CONTACT INFORMATION
Mining Records Curator
Arizona Geological Survey
416 W. Congress St., Suite 100
Tucson, Arizona 85701
520-770-3500
http://www.azgs.az.gov
inquiries@azgs.az.gov

WLK

File Memo

Quintana
Johnson Camp area
Cochise Co. Ariz

Bruce Kilpatrick of Quintana stated (11/7/78) that ~~the they had~~ their first two "near ore" holes at Johnson Camp, ~~next to~~ Quintana's ... Superior Oil holdings, ~~then next~~ Events then went downward from there & Quintana has completely pulled out.

"Completely" as far as their work is concerned, but he further stated that much residual events are taking place. 1) Sullivan is still bugging them about every other day for addition info. etc., & 2) the rancher has instigated a suit for "property damages.", & 3) other odd things.

JWS

AMERICAN SMELTING AND REFINING COMPANY
TUCSON ARIZONA

June 26, 1975

TO: W. L. Kurtz

FROM: J. D. Sell

Johnson Camp Area
Cochise County, Arizona

Recommendation — I recommend that the Superior Oil drilling information be obtained both as a possible joint venture and for future guidance of exploration activity in the Johnson Camp area.

Summary — In a discussion with Ben Dickerson, Exploration Manager of the Minerals Division of The Superior Oil Company, on June 20, 1975, I was informed of the following items.

Superior has drilled on three different mineral occurrences in the Johnson Camp area.

1. The Dragoon zone, which contains some 15 million tons of 0.5% copper as oxide.

2. The "Thing" zone, which wraps around the nose of the Texas Canyon stock, and is controlled by three ownership blocks: A) The NW portion by Sullivan, et al, contains some 55 million tons of 0.5% copper; B) the central portion, controlled by Cyprus Mines, has some 150 million tons of 0.5% copper; and C) the SE portion, held by Sullivan, et al, (and was drilled by Quintana), contains some 100 million tons at 0.5% copper. Apparently the entire zone contains some zinc values and both the copper and zinc are as mixed oxide-sulfide mineralization.

3. The Strong and Harris (S&H) zone contains 52 million tons of 0.64% copper and 0.7% zinc. In this area are some 3 million tons of 2.5-3.0% copper-zinc in a high grade zone in Abrigo Limestone.

Superior has returned, except for the Strong and Harris zone, all the options and data to the original owners. The Dragoon zone is held by the CF&I Corporation. (A cross-section through a line of drill holes in the Dragoon zone was recorded in Ted Eyde's article in the AIME Preprint 73-I-357 and the recent AIME Transaction Volume 256.)

Apparently metallurgical problems in the tactite mineralization and the zinc-copper distribution are one facet hindering development of the properties. Dickerson states that much of the S&H zone is either oxide or sulfide with little mixing. Also, the S&H zone is open to the north and the ultimate tonnage may be near 100 million tons for the zone. The adjacent two sections to the north are held by a California horse breeder and are probably available, but as yet have not been secured by Superior Oil. Ben further believes that a sizeable part of the S&H zone is of sufficient thickness to be mined by block-caving methods.

The S&H zone is held with a minimum of work and cash payments, with a moderate purchase price on future production royalties. Superior is looking for a partner and feels it has $825,000 invested to date.

The data have been shown to several other companies (AMAX being one mentioned), but no serious discussions have been undertaken.

All the mineralization is in tactite and no porphyry has been noted, except for a granite sill-like mass which is identical and traceable into the main Texas Canyon stock.

A short talk-discussion by Joe Kantor is apparently available on the S&H ground (and informally on the other two zones), and additional information is available for the serious joint-venture applicant.

One feature of the Johnson Camp mineral zone is that the limestone tactite is in excess of 15,000 feet long by 4,000 feet wide. This is probably one of the largest known tactites in Arizona with mineralization of this copper-zinc tenor, in which a porphyry source has yet to be delineated. Kantor, in his talk at Silver City in May, ascribes the mineralization source to be the granite sill which cuts through the limestones at a steep angle. This is based, apparently, on the fact that, as the drilling progresses away from the sill, the grade and extent of tactite-ore mineralization decreases. The block was subsequently uplifted, tilted, and much of the sill and upper Paleozoic units eroded and beveled to the present configuration.

A secondary possibility is that the Texas Canyon stock and associated granite sill were responsible for the tactite development, but that a porphyry source is lateral to the drilled portions and was the source of the ore mineralization which used the granite sill and tactite development as a channelway guidance system. Further information on any mineral zoning patterns and disseminated-replacement-fracture filling mineral occurrence patterns would aid in clarifying the problems at Johnson Camp.

Parts of the information needed should be available through Superior, Quintana, CF&I, Sullivan, and possibly Cyprus. Also, Continental Materials has also drilled a few holes north in the gravels and this information may be available for integration into an overall picture of tactite-mineral-porphyry(?) distribution.

James D. Sell

James D. Sell

JDS:lb

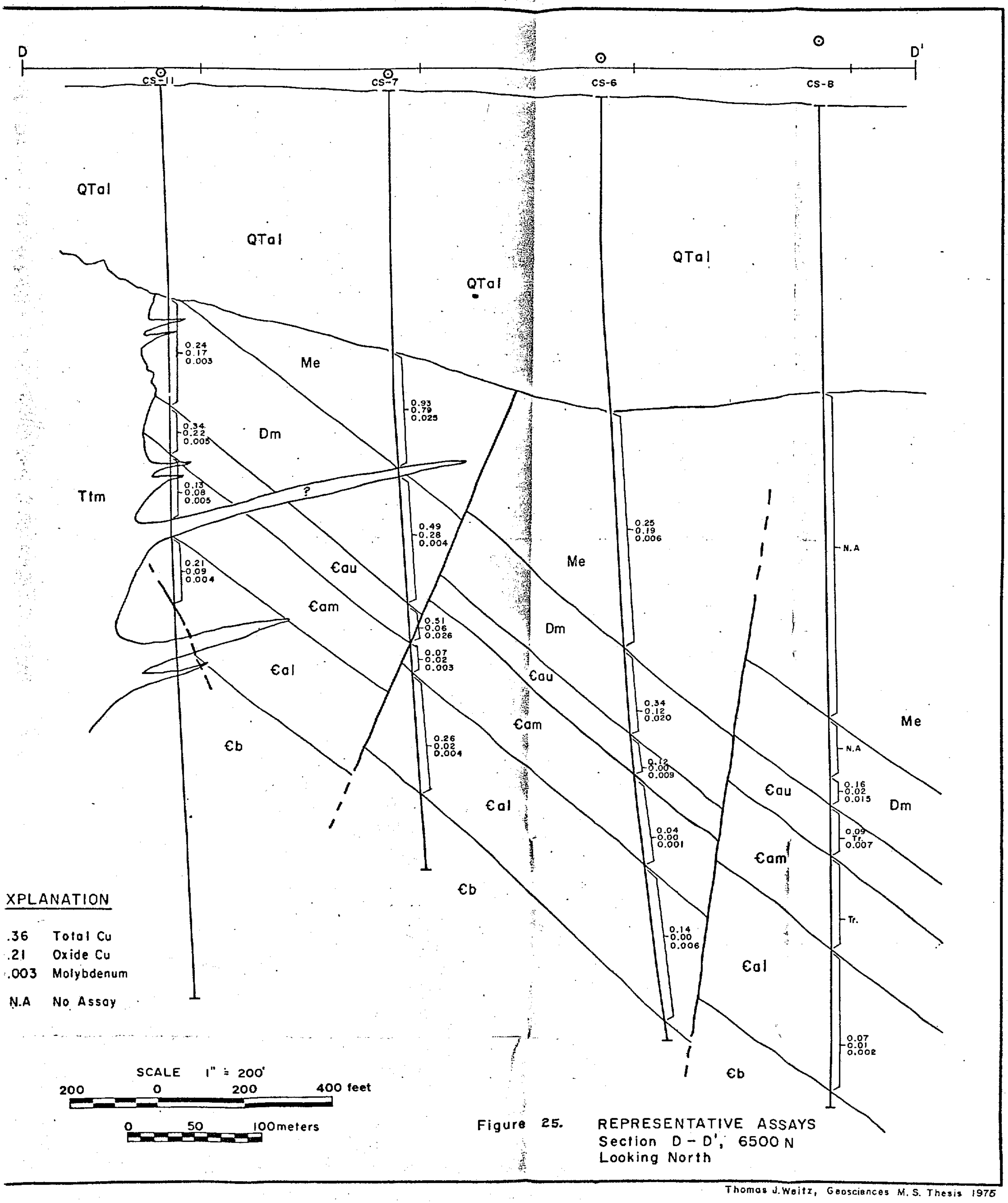

Figure 25. REPRESENTATIVE ASSAYS
Section D – D', 6500 N
Looking North

Thomas J. Weitz, Geosciences M. S. Thesis 1975

JDS - do you want to follow-up or do you want me to make contacts. Kurtz

AMERICAN SMELTING AND REFINING COMPANY
TUCSON ARIZONA

JUN 27 1975

June 26, 1975

Appears to be an excellent opportunity to evaluate a very large district (with abundant subsurface data) at very low cost. Where else in Ariz is there as much marginal mineralization, at relatively shallow depth, in an area of such complex geology, with as much post-mineral cover, and as much available data? An extensive, careful geologic evaluation of the data in this district would be a negligible expense as compared to several of our on-going projects which have very little marginal-grade mineralization to date. F.T.G.

I would agree that there should be a major pce copper buried some where in the district — but, as of now the chances of finding it look slim — JHC

TO: W. L. Kurtz

FROM: J. D. Sell

Johnson Camp Area
Cochise County, Arizona

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   I-10 deposit(?)

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AMERICAN SMELTING AND REFINING COMPANY
Tucson Arizona

October 1967

FILE MEMORANDUM

Johnson Camp Area
Cochise County, Arizona

On August 24, Mr. Welch, Mr. Richard and I visited Johnson Camp where Ira Moseley has started open cut work on a showing of oxide copper mineralization which he expects will produce siliceous flux for Hayden. Although mining had not progressed far enough to determine the extent of the deposit, the copper appears to be confined to a thin slab (±10 feet in thickness) of tactite immediately overlying the Dripping Springs quartzite of the Pre-Cambrian Apache group. (The principal production at Johnson Camp, around 800,000 tons of copper-zinc ore, reportedly came from tactite deposits in the overlying Cambrian Abrigo limestones).

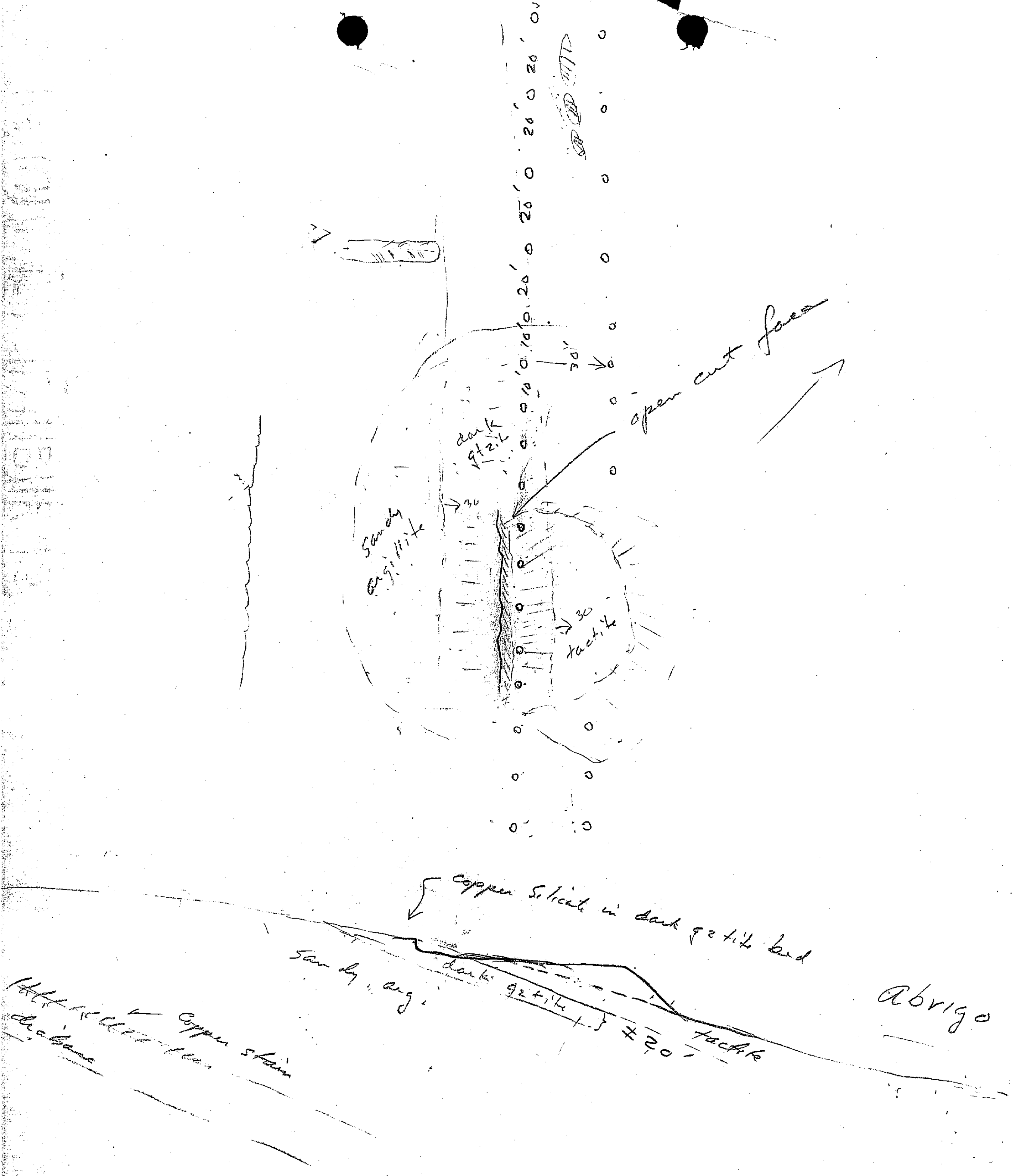
The principal copper minerals in the open cut are silicates, which formed essentially in place; however, in the quartzite in the footwall thorough leaching of original sulphide mineralization has taken place. This bed, from 100 to 200 feet thick, forms a low, northwesterly trending ridge about 1000 feet southwest of the Republic Mine. It contains a basal quartzite member (Barnes conglomerate) and is underlain by a black micaceous schist (diabase sill?) a gray-white sericite schist, quartzite and Pinal schist, in that order. The Scanlon conglomerate, from zero to two feet thick, lies at the base of the lower quartzite in sharp angular unconformity with the Pinal Schist (see geologic section attached).

As evidenced by outcrops along the ridge, the quartzite originally contained generally weak but pervasive disseminated pyrite-chalcopyrite mineralization. Dark maroon to black limonite-after chalcocite occurs sporadically along joint planes and occasionally as minute cavity fillings in the rock mass.

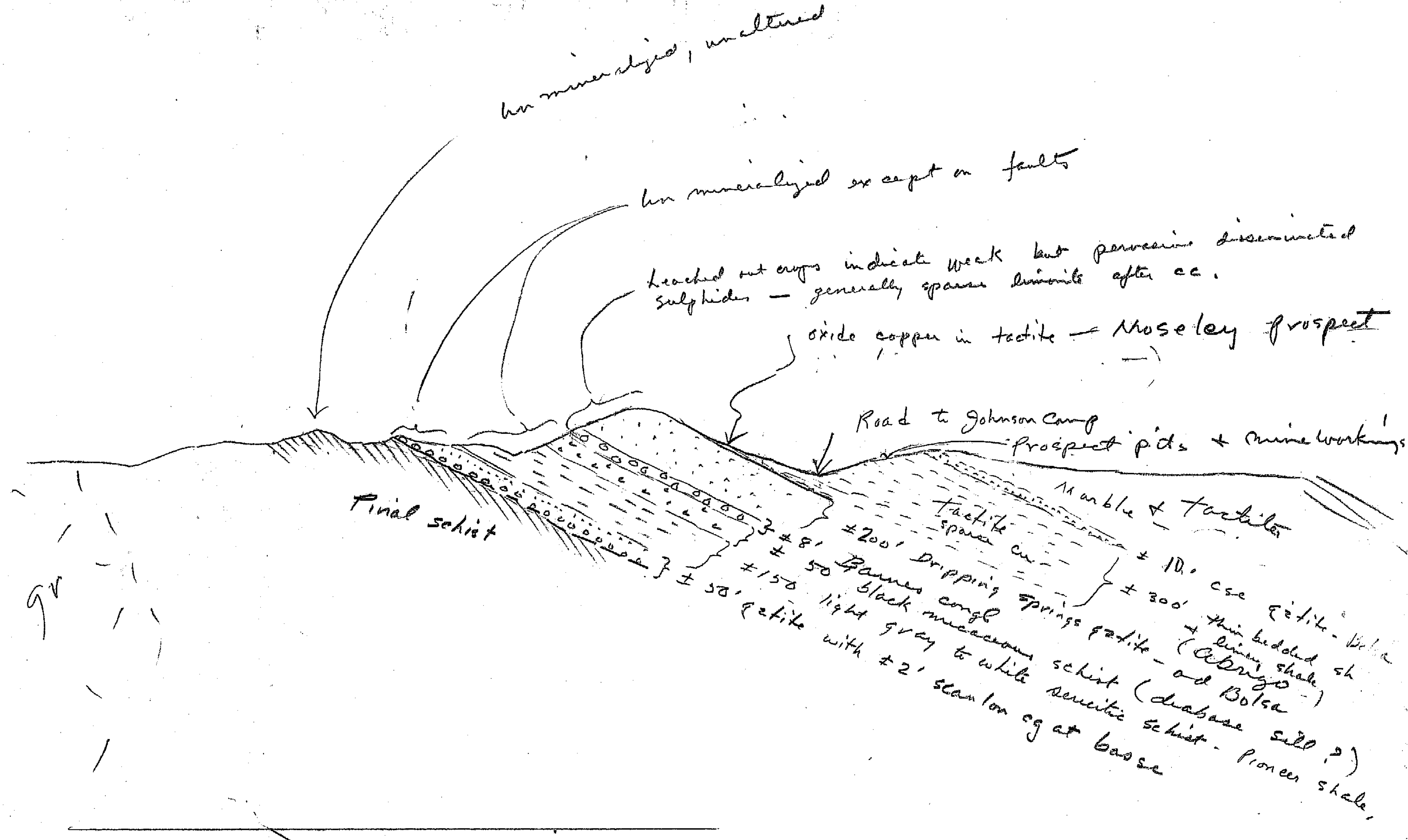
Similar outcrops were found along strike. Over a distance of a mile or more, diminishing in strength somewhat on the northwest. Exception are small outcrop, the bed is concealed by alluvium on the southeast, beyond the Keystone Mine area.

Several northeasterly faults cut across the beds, showing for the most part minor desplacements. Copper oxide minerals occur sparingly along these faults, which extend southwesterly into the Pinal schist, but the disseminated mineralization terminates abruptly at the base of the Barnes conglomerate.

J.H. Courtright



open cut face
dark qtzite
Sandy argillite
30
30
tactite
Copper Silicate in dark qtzite bed
Sandy arg.
dark qtzite
#20
tactite
Copper stain
Abrigo



Sketch section

Looking NW —

Line of section 1/4 mile S of

Johnson camp —

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

WAR DEPARTMENT

ARIZONA
(COCHISE COUNTY)
DRAGOON QUADRANGLE
15-MINUTE SERIES

Topography by R. C. Dewey,
C. C. Cooper, and K. A. Bunker

Surveyed in 1940-41

88

APPROXIMATE MEAN DECLINATION, 1941

(Benson 1/125000)

Scale 1/62500

1 0 1 2 3 4 Miles

1000 500 0 2000 4000 6000 7000 Yards

1000 0 3000 6000 9000 12000 15000 18000 Feet

1 .5 0 1 2 3 4 5 Kilometers

Contour interval 50 feet
Datum is mean sea level

ROUTES USUALLY TRAVELED
HARD IMPERVIOUS SURFACES
OTHER SURFACE IMPROVEMENTS
1943
U. S. ROUTE
STATE ROUTE

Polyconic projection. 1927 North American datum
5000 yard grid based on U. S. zone system, F
10000 foot grid based on Arizona (East)
rectangular coordinate system

(Pearce 1/125000)

DRAGOON, ARIZ.
Edition of 1943
N3200—W11000/15

88

THE TOPOGRAPHIC MAPS OF THE UNITED STATES

The United States Geological Survey is making a series of standard topographic maps to cover the United States. This work has been in progress since 1882, and the published maps cover more than 47 percent of the country, exclusive of outlying possessions.

The maps are published on sheets that measure about 16½ by 20 inches. Under the general plan adopted the country is divided into quadrangles bounded by parallels of latitude and meridians of longitude. These quadrangles are mapped on different scales, the scale selected for each map being that which is best adapted to general use in the development of the country, and consequently, though the standard maps are of nearly uniform size, the areas that they represent are of different sizes. On the lower margin of each map are printed graphic scales showing distances in feet, meters, miles, and kilometers. In addition, the scale of the map is shown by a fraction expressing a fixed ratio between linear measurements on the map and corresponding distances on the ground. For example, the scale $\frac{1}{62,500}$ means that 1 unit on the map (such as 1 inch, 1 foot, or 1 meter) represents 62,500 of the same units on the earth's surface.

Although some areas are surveyed and some maps are compiled and published on special scales for special purposes, the standard topographic surveys and the resulting maps have for many years been of three types, differentiated as follows:

1. Surveys of areas in which there are problems of great public importance—relating, for example, to mineral development, irrigation, or reclamation of swamp areas—are made with sufficient detail to be used in the publication of maps on a scale of $\frac{1}{31,680}$ (1 inch = one-half mile) or $\frac{1}{24,000}$ (1 inch = 2,000 feet), with a contour interval of 1 to 100 feet, according to the relief of the particular area mapped.

2. Surveys of areas in which there are problems of average public importance, such as most of the basin of the Mississippi and its tributaries, are made with sufficient detail to be used in the publication of maps on a scale of $\frac{1}{62,500}$ (1 inch = nearly 1 mile), with a contour interval of 10 to 100 feet.

3. Surveys of areas in which the problems are of minor public importance, such as much of the mountain or desert region of Arizona or New Mexico, and the high mountain area of the northwest, are made with sufficient detail to be used in the publication of maps on a scale of $\frac{1}{125,000}$ (1 inch = nearly 2 miles) or $\frac{1}{250,000}$ (1 inch = nearly 4 miles), with a contour interval of 20 to 250 feet.

The aerial camera is now being used in mapping. From the information recorded on the photographs, planimetric maps, which show only drainage and culture, have been made for some areas in the United States. By the use of stereoscopic plotting apparatus, aerial photographs are utilized also in the making of the regular topographic maps, which show relief as well as drainage and culture.

A topographic survey of Alaska has been in progress since 1898, and nearly 44 percent of its area has now been mapped. About 15 percent of the Territory has been covered by maps on a scale of $\frac{1}{500,000}$ (1 inch = nearly 8 miles). For most of the remainder of the area surveyed the maps published are on a scale of $\frac{1}{250,000}$ (1 inch = nearly 4 miles). For some areas of particular economic importance, covering about 4,300 square miles, the maps published are on a scale of $\frac{1}{62,500}$ (1 inch = nearly 1 mile) or larger. In addition to the area covered by topographic maps, about 11,300 square miles of southeastern Alaska has been covered by planimetric maps on scales of $\frac{1}{125,000}$ and $\frac{1}{250,000}$.

The Hawaiian Islands have been surveyed, and the resulting maps are published on a scale of $\frac{1}{62,500}$.

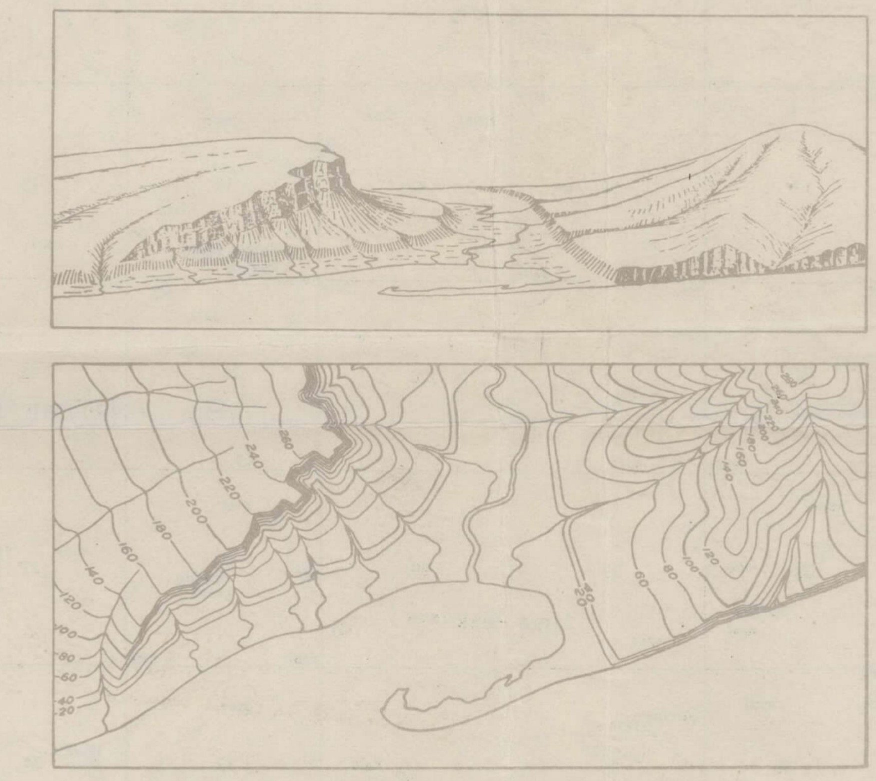
A survey of Puerto Rico is now in progress. The scale of the published maps is $\frac{1}{30,000}$.

The features shown on topographic maps may be arranged in three groups—(1) water, including seas, lakes, rivers, canals, swamps, and other bodies of water; (2) relief, including mountains, hills, valleys, and other features of the land surface; (3) culture (works of man), such as towns, cities, roads, railroads, and boundaries. The symbols used to represent these features are shown and explained below. Variations appear on some earlier maps, and additional features are represented on some special maps.

All the water features are represented in blue, the smaller streams and canals by single blue lines and the larger streams by double lines. The larger streams, lakes, and the sea are accentuated by blue water lining or blue tint. Intermittent streams—those whose beds are dry for a large part of the year—are shown by lines of blue dots and dashes.

Relief is shown by contour lines in brown, which on a few maps are supplemented by shading showing the effect of light thrown from the northwest across the area represented, for the purpose of giving the appearance of relief and thus aiding in the interpretation of the contour lines. A contour line represents an imaginary line on the ground (a contour) every part of which is at the same altitude above sea level. Such a line could be drawn at any altitude, but in practice only the contours at certain regular intervals of altitude are shown. The datum or zero of altitude of the Geological Survey maps is mean sea level. The 20-foot contour would be the shore line if the sea should rise 20 feet above mean sea level. Contour lines show the shape of the hills, mountains, and valleys, as well as their altitude. Successive contour lines that are far apart on the map indicate a gentle slope, lines that are close together indicate a steep slope, and lines that run together indicate a cliff.

The manner in which contour lines express altitude, form, and grade is shown in the figure below.



The sketch represents a river valley that lies between two hills. In the foreground is the sea, with a bay that is partly enclosed by a hooked sand bar. On each side of the valley is a terrace into which small streams have cut narrow gullies. The hill on the right has a rounded summit and gently sloping spurs separated by ravines. The spurs are truncated at their lower ends by a sea cliff. The hill at the left terminates abruptly at the valley in a steep scarp, from which it slopes gradually away and forms an inclined tableland that is traversed by a few shallow gullies. On the map each of these features is represented, directly beneath its position in the sketch, by contour lines.

The contour interval, or the vertical distance in feet between one contour and the next, is stated at the bottom of each map. This interval differs according to the topography of the area mapped: in a flat country it may be as small as 1 foot; in a mountainous region it may be as great as 250 feet. In order that the contours may be read more easily certain contour lines, every fourth or fifth, are made heavier than the others and are accompanied by figures showing altitude. The heights of many points—such as road intersections, summits, surfaces of lakes, and benchmarks—are also given on the map in figures, which show altitudes to the nearest foot only. More precise figures for the altitudes of benchmarks are given in the Geological Survey's bulletins on spirit leveling. The geodetic coordinates of triangulation and transit-traverse stations are also published in bulletins.

Lettering and the works of man are shown in black. Boundaries, such as those of a State, county, city, land grant, township, or reservation, are shown by continuous or broken lines of different kinds and weights. Public roads suitable for motor travel the greater part of the year are shown by solid double lines; poor public roads and private roads by dashed double lines; trails by dashed single lines. Additional public road classification if available is shown by red overprint.

Each quadrangle is designated by the name of a city, town, or prominent natural feature within it, and on the margins of the map are printed the names of adjoining quadrangles of which maps have been published. More than 4,100 quadrangles in the United States have been surveyed, and maps of them similar to the one on the other side of this sheet have been published.

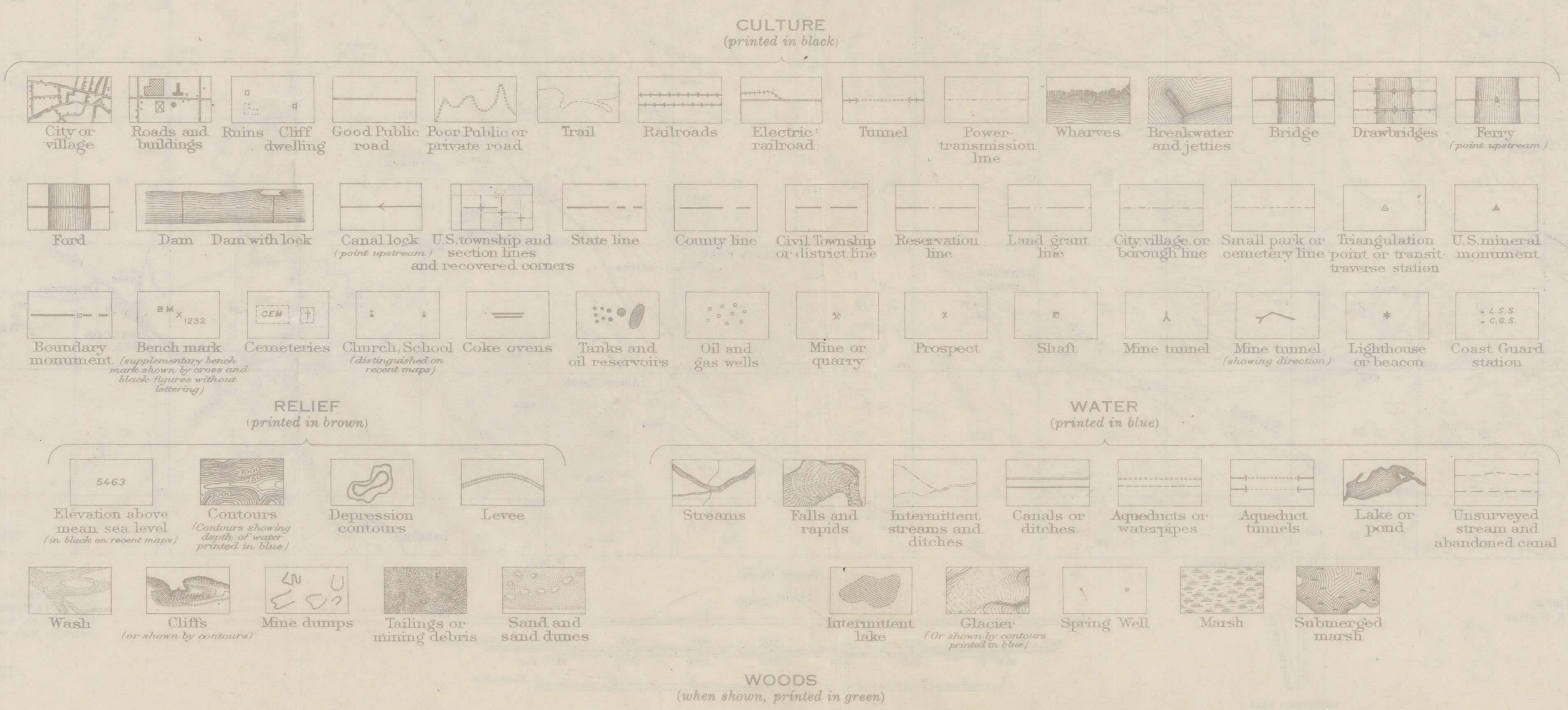
Geologic maps of some of the areas shown on the topographic maps have been published in the form of folios. Each folio includes maps showing the topography, geology, underground structure, and mineral deposits of the area mapped, and several pages of descriptive text. The text explains the maps and describes the topographic and geologic features of the country and its mineral products. Two hundred twenty-five folios have been published.

Index maps of each State and of Alaska and Hawaii showing the areas covered by topographic maps and geologic folios published by the United States Geological Survey may be obtained free. Copies of the standard topographic maps may be obtained for 10 cents each; some special maps are sold at different prices. A discount of 40 percent is allowed on an order amounting to $5 or more at the retail price. The discount is allowed on an order for maps alone, either of one kind or in any assortment, or for maps together with geologic folios. The geologic folios are sold for 25 cents or more each, the price depending on the size of the folio. A circular describing the folios will be sent on request.

Applications for maps or folios should be accompanied by cash, draft, or money order (not postage stamps) and should be addressed to

THE DIRECTOR,
United States Geological Survey,
November 1937. *Washington, D. C.*

STANDARD SYMBOLS



AMERICAN SMELTING AND REFINING COMPANY
Tucson Arizona
December 16, 1966

Mr. K. E. Richard, Chief Geologist
American Smelting and Refining Company
120 Broadway
New York, N. Y. 10005

JOHNSON CAMP
LITTLE DRAGOON MTNS.
COCHISE COUNTY, ARIZONA

Dear Sir:

Attached is Mr. Burt Devere's memorandum on recent developments at Johnson Camp.

Cyprus drilling downdip northeast of Mosely's silica flux pit has disclosed extensive ore grade mineralization as disseminated chalcocite and chalcopyrite in the tactites of the Abrigo formation which overlies the Bolsa quartzite. Above the chalcocite, there is a layer of partially oxidized copper ore. The results to date indicate 15 million tons of .8% Cu and .05% Moly. The occurrence of chalcocite in presumably somewhat limey tactites is, of course, an unusual situation.

You will recall our examination of this area back about the time the small pit was started in the Bolsa quartzite outcrop just west of the old Johnson Camp mine. It was noted at that time that the leached outcrops of the quartzite suggested possible ore grade mineralization for a strike length of 1000' and more. Although Cyprus had essentially abandoned the area some time back, they still held the property and were not interested in a deal of any kind other than a short term lease which was taken by McFarland and Hullinger for the purpose of mining a few pillars and ore remnants in the old underground workings.

Yours very truly,

J. H. Courtright

J. H. COURTRIGHT

JHC/kw
Enclosure
cc: RFWelch, w/encl.
BJDevere
Circulate file copy to SVonFay
WESaegart
BNWatson

AMERICAN SMELTING AND REFINING COMPANY
Tucson Arizona

J. H. C.

DEC 16 1966

December 9, 1966

TO: J. H. COURTRIGHT

FROM: B. J. DEVERE

JOHNSON CAMP
LITTLE DRAGOON MOUNTAINS
COCHISE COUNTY, ARIZONA

Introduction:

Friday, November 25, 1966, I spent touring the Cyprus Mines drilling operations at Johnson Camp. The trip was conducted by Mr. Bob Clayton, geologist in charge of the drilling. Mr. Clayton was good enough to show me the drill core, logs, maps, cross-sections, and the surface in the areas of present interest.

Attached are two maps and one cross-section. Attachment A shows the two areas of primary interest at the present time. Area Number One is in the process of drilling, while area Number Two will be drilled later next year. Attachment B shows the approximate location of the five operating drill rigs when I visited the property. The cross-section, attachment C, isdiagrammatic with some of the information from personal observation, and the sub-surface information from memory from sections shown me by Cyprus personnel.

Summary & Conclusions:

The Johnson Camp mineral occurrence, of copper and molybdenite, represents a possible orebody of economic size and grade. The present 15 million tons of .8% Cu. and .05% Mo. could be enough for a small, limited, operation.

The mineralization is mixed oxide, carbonate, sulfide ore in a siliceous diopside hornfels. The hornfels is developed from the shaly limestone of the lower portion of the Cambrian Abrigo formation.

The sulfide ore is largely chalcocite, coating and replacing pyrite. Chalcopyrite is evident but in small amounts (± .2% Cu.) along fractures and quartz veinlets.

Molybdenite mineralization is evident as veinlets and small blebs along quartz veins. Some drilled intervals are said to assay as high as .15% Mo. with the average Mo. grade around .05%

Of the 15 millions tons of .8% copper ore .3% Cu. is reported as oxides and carbonates and .5% Cu. as sulfides.

Geology:

The surface of the areas of interest (see attachment A) are about 70% covered by alluvium. The remaining 30% is Cambrian Bolsa quartzite, and Abrigo limestone altered to hornfels.

The quartzite and hornfels beds strike generally N 50° W, dipping to the NE at about 40°.

On the surface the hornfels has a leached appearance with considerable limonite staining and occasional copper stain along fractures . The chalcocite, in the hornfels, is found replacing pyrite along fractures, quartz veinlets and in very fine pinpoint disseminations.

"Live Limonite," after chalcocite, is not evident in the hornfels on the surface but is evident in the Bolsa quartzite. The strongest concentration of surface mineralization is in the Bolsa quartzite to the west of Mosely's silica pit and in the silica pit at the contact of the quartzite and the hornfels.

The pyrite to chalcopyrite ratio seems to be unusually high. A brief inspection of the core revealed small ($\pm$ .2%) amount of chalcopyrite mostly along fractures and quartz veinlets. The pyrite is present both as veinlets and pinpoint dissemination throughout the hornfels. The total primary sulfide content looks to be about 3-4 % which apparently has generated enough acid to completely neutralize the available calcium carbonate.

Current Exploration Activity:

At the present time the area of drilling is confined to the immediate area of the Republic Shaft and the Old Coronado Copper Company workings. Drilling will be stepped out, in the near future, to include all the area shown as Number One on attachment A.

Until recently the drilling has been restricted to the lower Abrigo formation along the Bolsa quartzite contact. Mineralization in this horizon was first recognized in the area of the Mosley's silica pit.

In the middle of November three drill rigs were moved about 1/2 mile to the east of the known mineralized zone (see attachment B). These rigs have cut chalcocite mineralization about 200 feet above the Bolsa quartzite contact, and about on the horizonal projection of the mineralization drilled along the contact zone.

Forty one drill holes had been completed at the time of my visit. About 30 of these holes penetrated the Bolsa quartzite and were stopped either in barren diabase or schist.

Cyprus presently has 5 truck mounted, Joy Diamond Drills working on the property. These rigs are working 2 shifts a day, 6 days a week. Mr. Clayton told me that Cyprus had approved $500,000 worth of drilling for the Johnson Camp area.

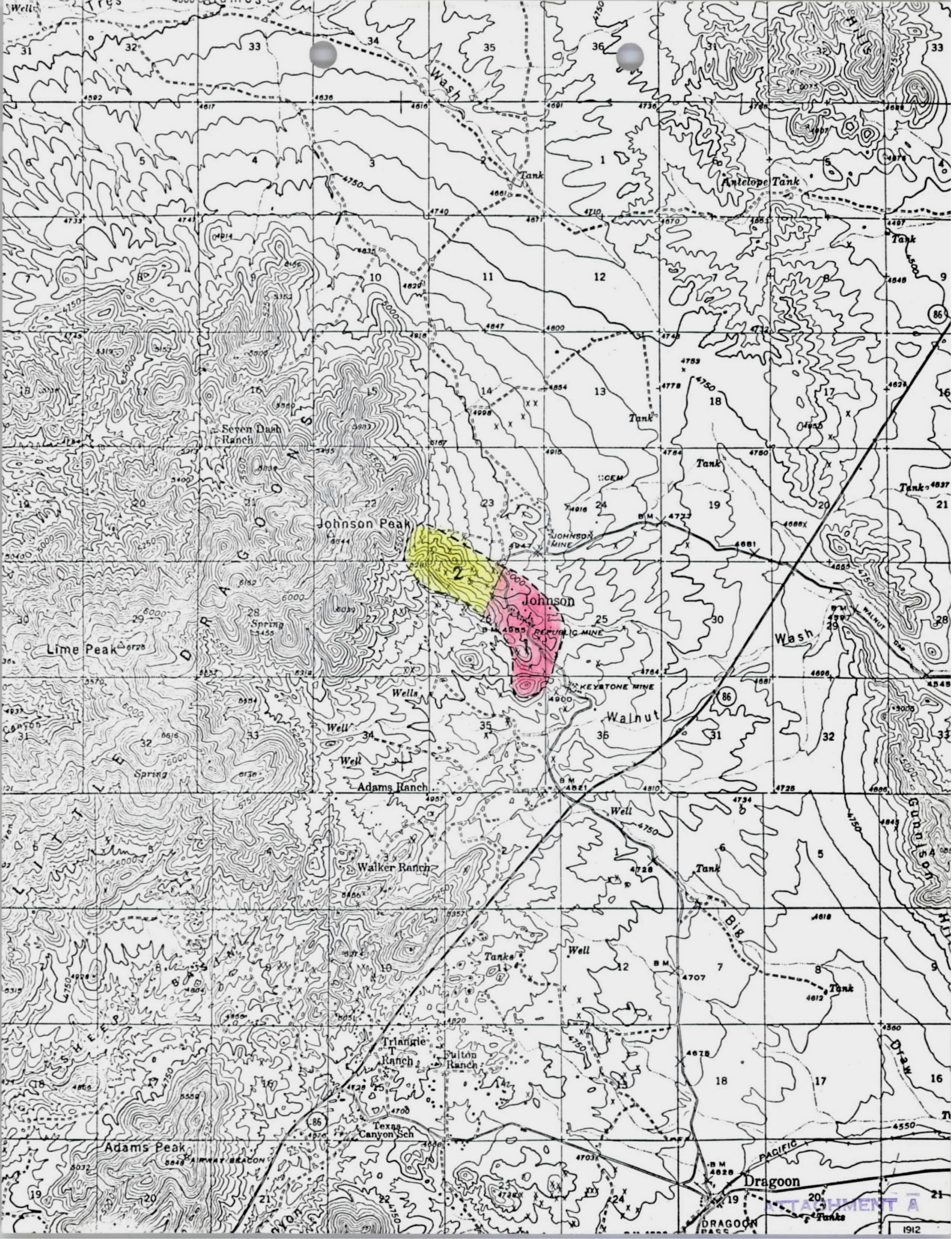
Land Status:

Cyprus Mines has tied up all the surrounding land through staking, state lease, and option, for several miles around the property. One small block of open ground is held by a Mr. Reys at the Keystone Mine, but his holdings are too small to be of much interest. The chance of getting a foothold into the area at this time looks very remote.

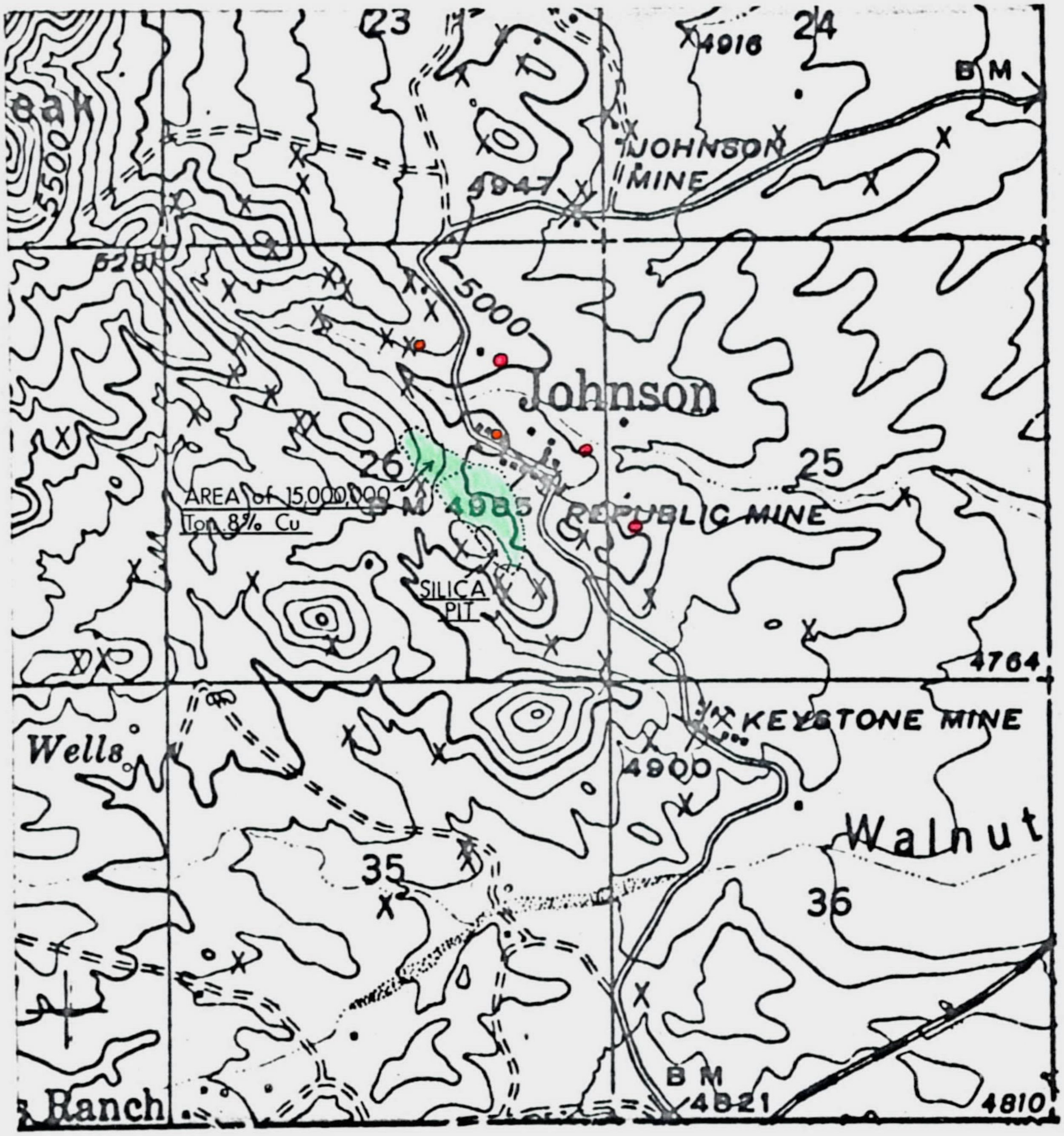
Burton Devere Jr.

BURTON DEVERE JR.

BD/mg
Attachments
cc: 4 Extra w/attachments



ATTACHMENT A

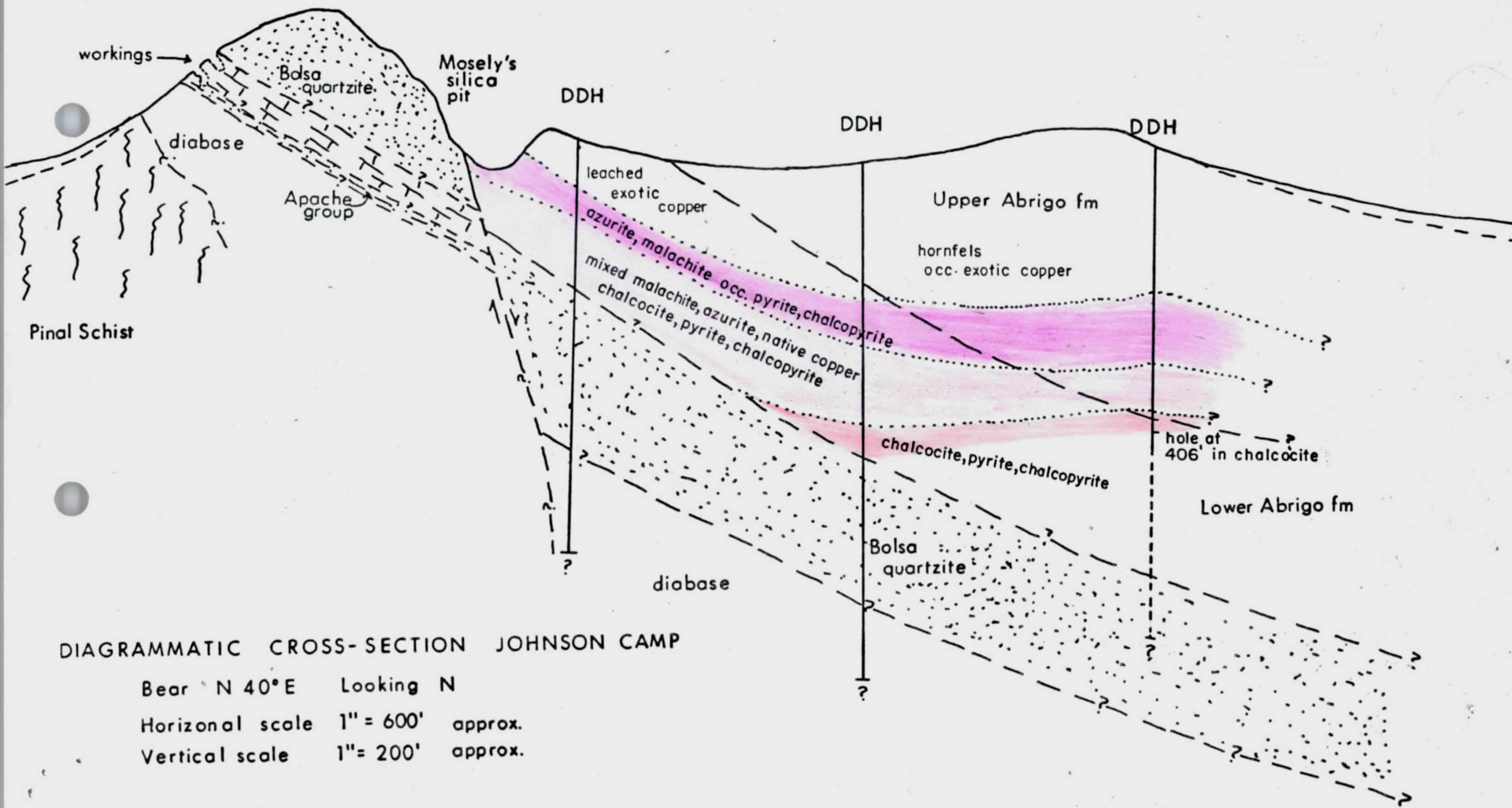


SCALE : 1" = 200'

Holes in Cu Oxides & Carbonate

Holes in Chalcocite

ATTACHMENT B



DIAGRAMMATIC CROSS-SECTION JOHNSON CAMP

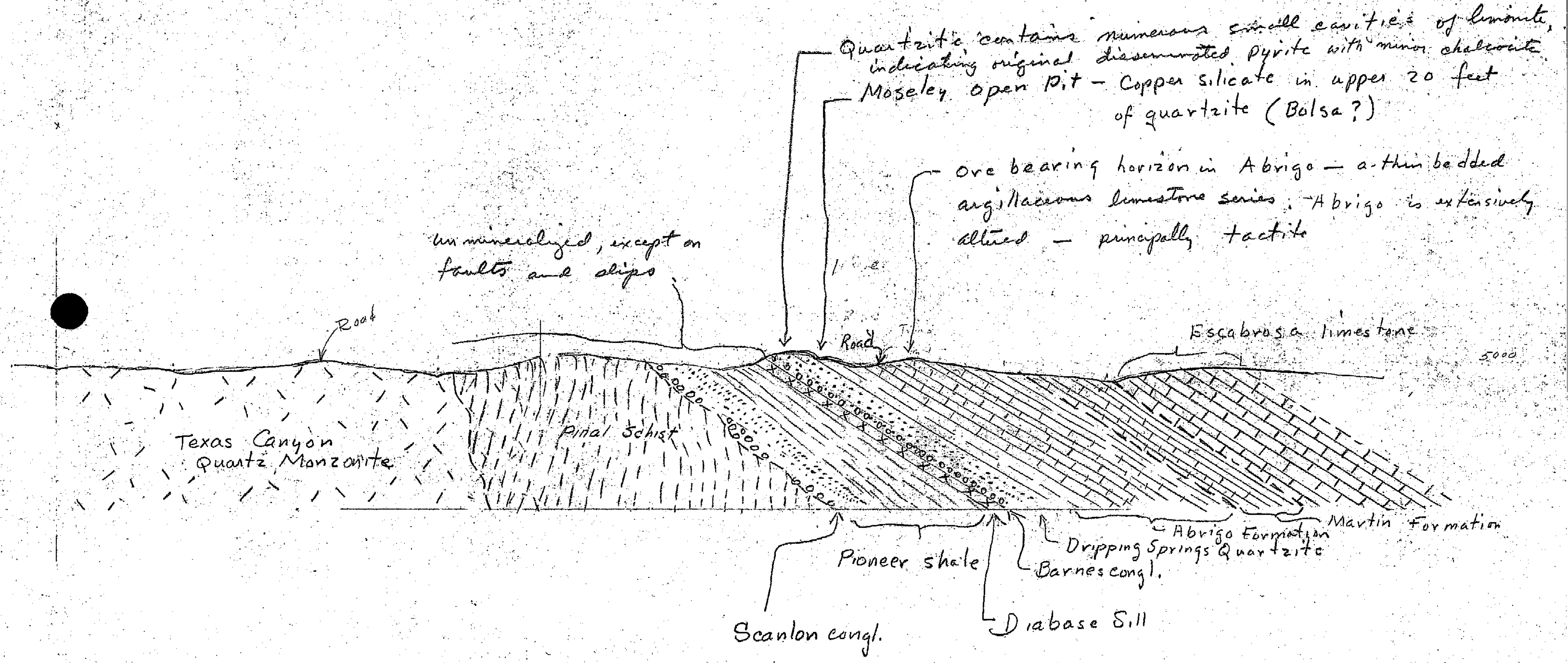
Bear N 40° E Looking N

Horizonal scale 1" = 600' approx.

Vertical scale 1" = 200' approx.

B. Devere

ATTACHMENT C



Section thru Johnson Camp
Looking Northwesterly
Cochise Co. Arizona

Scale 1" = 1000' (approx.)

Oct '58 J.H.C.

NOTE FILE ON "PORPHYRY COPPER"

Property JOHNSON CAMP
Area
District
Mt. Range Little Dragoons
State Arizona

Location: One mile north of Highway 86, Cochise County

Field Check by: Kenyon Richard and J. H. Courtright

Date August 26, 1958

Recommended Company Interest Classification:	
☐ Active ☒ Inactive ☐ None ☐ Scientific	Conclusion: Some enrichment of disseminated copper mineralization in quartzite is evidenced by limonite-after-chalcocite in leached outcrops. This mineralization persists along strike for over a mile, but is in general too sparse to be of interest exploration-wise.

Notes on Reconnaissance:

(Johnson Camp, credited with a production of over 800,000 tons of copper-zinc ore, is at present inactive, except for one small open cut mining operation which produces siliceous fluxing ore for shipment to Hayden.)

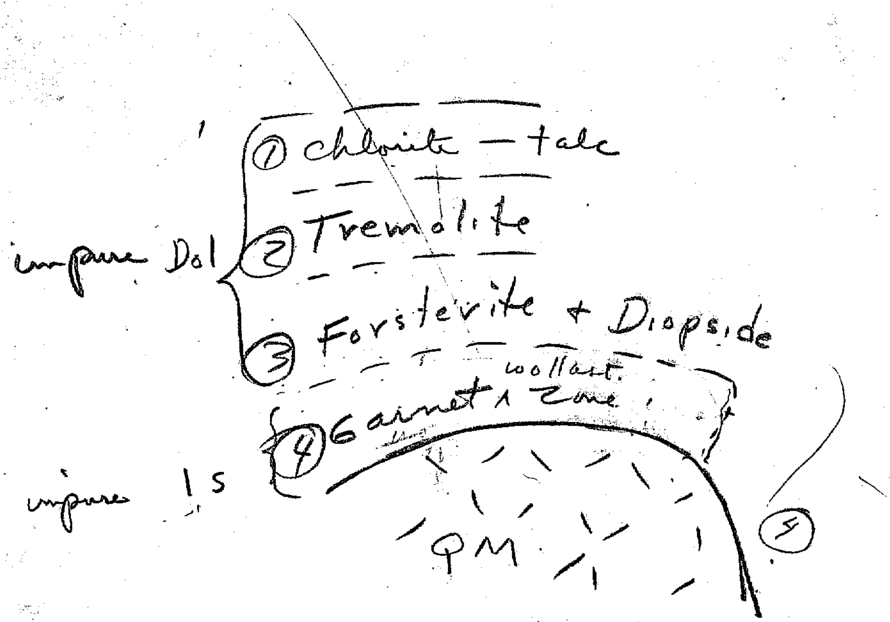
The mineralized quartzite (Dripping Springs?) has a thickness of 100 to 200 feet and lies in the footwall of a thick series of garnetized limey beds which contained the principal copper-zinc ore bodies of the district. The quartzite forming a low ridge just west of the Republic Mine is underlain successively by a black micaceous schist (diabase?), a light gray sericitic schist, quartzite and Pinal schist. As may be noted on the sketch section attached, all members of the Pre-Cambrian Apache group appear to be present. The strike of the beds is northwesterly and the dip northeasterly at around 30 degrees.

Typical outcrops of the quartzite are pale brown in color with occasional thin seams of dark maroon limonite. Minute specks of limonite are sparsely distributed throughout the rock. Some oxide copper mineralization occurs in narrow zones within faults which strike northeasterly across the bedding trend. Other than this, there is no significant alteration or mineralization below the conglomerate (Barnes?) which marks the base of the quartzite.

Date______________ By______________

Johnson Camp – GSA Bull May '57

By John R. Cooper



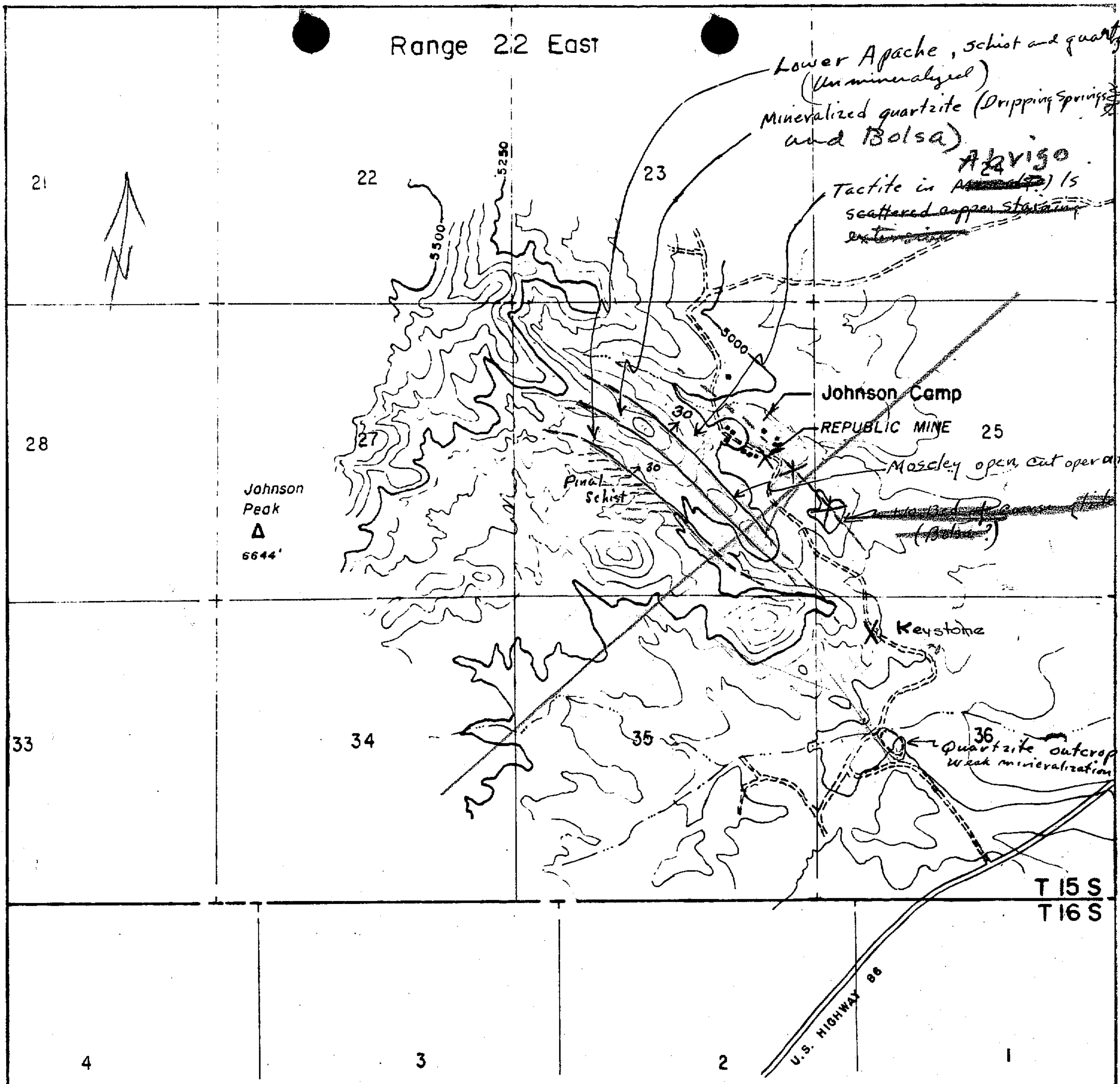
Note
no replacement of pure ls or dol

chemical action that can reasonably be inferred; release of CO_2 and formation of denser minerals with decrease in volume (as much as 30 %, by stratigraphic measurements) — [increase in spec. gravity as in Pima deposits]

Stratigraphy

	Feet
Quaternary & tert. alluvium — . . .	500 +
unconformity —	
Lower Cretaceous; Bisbee Grp.	
Morita – Cintura — — — — — — — —	2500
Glance Congl.	500
uncond.	
Jurassic or Triassic – Andesitic and Rhyolitic tuff breccia + congl – [of local occ.]	400
uncond.	

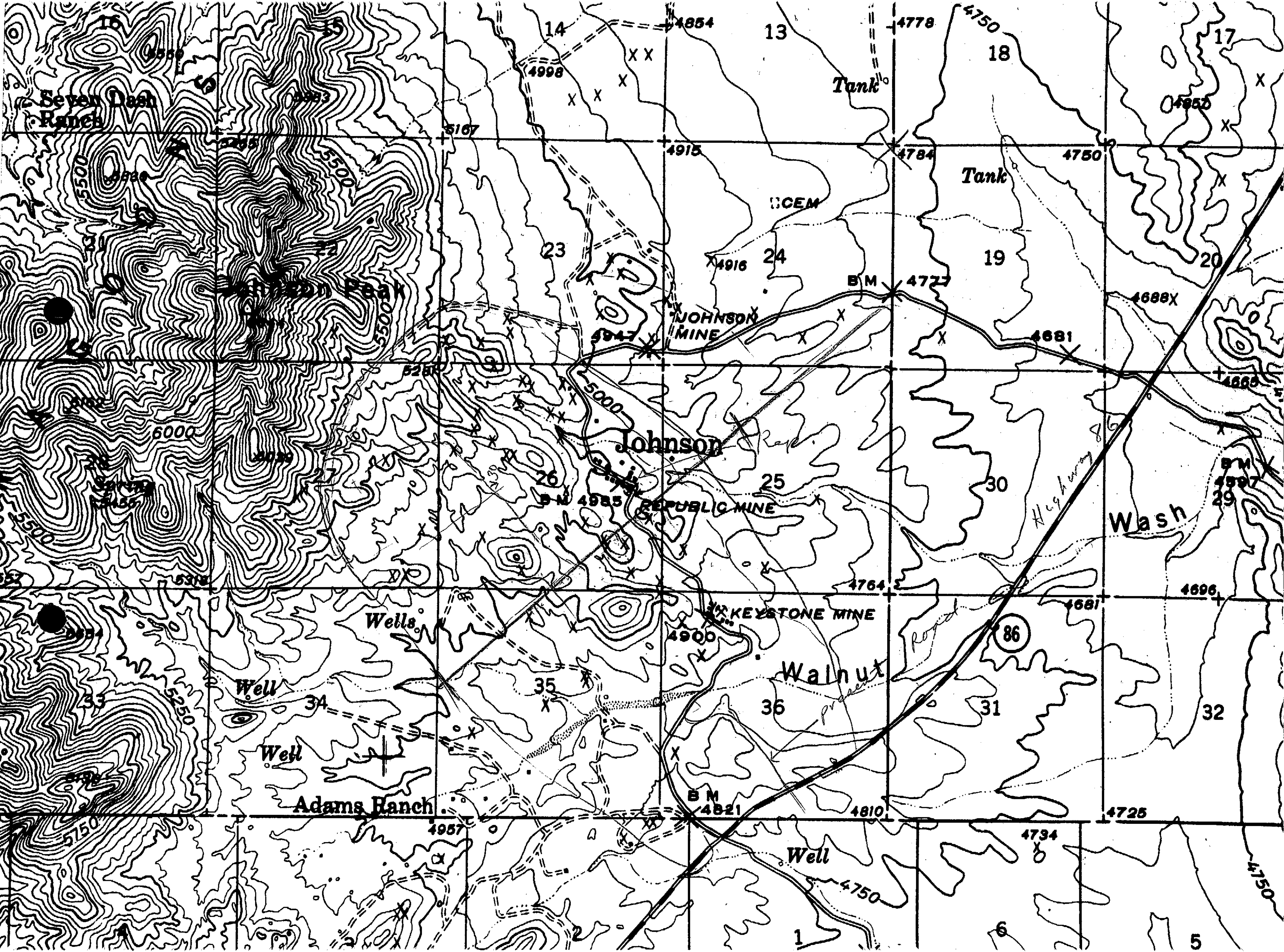
note →



Plan of Johnson Camp Area
Cochise Co. Ariz.
Showing areal extent of mineralized quartzite

Scale 1" = 1/2 mile

KR & J.H.C. Aug '58


Seven Dash Ranch
Johnson Peak
Spring
Tank
Tank
CEM
JOHNSON MINE
Johnson
REPUBLIC MINE
KEYSTONE MINE
Wells
Well
Well
Well
Adams Ranch
Walnut
Wash
86
B M 4777
B M 4985
B M 4597
B M 4821
4854
4778
4998
5167
4915
4784
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5261
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4696
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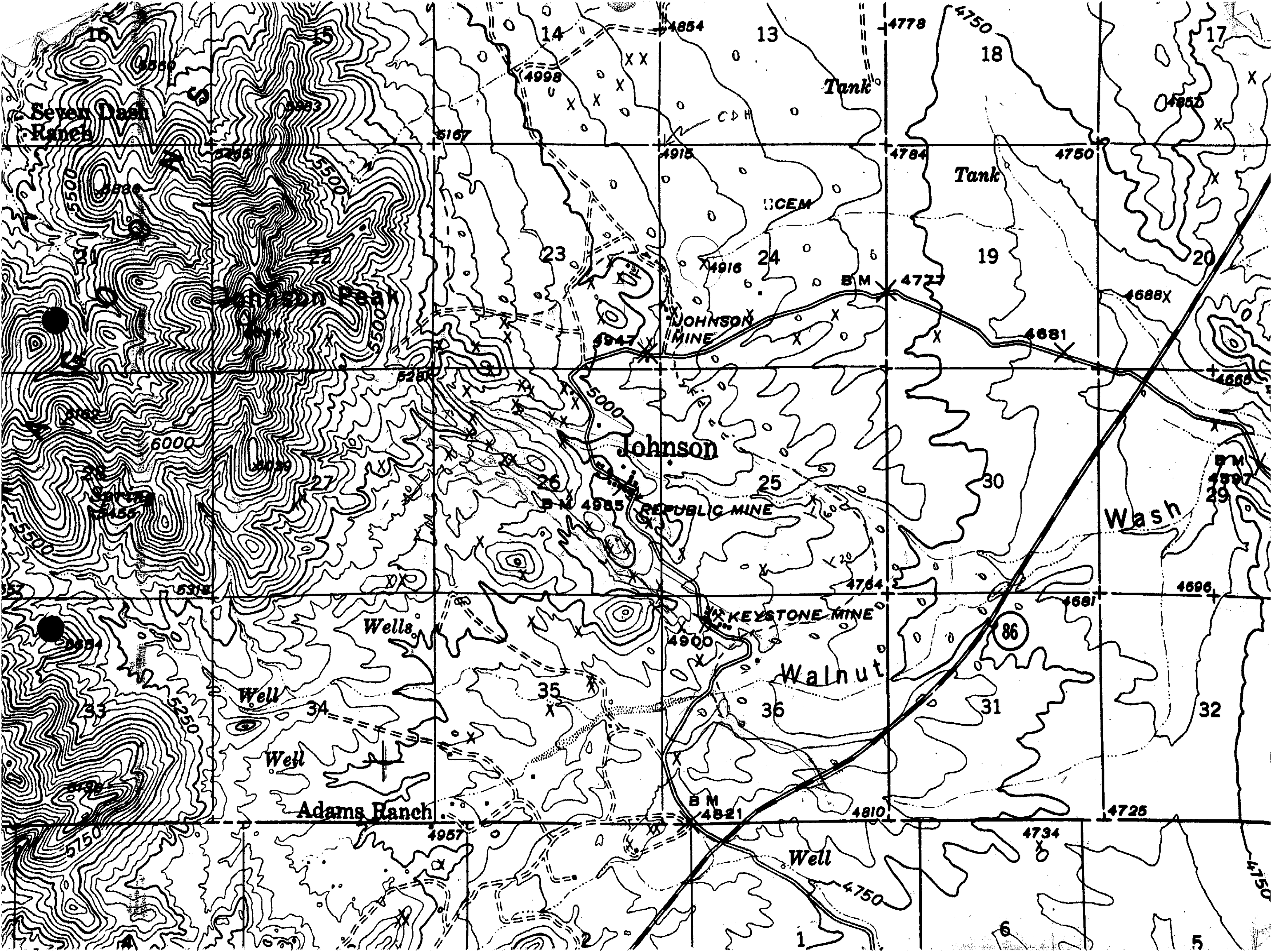
Seven Dash Ranch
Johnson Peak
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JOHNSON MINE
REPUBLIC MINE
KEYSTONE MINE
Adams Ranch
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CEM
Wells
Well
Well
Well
86
BM 4777
BM 4985
BM 4821
BM 4597
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5250
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4750

AMERICAN INSTITUTE OF MINING AND METALLURGICAL ENGINEERS

LOS ANGELES MEETING

MINING BRANCH

OCTOBER 24, 1952

LOCALIZATION OF PYROMETASOMATIC ORE DEPOSITS AT JOHNSON CAMP, ARIZONA

by

ARTHUR B. BAKER III

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LOCALIZATION OF PYROMETASOMATIC ORE DEPOSITS AT JOHNSON CAMP, ARIZONA

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INTRODUCTION

Johnson Camp is in the northwestern part of Cochise County, Arizona, about 50 miles east of Tucson. The nearest major mining districts are Tombstone and Bisbee, respectively 27 and 50 miles to the south, and the Superior-Miami-Globe-Ray porphyry copper group, about 90 miles to the northwest.

Like many mining camps of the Southwest, Johnson Camp is said to have been worked by the Spaniards. The earliest known production was in the early 1880's, when a large amount of oxidized copper-silver ore in the Peabody Mine was mined from replacement orebodies in the Pennsylvanian Naco formation. From 1904 to 1911 outcropping oxidized ores occurring in the Cambrian Abrigo formation were worked, and an estimated 100,000 tons of copper ore were shipped. In 1918 the first large sulfide orebody of the district, the Republic Manto Orebody, was discovered, and in the following few years some 250,000 tons of predominantly sulfide ore were shipped. The average grade of this ore was approximately 4.5% Cu, 6% Zn, 0.8 oz Ag, and 0.001 oz Au. The Republic, Copper Chief and Mammoth Mines were the principal producers during this period. Mining ceased in the district after 1920, and until 1943 only small-scale leasing operations were carried on.

In 1943 all of the mines that had been productive were acquired by the Coronado Copper and Zinc Co., the present operators, and in the nine years since that time the district production has amounted to approximately 350,000 tons of milling ore averaging 2% Cu and 6% Zn. Most of this ore was produced from the Republic and Mammoth Mines, but since 1950 a large part of the production has been from the new Moore Mine.

The total known production from the district, then, has been about 3/4 million tons of copper and copper-zinc ore of rather low grade. All of this ore was produced from orebodies associated with garnetite, occurring in the middle member of the Cambrian Abrigo formation. In addition to this known production, an unknown tonnage of ore was extracted from the Peabody Mine orebodies that lie in the Pennsylvanian Naco formation.

Published information on the geology of the district is limited. Aside from brief references in various mining journals, only three papers on the district have been published. * One of these is a U. S. Bureau of Mines report on a diamond drilling program. Of the other two, one is a brief paper on the general geology of the district, and the other is a report on geochemical experiments, with a section on the occurrence of the orebodies. Both of these are by John Cooper, of the United States Geological Survey, who has done much detailed work in the area.

(* See Bibliography at end of paper.)

The writer is indebted to the Coronado Copper and Zinc Company for permission to present this paper.

STRATIGRAPHY

The rocks of the mineralized area are Paleozoic sediments ranging in age from Cambrian to Pennsylvanian. Several disconformities are present in the stratigraphic column, the most important one being between the Cambrian Abrigo formation and the Devonian Martin formation. There are no angular unconformities. Within the district, the Paleozoic sediments lie in a fairly uniform monocline, striking northwest and dipping 30° - 40° northeast. This local monocline is part of a domal structure centered in the Little Dragoon mountains to the southwest.

South of the mineralized area is the Texas Canyon stock, a quartz monzonite body intruded probably during the Laramide revolution (2, p. 33). The Paleozoic rocks dip away from the stock, and on the surface are separated from it by a belt of Pre-Cambrian schist 1500' wide at its narrowest point. The outcrop pattern of the northern edge of the stock suggests that it may plunge rather gently north, passing below the mineralized area at moderate depth. No quartz monzonite has been found in mine workings or diamond drill holes, which reach to depths of 1000'. The only igneous rock found in the mineralized area is a lamprophyre dike cutting the Naco limestone in and near workings of the Peabody Mine.

With the exception of the lowermost beds -- the Bolsa quartzite and the shaly lower member of the Abrigo formation -- the Paleozoic sediments are predominantly carbonate rocks (Fig. 1). The middle member of the Abrigo formation, which contains the principal ore-bearing beds, is a limestone with thin shale partings throughout most of its 250' thickness. Near the top of this member is a sandy bed some 25' thick. The upper member of the Abrigo formation and the lower half of the overlying Devonian Martin formation are dolomitic, with numerous quartzite beds and sandy dolomite beds. The upper half of the Martin formation is principally pure dolomite, while the Mississippian Escabrosa formation and the Pennsylvanian Naco formation are chiefly pure limestone.

Small lenses and stringers of ore minerals occur in all of the Paleozoic sediments, and in a few places in the Precambrian rocks. Commercial orebodies, however, are found only in the middle member of the Abrigo formation, with the exception of the Peabody Mine orebodies which lie in the Naco formation. The scope of this paper is limited to consideration of the orebodies in the Abrigo formation, and their associated metamorphic rocks. The metamorphism associated with the mineralization has affected not only the middle member of the Abrigo formation, but also the impure dolomites of the upper member of the Abrigo formation and the lower half of the Martin formation.

STRUCTURE

Faulting

The sedimentary rocks are broken and displaced by three groups of fractures: The Northeaster faults, the Easter faults, and the Northwester faults.

Included in each of these three groups are not only faults with appreciable displacement, but also numerous non-displacing fractures that have the same characteristics as the faults except displacement. Included in the Northeaster fault group, for instance, are about 30 known faults with displacements, and some 200 identical fractures without displacement.

The Northeaster faults are normal faults striking N 15° - 20° E and dipping 65° - 75° E. On those faults of the group that have appreciable displacement, the movement has been directly down the dip of the fault surface. Two faults of the group displace the beds by as much as 200', but for the others the maximum displacement is 40', with the great majority having no displacement at all.

Vuggy, symmetrically banded quartz-orthoclase veins up to one foot wide are common in Northeaster fractures where the walls are either ore or metamorphic rocks, but in unmetamorphosed sediments there is usually only a slightly silicified zone a few inches wide. Chalcopyrite, pyrite, bornite, scheelite, argentiferous tetrahedrite, fluorite, wolframite and galena have been found in the veins. The last four of these are found only in the Northeaster veins; they do not occur in the bedded orebodies. No zinc minerals are found in the veins. The veins are nowhere wide enough to constitute orebodies in themselves, and the sulfides are abundant in them only where the walls of the veins are ore of the bedded orebodies. The sulfides are later than the vein silicates, since they mould around silicate crystal faces and replace silicates along fractures. The walls of most Northeaster fractures are chloritized to the depth of about 1", regardless of whether the fractures carry sulfides or other vein matter. On all of the displacing faults, and on many of the non-displacing ones, this chlorite is strongly sheared.

The faults of the Easter group strike N. 70° E, to S 70° E, and dip either about 45° S or 80° S. Most Easters are normal faults, offsetting the beds by as much as 250', but one major Easter is a reverse fault with offset ranging from 50' to 150'. At most places Easter faults consist of a zone of sheared chlorite a few inches to three feet thick, with occasional fragments of partially chloritized wall-rock embedded in the chlorite. Where the faults pass through orebodies, this main zone is sometimes bordered by a zone in which the ore wall rock has been shattered and then partially replaced by chlorite along the fractures. The chlorite in these zones is sheared like that of the zones of major movement, but the wall-rock fragments have been neither rotated nor moved any appreciable distance. In rare instances, at or near the intersections of the Easter faults with orebodies, chalcopyrite occurs in the fault zones, intergrown with unsheared chlorite. In one small area of an Easter fault zone, molybdenite occurs as a replacement of chlorite along shear surfaces.

Faults of both the Northeaster and the Easter groups are distributed fairly uniformly throughout the district. Northwester faults, however, are common only in the western end of the district, and are almost entirely absent toward the eastern end. The Northwester faults strike about N 10° W and dip steeply either east or west. The maximum known displacement is 150'. The Northwester fault zones sometimes contain quartz veins similar to those of the Northeaster faults, but more often they are simply sheared zones a few inches to a few feet in width.

Movement on all three groups of faults was essentially contemporaneous, as is shown by the fact that faults of each group are cut and offset by faults of the other two groups at one place or another in the district. The initial development of the faults began before the metamorphism and mineralization, since faults of both the Northeaster and Easter groups locally influenced the distribution of the metamorphic rocks and ore. Ore fragments found in the shear zones of faults of all three groups demonstrate that some of the movement was later than the mineralization. The final fault activity in the district was the movement that produced the 100' and greater displacements on the major Easter faults, since these Easters offset all the faults of the other two groups that they intersect.

Folding

Superimposed on the regional monocline of the Paleozoic sediments are two sets of shallow warps - the Manto folds and the Winze folds. The axes of the two sets of folds are at right angles to each other: the Manto folds trend between due east and S 70° E and plunge 15° E, while the Winze folds trend about N 10° W and plunge 30° N. Folds in both groups are best developed in the ore-bearing beds, decreasing in intensity above and below these beds. Although all of the folds are very shallow, some of them are at least 700' long.

The most completely developed fold in the district is the Republic Manto fold, which along part of its length is an anticline some 150' broad with about 20' of closure. The four other known Manto folds are simply structural terraces not more than 60' wide (Fig. 2). The axial plane of the Republic Manto fold dips steeply south, but the axial plane attitudes of the other Manto folds are not known. All of the known Manto folds lie approximately parallel to the intersections of major Easter faults with the beds, but from 50' to 150' away from these intersections. The parallelism suggests that the two kinds of structures are genetically related. The Manto folds are somewhat earlier than the Easter faults, however, since in one case a Manto fold is cut off by a warped portion of an Easter fault.

The Winze folds are much less clearly defined than the Manto folds, and in some cases the presence of a fold is inferred from very limited evidence. The difficulty in outlining Winze folds stems principally from their extreme shallowness; the presence of numerous small faults further complicates the matter. The most well-exposed of the Winze folds is the Northeast Winze Fold, an anticline some 300' broad with closure of 15' (Fig. 3). Of the two other known Winze folds, one is a shallow syncline 150' broad, and the other is an anticline 75' to 150' broad with scarcely discernible closure. Where the folds cannot be directly mapped, their presence is inferred from changes of a few degrees in strike and dip of the bedding.

The axial plane attitudes of the Winze folds are unknown. The folds trend approximately parallel to the strike of the Northwester faults, but two of the Winze folds are 500' or more from the nearest Northwester fault, so a genetic relationship is doubtful.

Both the Manto folds and the Winze folds are offset by faults of the Northeaster and Easter groups, and therefore are older than those faults. There is no direct evidence as to the folds' ages relative to the Northwester faults, but probably the folds are older than those faults also. Since the faults are older than the metamorphism and mineralization, the folds must also be older, a conclusion that is borne out by the fact that nearly all of the ore and some of the metamorphic rocks of the district are localized in shoots lying along the axes of folds of both groups.

METAMORPHISM AND MINERALIZATION

Description of the Rocks

Two kinds of rocks resulted from the metamorphism at Johnson Camp; they are known locally as white tactite and garnetite. A third type of rock, formed during the mineralization phase rather than the metamorphic phase, is the ore itself.

The white tactite is a very fine-grained greenish-gray to white rock, composed of diopside, quartz and orthoclase. Diopside is the predominant mineral, making up from 40% to 80% of the rock, with either quartz or orthoclase or both making up the remainder. Diopside grains are subhedral to euhedral, and always less than 0.5 mm in diameter, while quartz and orthoclase form ragged intergrown masses with a maximum dimension of about 5 mm. In a few thin sections, thin beds of fragmental orthoclase are found.

The garnetite is a coarser-grained reddish rock made up of roughly 50% grossularite, 30% diopside, and 20% quartz and/or calcite. As in the tactite, the diopside is in very small subhedral to euhedral grains, while the quartz and calcite form irregular masses. Much of the grossularite occurs in bands composed of nearly pure grossularite, and in these bands it forms anhedral grains up to 5 mm. in diameter. Outside of these bands, where crystals did not interfere with each others' growth, the grossularite is euhedral. Two types of grossularite, both of them anisotropic, are always present. The older type which forms the cores of isolated crystals and makes up the bulk of the purer grossularite bands, is dodecahedrally twinned. The younger type, which forms euhedral rims around cores of the older type, is twinned in concentric bands parallel to the rims. This younger grossularite contains a relatively high proportion of manganese.

The ore of the district is markedly banded parallel to the bedding, with the sulfides and associated minerals being concentrated in bands from 2" to 14" thick, separated by bands of garnetite waste of similar thickness. Aside from scattered spots of sulfides, the garnetite bands are barren. The grade of the sulfide bands is approximately constant, so that the grade of ore broken depends largely on the relative thickness and number of sulfide bands and garnetite bands.

The minerals of the sulfide bands are sphalerite, chalcopyrite, tremolite, chlorite, calcite, pyrite, bornite, molybdenite, scheelite, magnetite and hematite. These minerals always occur together, and in thin section they are seen to be always younger than the minerals of the metamorphic rocks. They form a genetic group distinct from the metamorphic minerals. Sphalerite and chalcopyrite are the most abundant minerals of the group, making up the bulk of the volume of the sulfides bands. Tremolite, chlorite and calcite are the most consistently abundant of the non-metamorphic gangue minerals; only scattered crystals of the others are found in most of the ore.

Within the sulfide bands, which are more or less continuous over the entire length and breadth of a single orebody, sulfides often form nearly solid masses, with only scattered grains of gangue minerals. The only garnetite minerals present are corroded crystals of grossularite and occasional remnants of diopside grains. Since the intervening garnetized beds were so unfavorable for sulfide deposition, it is probable that the beds that now contain the sulfides were at no time very thoroughly garnetized. This conclusion is supported by the fact that at the edges of orebodies, sulfide bands often grade out into ungarnetized limestone, while the garnetite bands continue several feet or several yards beyond the ends of the sulfide bands.

Outside of the orebodies, sulfides occur in scattered small spots in both garnetite and white tactite. For the most part these spots are concentrated in particular beds of the metamorphic rocks, and the bulk of the rocks are barren. In these disseminations, as in the orebodies, the sulfides and their associated minerals are always younger than the metamorphic minerals.

Distribution of the Rocks

Stratigraphy was a highly important factor in localizing both the white tactite and the garnetite. Garnetite was formed only in the limestones of the Middle Abrigo and in limy lenses of the Lower Abrigo, while with rare exceptions, white tactite was formed only in the impure dolomites of the Upper Abrigo member and the lower half of the Martin formation. The known exceptions to this latter rule are two areas in which Middle Abrigo limestones, which would normally be garnetized, are tactitized in the footwall of major Easter faults. The most notable such area is in the Republic Mine, where a pipe of white tactite 150' thick (stratigraphically), 200' wide (down the bedding dip) and 1500' long lies under the Republic Fault, an Easter Fault. (Fig. 2).

Within the beds favorable for its formation, the white tactite is much more widely distributed than are the garnetite or the ore in their favorable beds. Throughout the district, most of the beds of the impure dolomites have been altered to quite uniform white tactite, regardless of variations in proportions of silica and dolomite from bed to bed in the original sediments. The beds most resistant to the tactitization were the purer quartzites and dolomites. In some areas, particularly above orebodies, even these resistant beds are thoroughly tactitized. Except for these more intensively metamorphosed areas, the susceptible beds are uniformly tactitized throughout their known extent - about 10,000' along the strike and 2,000' down the dip.

The limestones were much less uniformly metamorphosed. Although the entire thickness of the Middle Abrigo and part of the Lower Abrigo were garnetized around the area of abnormal tactitization below the Republic Fault, only the uppermost 50' of the Middle Abrigo were consistently favorable for garnetization. These beds, from the bottom up, are 30' of limy sandstone; 20' of coarse-grained limestone; and 25' of similar limestone with numerous shale beds up to 3" thick. The top of the uppermost bed is the contact with the tactized Upper Abrigo. Usually only the sandstone and the non-shaly limestone are garnetized, but in some disturbed areas the shaly limestone also is garnetized. The beds below the sandstone are rarely altered. Even within these beds most susceptible to garnetization, large areas are essentially unaltered: outside of the abnormally metamorphosed areas, nearly all of the garnetite is confined in distinct shoots.

Four garnetite shoots are known in the district: the Northeast Winze and 760 Garnetite Shoots in the Republic Mine (Fig. 4), and two others in and near the Moore Mine, at the western end of the district. Three of these shoots contain ore as well as garnetite. The shoots are at least 500' long and from 100' to 300' wide. The thickness ranges from 50' in places where only the most susceptible beds are garnetized, to 75' where the overlying limestone as well is garnetized. Within the shoots, most of the rocks are thoroughly garnetized, except some of the purer bands of the sandstone bed and the ore-bearing portions of the shoots, where as much as 50% of the rock may be ore. The hanging and footwalls of the shoots are bedding planes, and therefore quite regular, but the edges are very irregular in cross-section, since the extent of garnetization along individual thin beds is variable.

The long axes of three of the garnetite shoots trend N 10° W, and in each of these shoots the outline of Winze folds can be discerned locally, but the folds are too shallow to be traced continuously along the entire length of the shoots. The fourth garnetite shoot is known only from diamond drill hole exposures, so no fold can be distinguished. The shoot trends easterly, however, so it probably lies along the axis of a Manto fold.

The mineralogical composition of the metamorphic rocks, as well as their distribution, demonstrates the importance of stratigraphy in their localization. The white tactite, which is composed largely of the magnesian mineral diopside with two exceptions was formed only from dolomitic sediments. The garnetite, composed largely of the limy non-magnesian mineral grossularite with minor amounts of diopside was formed only from limy sediments. The distribution of the metamorphic rocks within their chemically favorable beds is also in part a reflection of stratigraphic characteristics: permeability and competence. The dolomites were evidently highly permeable at the beginning of metamorphism, since they were widely tactitized. Whether this permeability was due to porosity or to shattering, i.e. competency, is not known. The limestones, on the other hand were not generally permeable, but because of their competency they were shattered along zones of structural deformation. The garnetization, therefore, was limited to well-defined zones where the metamorphosing solutions were able to penetrate the rocks along the deformed zones.

Structures were evidently of minor importance in localizing the white tactite, except in the cases of the anomalously tactitized areas of the Middle Abrigo. Here, faults seem to have acted as barriers, but their exact mechanism, and the chemical processes that took place, are not known. In the dolomites, where white tactite was the normal result of metamorphism, the only indication of structural control is the presence of areas more intensively tactitized then usual above ore and garnetite shoots.

Both faults and folds localized garnetite masses, and the total volume of garnetite localized by each kind of structure is about the same. However, the garnetite localized by a fault is all in one large mass, beneath the Republic Easter Fault, while there are four separate shoots of garnetite localized by folds. In general, therefore, it may be said that folds are more common than faults as localizing structures for garnetite.

For practical purposes, the ore like the metamorphic rocks, can be considered partially localized by stratigraphy: with three small exceptions all of the orebodies lie in the uppermost 50' of the Middle Abrigo member. The most persistently ore-bearing bed is the non-shaly limestone that is also commonly garnetized, but locally ore extends into the beds above and below.

All of the orebodies, without exception, lie within garnetite masses, the sulfides being interlayered with the uppermost beds of garnetite. The orebodies associated with distinct garnetite shoots such as the Northeast Winze and 760 Winze Orebodies of the Republic Mine have the same general size and outline in horizontal projection as do their containing garnetite shoots (Fig. 4). The orebodies in the anomalously metamorphosed area of the Republic Mine are much smaller than the garnetite mass, but their axes are parallel to the long axis of the area. The three orebodies occurring outside of the main ore-bearing beds are in this area. They lie in two lower beds of the Middle Abrigo, but because the Middle Abrigo is here anomalously tactitized, they are nonetheless in the uppermost part of the garnetite (Fig. 2).

This confinement of ore to the topmost garnetized beds, whatever their stratigraphic position may be, suggests that the top of the garnetite, rather than any particular bed, forms the favorable ore zone. Throughout most of the district, however, only the beds near the top of the Middle Abrigo are garnetized, so that in general the ore may be considered somewhat distantly localized by stratigraphy.

Most of the orebodies of the Middle Abrigo are elongate lenses from 12' to 40' thick and 35' to 300' wide. The length ranges from 150' to 800'. The orebodies lie along the axes of either Manto or Winze folds, and their dimensions are largely reflections of the character of the folds containing them. Orebodies lying in the broad shallow Winze folds are wide and thin, while those lying in the narrower, tighter Manto folds are narrow and relatively thick. An exception to this general rule is the West Orebody of the Republic Mine, which is a broad irregular lens with variable thickness (Fig. 4). Its irregularity probably results from the fact that it lies at the junction of the Republic Manto Orebody and the 760 Winze Orebody, and therefore has some of the characteristics of both, plus features not found in either.

In all the ore of the district, the sphalerite contains numerous blebs of chalcopyrite ranging in size from 0.003 mm. to 0.1 mm. in diameter. The pattern formed by these blebs within individual sphalerite crystals is roughly the same throughout the district, but it varies in one feature. Around the edge of each crystal is a narrow zone, some 0.2 mm. wide, in which there are no blebs, and within this is a zone about 0.7 mm. wide in which blebs are abundant. In this intermediate zone, the blebs increase in size from the outer edge inward. The variations in the pattern of the blebs appear in the centers of the grains, within the intermediate zone. In the deeper portions of orebodies, the grain centers are nearly filled with large blebs, but in shallower ore the blebs are smaller and less numerous. In some of the very near-surface ore, the centers of the sphalerite grains contain no chalcopyrite at all. This change in the pattern of chalcopyrite blebs is recognizable not only from ore body to orebody, but also along the length of individual ore bodies. Thus in the Republic Mine, the sphalerite cores in the deepest workings on the Northeast Winze Orebody contain numerous large blebs; higher up in the same shoot the blebs are smaller. This progressive change does not stop at the top of the Northeast Winze Orebody, where the ore takes a sharp change in direction and acquires a new name - the

Republic Manto Orebody. Along the length of this orebody, the diminution in bleb size continues, showing that the Northeast Winze and Republic Manto Orebodies are genetically a single orebody, in spite of the marked difference in their shape and direction.

Stratigraphy was as important in the localization of the ore as it was in the localization of the metamorphic rocks, although in the case of the ore it may have acted in a rather roundabout way. The primary action of stratigraphic features was to localize the garnetite within certain beds, and this garnetite in turn localized the ore.

The structural localization of the ore within the favorable beds is much more closely tied to the folding than to the faulting. Only one orebody, a small pipe in the Mammoth Mine, was definitely localized by a fault: it lies along the intersection of a Northeaster fault with the ore beds. The orebodies in the anomalously metamorphosed area of the Republic Mine lie near and parallel to the Republic Easter Fault, but with the exception of the West Orebody all of them are unquestionably in the crests of Manto folds so these folds, rather than the fault, must be considered the localizing structures. The relationship between orebodies and Winze folds is less clearly demonstrable, because the Winze folds are so shallow that they are recognizable in only a few places.

The presence of sulfides in some of the Northeaster Fault veins suggests the possibility that these structures were the ore localizers for the Winze orebodies. There are four lines of evidence against such a hypothesis, however: (1) They are about as abundant in barren portions of the ore beds as they are in orebodies. (2) Neither ore nor garnetite extend into the footwall along the faults, as they would be expected to do if the ore solutions used the faults as channels to flow across the bedding. (3) The change in the pattern of chalcopyrite blebs in sphalerite indicates that the ore solutions flowed along the present length of the orebodies, rather than flowing up faults and then spreading out in the favorable beds. (4) The orebodies are not parallel to the Northeasters, but rake across them at an angle of about 40°; if ore solutions flowing along the beds used the fault zones as channelways, they would in all probability follow the same faults all the way up, as did the solutions that formed the above-mentioned small ore pipe in the Mammoth Mine.

The bulk of the evidence indicates that the Northeasters were not the localizing structures for the Winze type orebodies. The Winze folds, shallow and indistinct though they are, evidently provided the channels for the ore solutions. The presence of the locally rare minerals in the Northeaster veins remains a knotty problem; possibly the chemical and physical conditions in the veins, being different from those in the beds, caused the ore solutions that chanced to pass through them to deposit an abnormal suite of minerals.

SUMMARY AND CONCLUSIONS

The alteration in that part of the Johnson Camp district under consideration here can be considered as a two-stage process. In the first stage, no new material was added to the rocks, and only the two metamorphic rocks, white tactite and garnetite, were formed. In the second stage, large quantities of exotic material, principally sulfides, were introduced, and the ore was formed.

Both stratigraphy and structure were important in localizing the metamorphic rocks and the ore. As a result of differences in the chemical composition of the sediments, white tactite was localized in the dolomitic beds of the Upper Abrigo member and the lower half of the Martin formation, while garnetite was confined to the limy Middle Abrigo member. Other stratigraphic characteristics of the sediments, permeability and competency, in part controlled the distribution of these rocks within the beds chemically favorable for their development. The ore also was localized within particular beds, chiefly because parts of these beds were favorable for the earlier garnetization.

All of the structural features of the district are older than the metamorphic rocks and the ore, and therefore were potentially able to localize the rocks and ore within the favorable beds. Faults localized some of the metamorphic rocks, but in general were not effective in localizing ore. The important ore localizers were shallow folds of both the Winze and Manto groups.

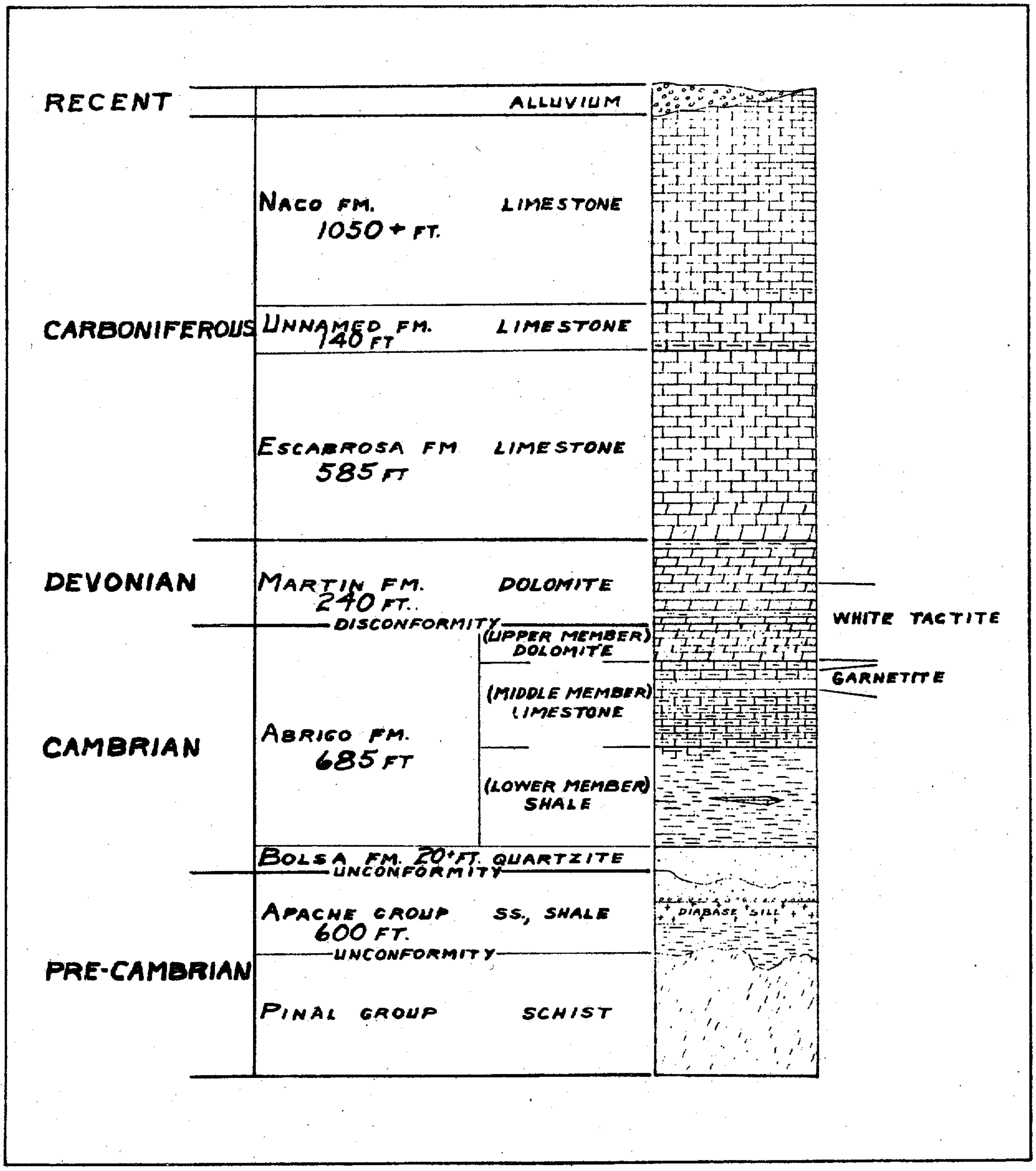

Figure 1. Stratigraphic column at Johnson Camp. (After Cooper)

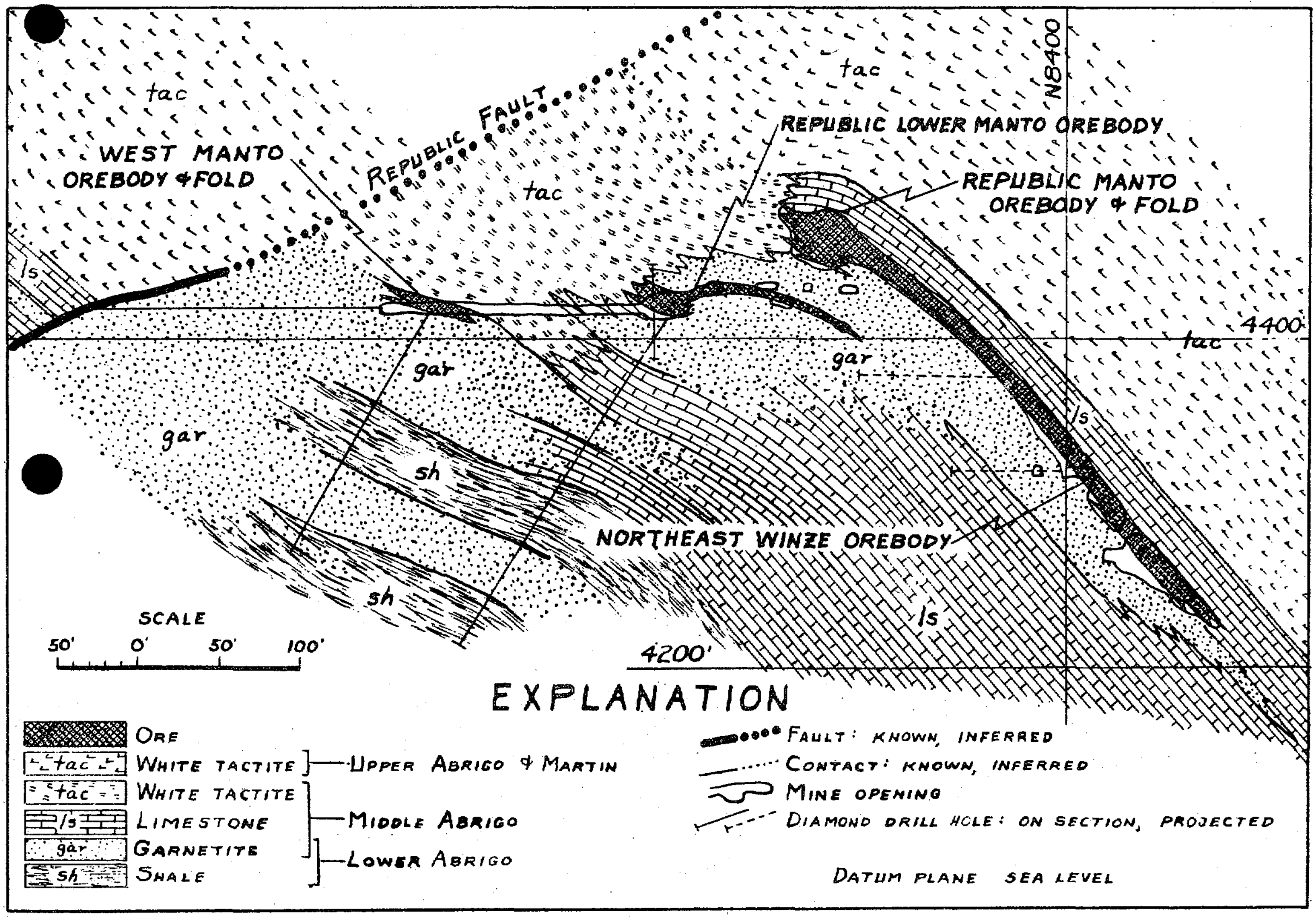

Figure 2. Cross-section through part of Republic Mine, showing relationship of metamorphic rocks and ore to structure and stratigraphy.

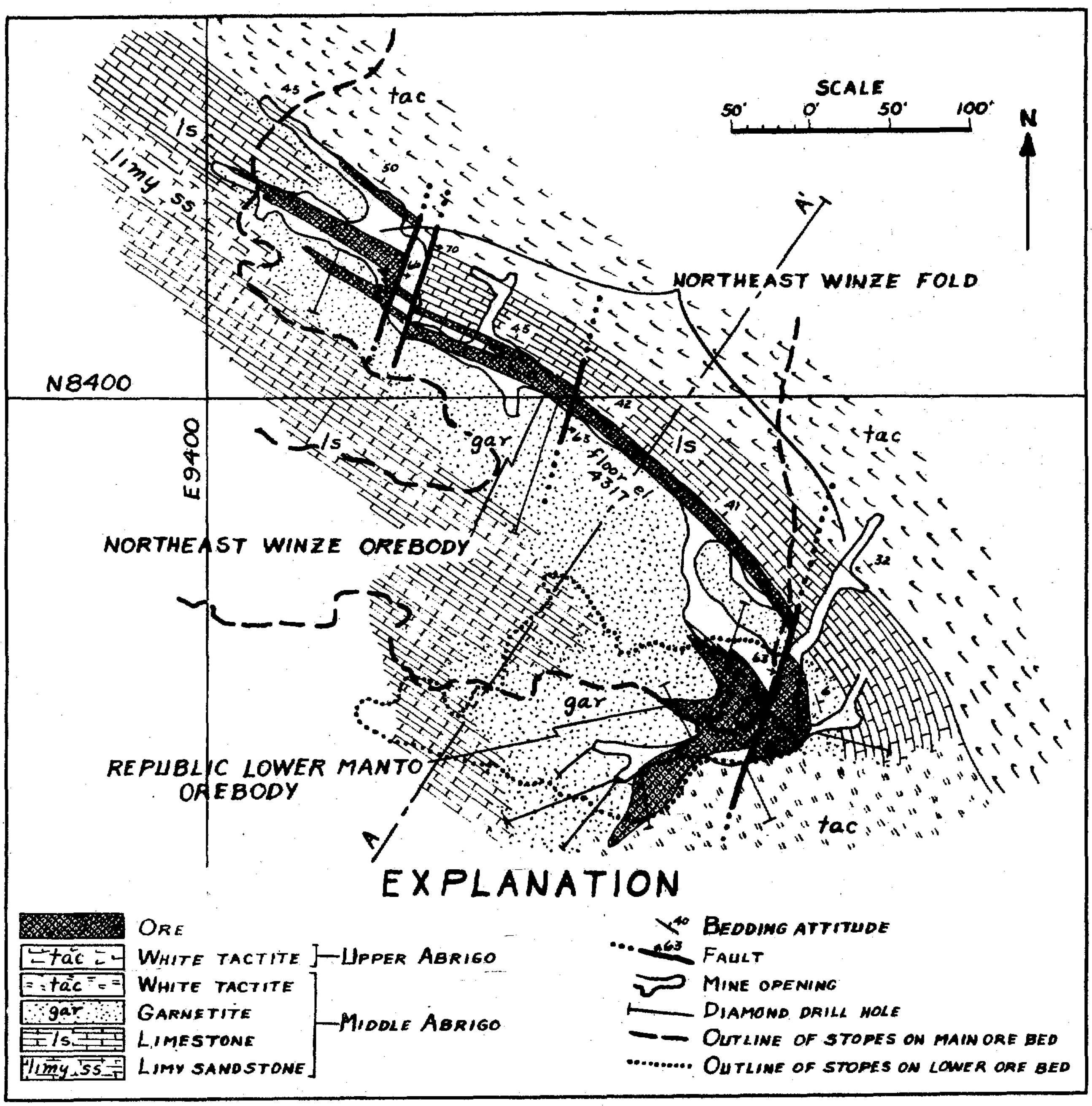

Figure 3. Republic Mine 1100 Level geologic map, showing relationship of metamorphic rocks and ore to structure and stratigraphy.

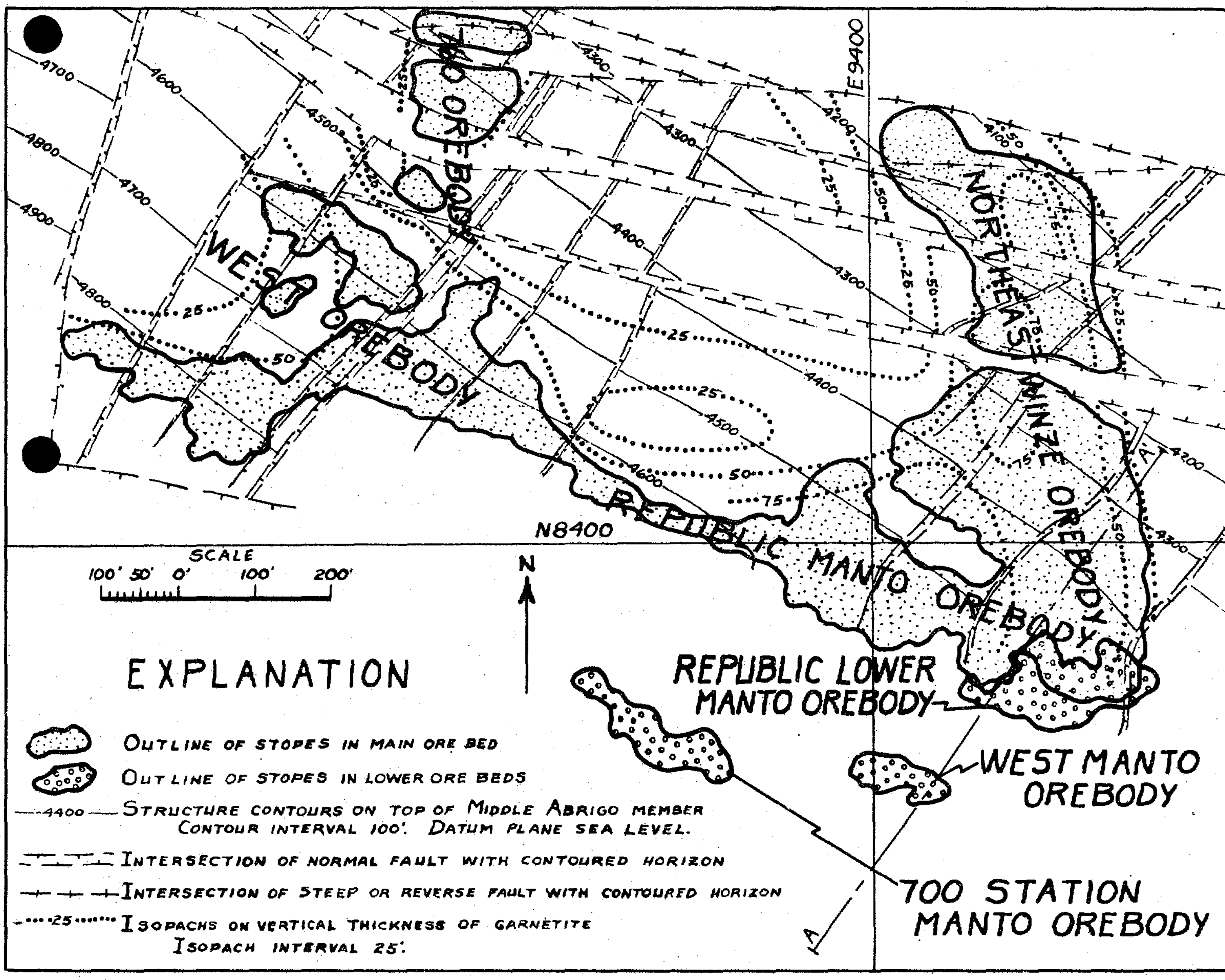

Figure 4. Republic Mine Area structure contour and garnetite isopach map, with outline of orebodies projected to horizontal plane.