant primary sulphide of the district, and together with quartz makes up practically all of the original vein and replacement material. It is usually granular, and crystal faces or outlines are not very commonly seen. It is found throughout the mineralized area.

Chalcopyrite.—This mineral is distributed widely in the district but in very small amounts, and in such minute specks that it cannot, as a rule, be seen in the hand specimen, but its presence can be detected by microscopic examination of polished sections (Fig. 22). It may occur in pyrite or in quartz gangue, and is undoubtedly an original mineral. It appears to be very unevenly distributed.

Sphalerite.—Sphalerite was found in very few of the many specimens examined, and seems to be extremely rare, but, like chalcopyrite, it is present in such minute grains that its existence can seldom be noted except with the microscope (Fig. 17). There seems to be no doubt that it is of primary character, occurring with the pyrite and chalcopyrite.

Chrysocolla.—This hydrous copper silicate is the most abundant oxidized copper mineral found in the camp, and is chiefly responsible for the blue color of the outcrops at Copper Mountain, as well as at the Boston, No. 1, St. Louis, and McKinley shafts, etc. It not only occurs scattered irregularly through the surface portions of the rocks, but also may be found in small, clean-cut veins that are made up wholly of this mineral (Fig. 13). These are too free from quartz to represent former veins that have been changed to chrysocolla, but are probably later fractures in which solutions have deposited the hydrous copper silicate.

[5] Emmons, S. F.: Los Pilares Mine, Nacozari, Mexico, *Economic Geology*, vol. i, No. 7, p. 633 (July-Aug., 1906).

The chrysocolla is colored various shades of blue and bluish green when pure.

A black, pitchy material is occasionally associated with the blue-green varieties of chrysocolla, as, for example, in the large fissure about ⅓ mile southwest of Leopold. This contains manganese, and is probably copper pitch, or the German *Kupferpecherz*, a variety of chrysocolla stained brown or black with manganese oxide, which is well known at Globe.[6] It is deeper black in color than much of the material from Globe.

Malachite.—Malachite is occasionally found in the district, though not in any abundance. At Copper Mountain it occurs in veinlets and coatings more or less intermixed with chrysocolla. It is fibrous, but the fibers are seldom more than 2 mm. in length.

Azurite.—Deep blue azurite occurs in very small quantities at Copper Mountain, but is rarely seen in any other part of the district. On the whole it is much more uncommon even than malachite. It is in small, irregular vein-like masses, and usually shows a thin streak of malachite running through the center of it.

Cuprite.—This mineral has been reported from the district,[7] but did not come under the observation of the present writer.

Native Copper.—A few very small flakes of native copper have been found in monzonite in the Niagara tunnel about 3,000 ft. from the portal. They occur in very small and irregular fractures, and are usually accompanied by a red powdery hematite.

Limonite.—Limonite is very abundant as a surface stain and a filling of fracture spaces in the zone of oxidation. It is found throughout the mineralized area with the exception of a few localities where the oxidized form of the iron is hematite, and its quantity varies directly with the intensity of the primary pyritic mineralization. It shows a pronounced tendency to leach out on to the surface of the outcrops and talus fragments, thereby covering the surface with a thin brown film and giving the district its consistently rusty appearance.

Hematite.—In the northern part of the area, hematite seems to take the place of limonite to some extent in surface outcrops. It is red and finely divided and occurs either as a powdery material, or disseminated as a coloring matter in quartz. It is also found in considerable quantity in the volcanic breccia in the northeastern part of the district.

Chalcocite.—As at Butte, both massive and sooty varieties have been found in the Burro Mountains.[8] No crystals, however, have been

[6] Ransome, F. L.: Geology of the Globe Copper District, Ariz., *Professional Paper No.* 12, *U. S. Geological Survey*, p. 123 (1903).

[7] Lindgren, Graton and Gordon: Ore Deposits of New Mexico, *Professional Paper No.* 68, *U. S. Geological Survey*, p. 322 (1910).

[8] Sales, Reno H.: Ore Deposits at Butte, Mont., *Trans.*, xlvi, 49 (1913).

tion of an inch in width. They have no regularity in direction or length. Their abundance depends on the brittleness of the rocks, and while in most of the monzonites they appear simply as frequent hair-like cracks, in the brittle granite they are much more abundant, and sometimes have developed to such an extent that breccias are the result. The breccia fragments vary in size up to about 1 ft. for the largest dimension, and may be found in small masses or in large bodies of lens-like form several hundred feet in length. That the brecciation is due to the brittleness of the granite is well shown by the fact that dikes of monzonite passing through a mass of breccia, though affected by the same stresses, are not fractured to the extent of brecciation.

Brecciation has caused at least one very important orebody in the district, which has been opened up between the 300 and 400 ft. levels in the shaft No. 3 workings. In addition to this occurrence breccia is found at one or two other points underground, and also at several places on the surface.

Origin of the Fractures.—While at best only a speculation, nevertheless it may be worth while to formulate a theory for the origin of these fractures.

They could not have been caused by contraction of the monzonite on cooling, since they are found only along a small portion of the monzonite mass.

They may possibly belong to a shear zone, but this seems rather improbable, for two reasons. In the first place, a shear zone of such great width and length would be expected to show much greater evidences of displacement than are found in the Leopold-Tyrone area. In the second place, it is very difficult to imagine a closed shear zone in which the fractures in each half dip toward the center. A fairly consistent dip in one direction would be expected.

The writer believes that this fracture zone can be explained by assuming a caving of the surface due to the extrusion of molten material from immediately beneath. There has been igneous activity all about this district in fairly recent times, and especially later than the monzonite there has been the intrusion of stocks of rhyolite which are found directly across the Mangas Valley from the fractured area.[9] The fracturing was caused by the movement of this rhyolite, and probably commenced some time before the rhyolite became solidified in its present position. It continued, however, after the solidification of the rhyolite, since a few fractures are found in the latter, and their northeast strikes indicate that they are continuations of the fractures to the south of the Mangas.

With this hypothesis as a basis, the characteristic features of the fractured area can be readily accounted for.

[9] Paige, Sidney: *Bulletin No.* 470, *U. S. Geological Survey*, p. 133 and map (1911).

the different directional systems of fractures are impossible. No one system is distinctly older or younger than another.

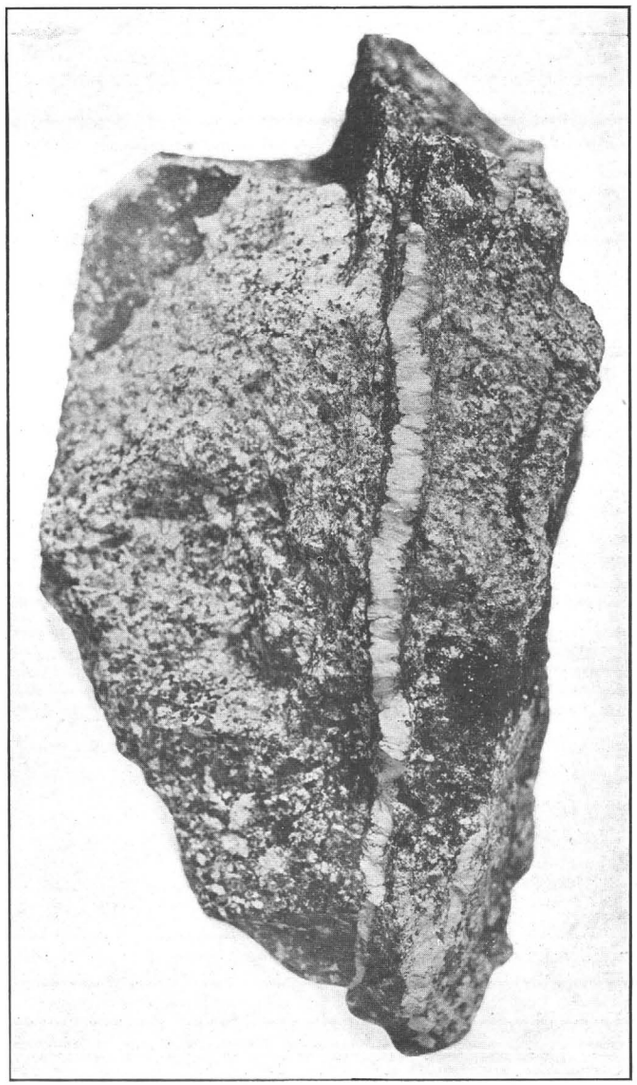

FIG. 13.—VEIN OF PURE CHRYSOCOLLA IN MONZONITE. NATURAL SIZE.

Smaller Fractures and Breccia.—Besides these larger breaks with their more or less consistent strikes and dips, there are very many small fractures, never more than a few inches in length, and often the merest frac-

noted. The massive chalcocite is dark steel gray in color, and very homogeneous. It is by far the more common. The porous, sooty variety is occasionally seen where the massive chalcocite has been affected by meteoric waters in the upper parts of the chalcocite zone. Chalcocite shows well in polished sections (see Figs. 17 to 19). Its distribution is one of the main considerations of the district and will therefore be taken up under a later heading.

Sericite, Chlorite, and Epidote.—As will be discussed below, sericite, chlorite, and epidote have been developed by hydrothermal action upon the feldspars and ferro-magnesian minerals in the country rocks. The first is very abundant, the second rather uncommon, and the third rare.

Kaolinite.—Kaolinite has been formed from the non-metallic minerals of the rocks by meteoric waters, as will be noted in a later portion of this paper.

3. *Occurrence of the Ores*

The ores occur in two forms: (1) as the filling of open spaces, such as fissures of varying size and the interspaces of breccia; and (2) as disseminated grains in the walls adjacent to these open spaces.

(1) *Filling of Open Spaces.*—The district is characterized by a rather well-marked zone of fracturing, the surface outcrop of which is roughly triangular in form, with its apex toward the southwest, its sides on the west and southeast (see map, Fig. 6). Within this triangular area there are fractures of all sizes, from fissures that are prominent both on the surface and underground, to minute breaks that are visible only under the microscope. The fractured zone lies partly in granite and partly in monzonite, and shows some rather definite characteristics.

Larger Fractures.—The larger fractures, or "slips," as they are called in the Burro Mountains, which vary from a fraction of an inch to a foot or more in width, are usually rather straight, and approximately parallel to each other over small areas. Their spacing varies from several inches to a few feet, and the dips are mostly steep.

The larger slips are often quite continuous and sometimes a single fissure may be followed for a considerable distance either on the surface or in the underground workings. More often, however, there appears to be a zone made up of two or more of these strong fractures accompanied by the usual large number of smaller breaks, and this zone may persist for 1 or 2 miles.

The slips at shaft No. 1 are good examples of large persistent fractures and all along the western side of the fractured area from this shaft to Copper Mountain the fissures form a well-marked, though somewhat irregular, zone. About ½ mile southwest of Leopold there is a strong slip which is part of a zone that can be traced for nearly a mile across the country in a direction about 10° north of east. Likewise the southern-

most fissure plotted on the map is a part of a distinct zone extending to the northeast, and readily traceable on the surface from one end to the other.

It is an important fact, however, that only along the sides of the area do we find fissures or fracture zones of one general strike, with comparatively few and unimportant cross fractures. In the center of the area, as, for example, around Leopold and Tyrone, there are several fracture zones, which cross each other at various angles. These fissures are fully as strong as those along the boundaries, but not quite as persistent. Furthermore, some of them are not as straight, such as the so-called "St. Louis slip," for instance, which is shown at the St. Louis shaft. Southward from the shaft it has a general northeasterly strike, but on the north it curves until it has an easterly strike, which it holds until it has crossed the gulch in which Leopold is situated, when it turns back to a northeasterly trend. The most important direction of cross fracturing is roughly north and south, as for example in the immediate vicinity of Leopold; and again, near the Niagara and Boston shafts. The broad result of the fracturing, then, seems to have been a generally broken condition along the center of the area grading into a few consistent fissures along the sides. The latter do not cease abruptly as the distance from the center increases, but gradually diminish in size and number until solid rock is reached.

Two important structural characteristics of the fractured zone are defined by the larger fractures. In the first place, there is an apparent convergence of many of the slips toward an imaginary point about 2 miles southwest of Leopold. This may be noted on the map and is most pronounced toward the lateral boundaries of the area, where cross fracturing is uncommon. It is less marked in the center, where fissures of several systems are present, but even there it appears to be a strong tendency. On the north and northeast the gravels cover the continuation of the fissures, and thereby conceal their structure in that direction. At the eastern corner of the fractured zone, however, the fractures seem to be branching and fraying out, and it is quite likely that this structure is continued to the north.

Another noteworthy tendency is in the directions of dip taken by many of the slips. If the angle which the fractures make by their convergence be bisected, most of the fissures in the western half that are not vertical dip toward the east and southeast, while those in the southeast half show a tendency to dip to the northwest. This, of course, refers to the majority, but nevertheless the exceptions are comparatively few.

It is seldom possible to say whether or not there has been movement along the fractures. Since the rocks are massive, the displacement of strata cannot be used as a criterion, and recourse must be had to the less often observed evidences of displacement of dikes and cross fractures,

presence of gouge, and slickensides. Most of the fractures show none of these, and there is no indication of a big fault such as might cut off an entire rock formation, or leave a marked escarpment on the surface. On the other hand, some faulting is undoubtedly present. Slickensides are occasionally seen, a good example being in an outcrop on the road just south of Tyrone. Gouge may be found in a few slips, the St. Louis for instance. Small displacements of fissures may be observed, as in one of the Leopold orebodies, where such movements were noted as a 1-in.

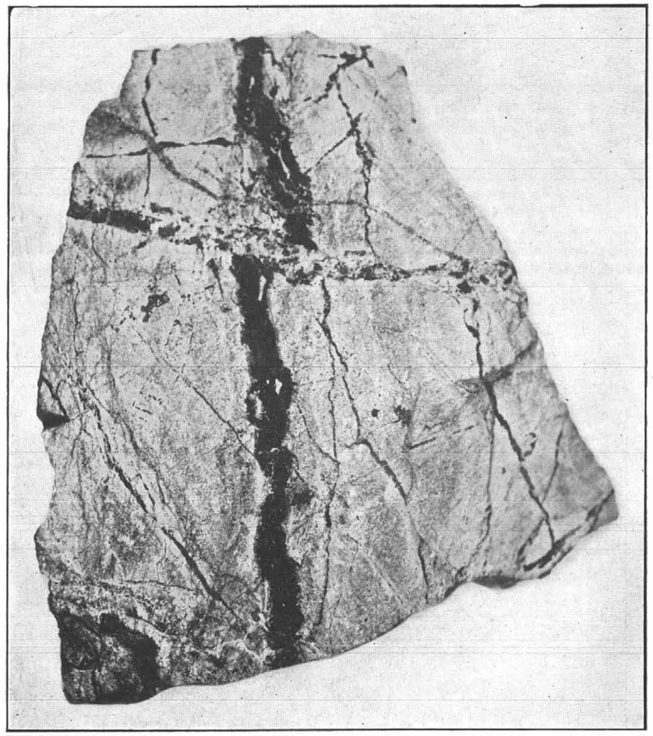

Fig. 12.—Limonite-Filled Veinlet in Fine-Grained Monzonite, Showing Small Displacement. Natural Size.

fissure displaced 6 in. Very small displacements are shown in hand specimens from shaft No. 1 (Fig. 12). The evidence, therefore, points to the existence of small and irregular faults, perhaps in abundance, with big movements very doubtful and as yet unproved in any given instance.

Another question is in regard to the relative ages of fissures of different strikes. That some of the fractures are younger than others is clear in many instances. The small displacements noted above are cases in point. In the writer's opinion, however, generalizations regarding

Notes from E. Gillerman, 1967: STRUCTURAL FRAMEIRK AND CHARACTER OF MINERALIZATION, BURRO MTS.,N.M. Econ.Geol.vol. 62,370-375

370. Precambian: Main rovk in NW Big Burro Mts. and flanks is granite, inprusive into matased.and metaigneous schists,amphibilites, gneisses and quartzite. Scarce in the mts.but crop out to SW,NW. Tyrone stock intrudes
571 the granite in NE part of Big Burro Mts.;slight elongation NE. 4 x 5 mi. Mainly QM.

572 Structuarl Frameowrk: Big Burro Mts . are structurally high,lying between the NW Mangas fault on the N and a graben on the SW. Within the block, 5 major NE faults.Austin-Amazon, bounding Tyrone stock on NW, and Spouse-Copeland,bounding it on the SE,are the most imprtant. Faults are wide complex zones. Tyrone stock lines within the central Tyrone-Burro Peak block.NW and SE bou ndaries thought fault-controlled. Cetral block is a horst,upthrown with reference to the block on the NW and that on the SE.

Roof lendants of meta rocks are preserved in the block to the NW and SE,but are lacking in the Tyrone-Burro Peak block. Rocks here represent a deeper part of the batholith,the upper portions of which have been removed due to the uplift. Apical part of stockalso removed. Central block was tilted NE in Late Tertiary. This tilting probably inckuded much of the Burro Mts.Uplifting of the Tyrone-Burro Peak block predeated the tilting.
373 An oxidized and a supergene enriched zone had been formed in the mineralized area in the NE part of this block prior to tilting;the roof rocks and apical portion of the stock had been at least partly removed by erosion.

Mineralization: 2 period of primary mineralization.(1) Late K or early Tertiary;(2) Late Tertiary. (1) is post QM,pre-late Tertiary volc.(2) is post Late Tertiary volcanism. (1),base metal,with silver,probably some gold. (2) fluorspar deposits,probably some gold. Discussion below limited to (1).

Central Tyrone-Burro Peak block includes Tyrone copper ore body and adjacent deposits. Tyrone fistrict,copper pervasie in an intensely fractured area in granite and in QM. Away from tje central area,mineralization confined to individual fractures,fracture zones. More intensely mineralized areas have NE elongation. Ccpy,py only primary metallic minerals,except for minute specks of ZnS and moly seen in some ores. Gangue, qtz and CR.

In White Signal block to SE,most deposits in filled fractures along faults in the granite or in association with numerous dikes. Types of veins: qtz-pyrite,qtz-specularite, high-silver and lead -silver veins. Minerals in veins in this block include gold,silver minerals,ccpy,PbS, specularite,magneite, Bi minerals,barite, ZnS -. All produced commercially except ZnS.

Willos Creek block to NE: deposits in major fracture zones in granite, mainly in the 2 major faults here (NE). Au, ccpy,py, Ag and Bi minerals, ZnS, moly.All but last mined.

374. ~~Author belief that~~ Simple ccpy-py in central blcok with pepvasive alteration, Base metal except Cu, bismuth, precious metals,barite,carbonate gangue minerals all lacking. Higher T indicated by the ccpy;deeper burial with fewer open fractures indicated by distribition of ore minerals and manner of mplacement. Spacial associaiion and concentration of copper depositd at Tyrone in the area~~s~~ of the stock suggests a genetic assoviation between the stock and emplacement of ccpy in a central area of higher T. This, combined with the encircling position of the other mineral deposits with reference to the Cu deposit suggests horizontal zoning. Author rejects this,and claims difference in mineralization due to verticsl zonattion and differential uplift of the blocks betwen their bounding faults. Central horst exhibits rocks once at deeper horizons than in adjoining blocks. Mineral deposits now exposed in this block were originally amplaced at greater depth than those exposed in the other blocks. Tyrone Cu exmplaced at great depth;varied mineralization of other blocks emplaced nearer the then surface. Deposits of Pb,Zn precious metals may have existed above the ccpy deposit. If somrenoved by erosion as block uplifted.

375: At Tyrone, rotts of ofe body exposed;elsewhere,the tops are still present.

E.W.:Looks fishy to me. The Osmer and Bismuth Foster Beaumont fault in the NW bock are definetly premineral,for the minerals are concentrated along them. If the faults bounding the central block are included in the general distiption of the NE faults,then these are probably premineral : 372 these are "... zones up to 100 feet wide that consist of innumerable parallel and en echelon fractures,intertwing dikes and segments of dikes, bracciated areas,gouge zones,silicified and argillized areas,and concentrations of minerals.The silicified zones result in topographically prominent outcrops along the trace of the faults." The Copeland mine lies along the Sprouse Copeland fault.

It is doubtful whether the NW and SE borders of the stock are fault contacts.The NW contact is dashed (fault) with a ? A segment of QM lies SE of the Sprouse Copeland fault,meaning that it reached the elevation of t e SE block,supposedly much closer to the mineralization surface.

How do you measure displacement on faults in granite? P.373: Copper mineralization pervasive in an intensely fractured area in granite & QM. 374: Deeper burial of the copper ore body indicated by fewer open fractures.

Looks like perfect~~s~~ example of horizntal zoning-Bingham type.The QM would be a central hot spot.

At any rate, as author~~s~~ says, Big Burro Mts.with their Precambrian rovks form a structural high. Most copper stocks are hypabyssal.

process water from the dam to the plant.

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SOCIETY OF

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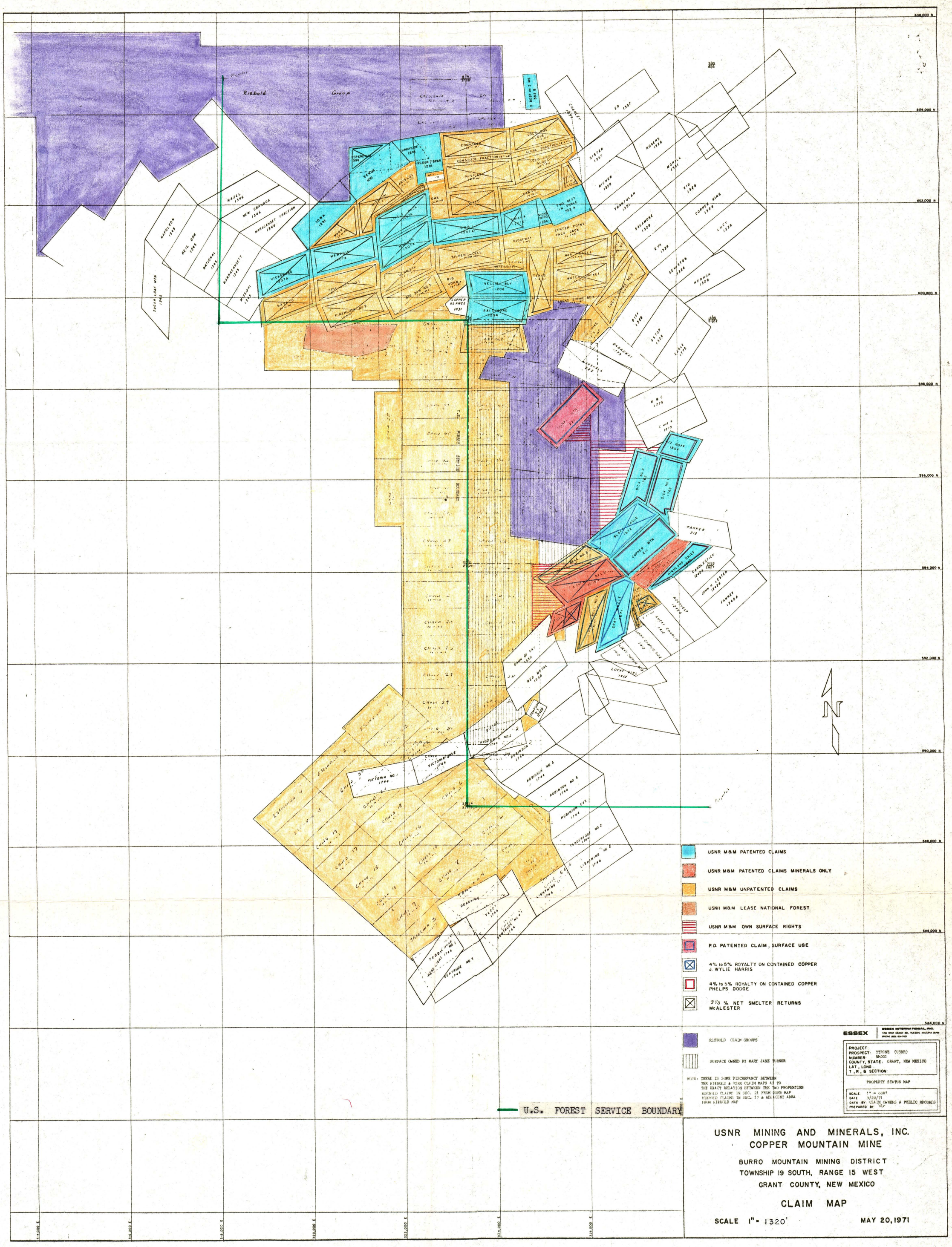
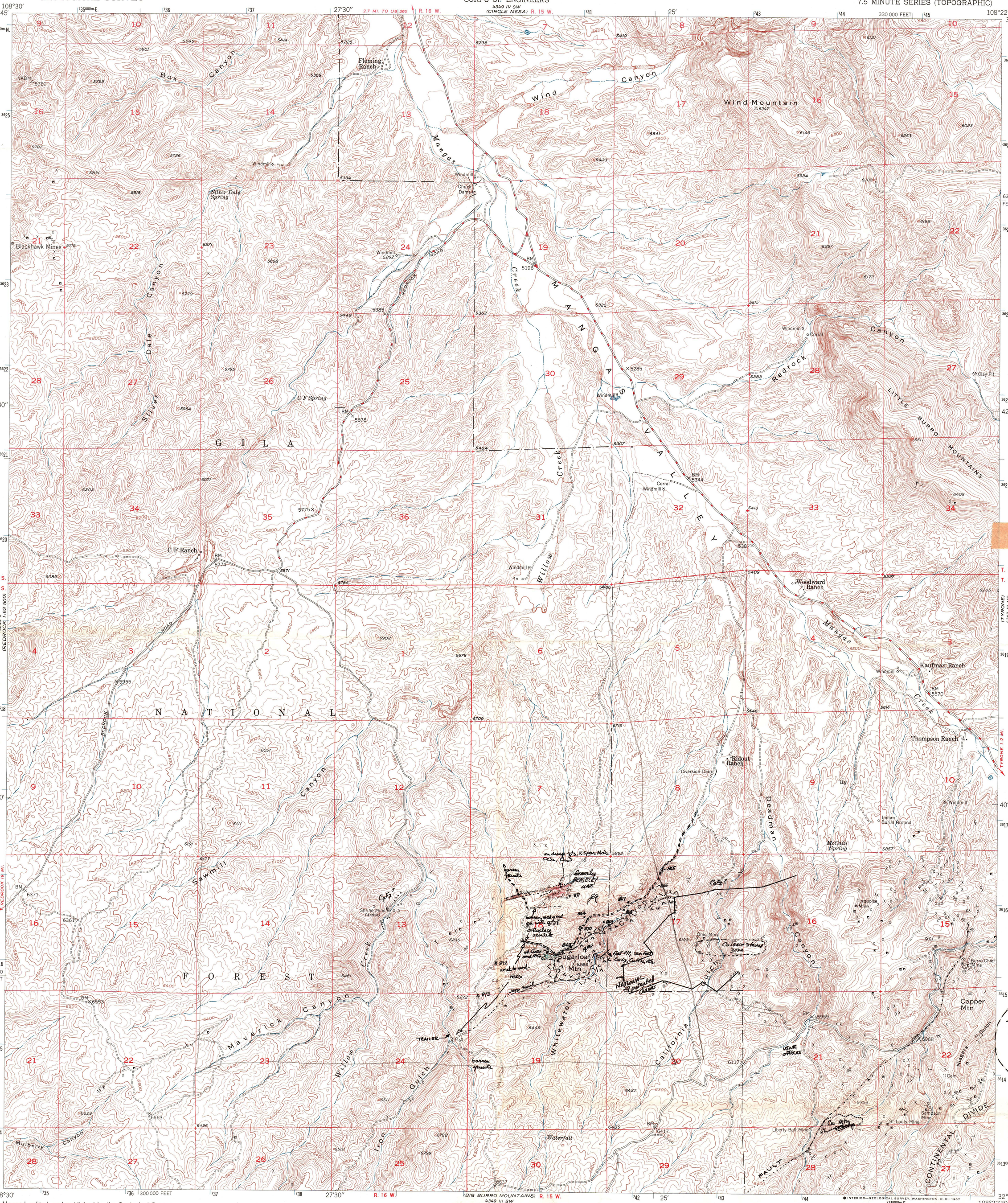

Riebold Group
U.S. FOREST SERVICE BOUNDARY
USNR M&M PATENTED CLAIMS
USNR M&M PATENTED CLAIMS MINERALS ONLY
USNR M&M UNPATENTED CLAIMS
USNR M&M LEASE NATIONAL FOREST
USNR M&M OWN SURFACE RIGHTS
P.D. PATENTED CLAIM, SURFACE USE
4% to 5% ROYALTY ON CONTAINED COPPER J. WYLIE HARRIS
4% to 5% ROYALTY ON CONTAINED COPPER PHELPS DODGE
3 1/3 % NET SMELTER RETURNS McALESTER
RIEBOLD CLAIM GROUPS
SURFACE OWNED BY MARY JANE TURNER
NOTE: THERE IS SOME DISCREPANCY BETWEEN THE RIEBOLD & USNR CLAIM MAPS AS TO THE EXACT RELATION BETWEEN THE TWO PROPERTIES RIEBOLD CLAIMS IN SEC. 21 FROM USNR MAP RIEBOLD CLAIMS IN SEC. 17 & ADJACENT AREA FROM RIEBOLD MAP
ESSEX
ESSEX INTERNATIONAL, INC.
PROJECT
PROSPECT: TYRONE (USNR)
NUMBER: M4001
COUNTY, STATE: GRANT, NEW MEXICO
LAT, LONG
T, R, & SECTION
PROPERTY STATUS MAP
SCALE 1" = 600'
DATE 9/20/71
DATA BY: CLAIM OWNERS & PUBLIC RECORDS
PREPARED BY: DLF
USNR MINING AND MINERALS, INC.
COPPER MOUNTAIN MINE
BURRO MOUNTAIN MINING DISTRICT
TOWNSHIP 19 SOUTH, RANGE 15 WEST
GRANT COUNTY, NEW MEXICO
CLAIM MAP
SCALE 1" = 1320'
MAY 20, 1971

PROPERTY

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

UNITED STATES
DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS

WIND MOUNTAIN QUADRANGLE
NEW MEXICO-GRANT CO.
7.5 MINUTE SERIES (TOPOGRAPHIC)



Mapped, edited, and published by the Geological Survey

Control by USGS and USC&GS

Topography from aerial photographs by multiplex methods
Aerial photographs taken November 1945. Field check, 1950

Polyconic projection. 1927 North American datum
10,000-foot grid based on New Mexico coordinate system, west zone

All mines are inactive unless otherwise indicated

1000-meter Universal Transverse Mercator grid ticks, zone 12, shown in blue

UTM GRID AND 1950 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET
(GN, MN; 1°23' 25 MILS; 13° 231 MILS)

SCALE 1:24 000

CONTOUR INTERVAL 20 FEET
DATUM IS MEAN SEA LEVEL

OPHR CLAIMS in sections
17, 18, 19, 20
96 unpatented claims
13 patented

ROAD CLASSIFICATION

HARD-SURFACE ALL WEATHER ROADS		DRY WEATHER ROADS
Heavy-duty	4 LANE / 2 LANE	Improved dirt
Medium-duty	4 LANE / 2 LANE	Unimproved dirt

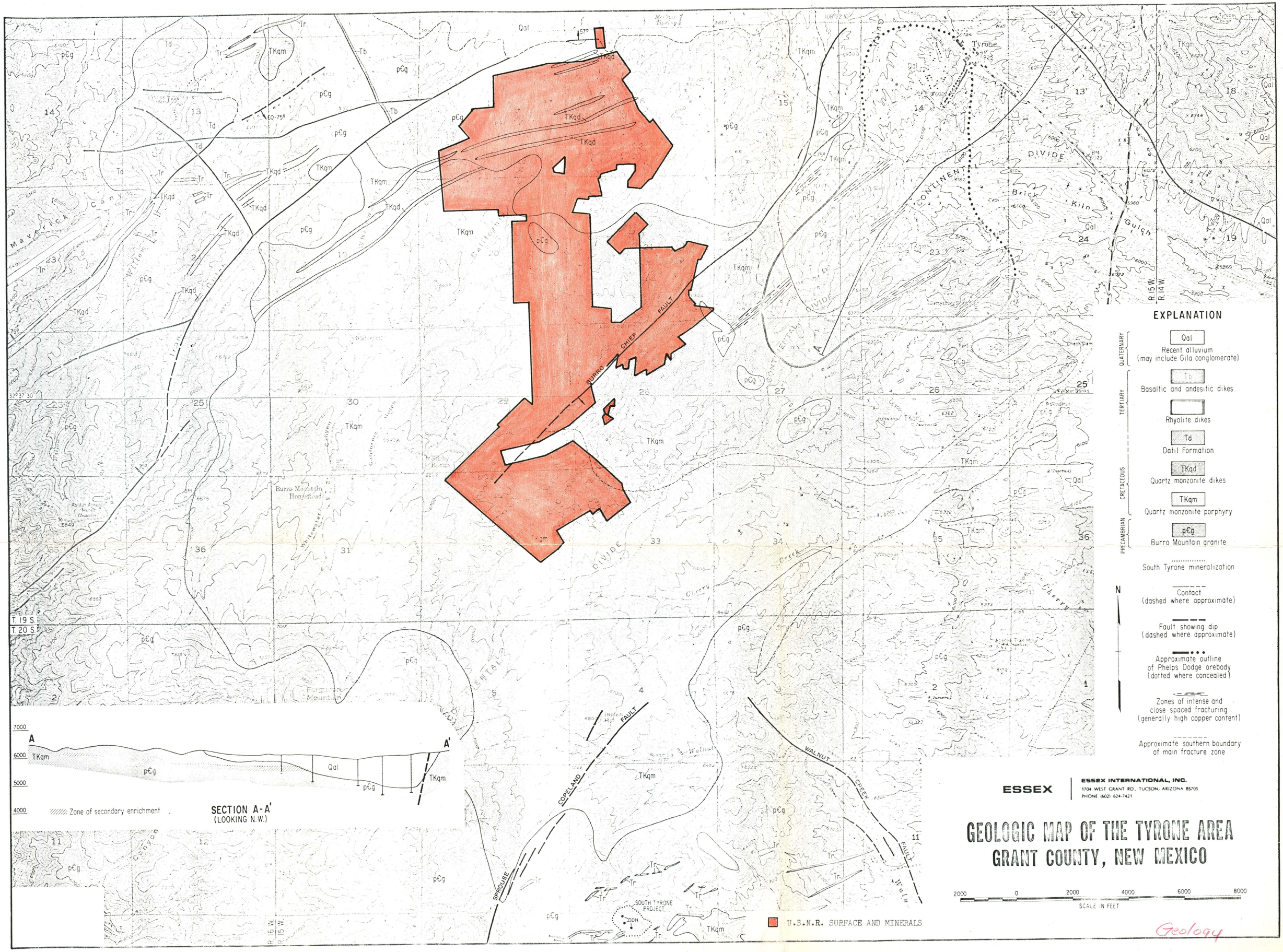
Loose-surface, graded, or narrow hard-surface

U. S. Route — State Route

THIS MAP COMPLIES WITH NATIONAL MAP ACCURACY STANDARDS
FOR SALE BY U. S. GEOLOGICAL SURVEY, DENVER, COLORADO 80225 OR WASHINGTON, D. C. 20242
A FOLDER DESCRIBING TOPOGRAPHIC MAPS AND SYMBOLS IS AVAILABLE ON REQUEST

WIND MOUNTAIN, N. MEX.
N3237.5—W10822.5/7.5
1950
AMS 4349 III NW—SERIES V881

INTERIOR—GEOLOGICAL SURVEY, WASHINGTON, D. C.—1967


EXPLANATION
QUATERNARY
Qal
Recent alluvium
(may include Gila conglomerate)
TERTIARY
Tb
Basaltic and andesitic dikes
Rhyolite dikes
Td
Datil Formation
CRETACEOUS
TKqd
Quartz monzonite dikes
TKqm
Quartz monzonite porphyry
PRECAMBRIAN
p€g
Burro Mountain granite
South Tyrone mineralization
Contact
(dashed where approximate)
Fault showing dip
(dashed where approximate)
Approximate outline
of Phelps Dodge orebody
(dotted where concealed)
Zones of intense and
close spaced fracturing
(generally high copper content)
Approximate southern boundary
of main fracture zone
N
ESSEX
ESSEX INTERNATIONAL, INC.
1704 WEST GRANT RD., TUCSON, ARIZONA 85705
PHONE (602) 624-7421
GEOLOGIC MAP OF THE TYRONE AREA
GRANT COUNTY, NEW MEXICO
2000 0 2000 4000 6000 8000
SCALE IN FEET
U.S.N.R. SURFACE AND MINERALS
SECTION A-A'
(LOOKING N.W.)
Zone of secondary enrichment
7000
6000
5000
4000
A
A'
TKqm
p€g
Qal
BURRO CHIEF FAULT
COPELAND FAULT
WALNUT CREEK FAULT
SPROUSE
CONTINENTAL DIVIDE
Brick Kiln Gulch
Tyrone
Burro Mountain Homestead
SOUTH TYRONE PROJECT
DDH
T 19 S.
T 20 S.
R 16 W.
R 15 W.
R 14 W.
Geology