CONTACT INFORMATION
Mining Records Curator
Arizona Geological Survey
3550 N. Central Ave, 2nd floor
Phoenix, AZ, 85012
602-771-1601
http://www.azgs.az.gov
inquiries@azgs.az.gov

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WEBB DISTRICT

Location:

We have applied this name to a broad area in the northern Gila Bend Mountains which contains several prospective areas of copper-precious metals mineralization. One of these is near Webb Mountain centrally located in the area of interest, so we have arbitrarily referred to the overall areas as the Webb district or region. The region is found west-southwest of the small community of Arlington, a few miles west of Buckeye and includes T2S, R7, 8 & 9W. The area of interest is included on the SW¼ of the Arlington, N½ of the Woolsey Peak and N½ of the Dendora Valley 15' quadrangles.

Geology and History:

The district occurs in an area largely capped by rather extensive outcrops of mid to late Tertiary volcanic rocks of felsic to intermediate composition and overlying buttes and mesas of $<$ 15 m.y. old basaltic flows and conglomerates such as make up the topographic points of Black Butte, Yellow Medicine Hills (Arlington quad.), or Yellow Medicine Butte (Dendora Valley Quad) and Woolsey Peak. The earlier volcanic sequence consisting of andestic-dacite flows, felsic tuffs and volcaniclastic sediments occurs as tilted fault blocks, whereas the basalts are relatively flat-lying.

Outcropping from beneath the volcanic cover are isolated exposures of Precambrian granitic rocks, gneisses and schists. Many of the intrusive rocks are diorites and granodiorites showing various degrees of foliation. The metamorphics include quartzites, muscovite, schists, amphibolite and metarhyolites which generally strike NNE with steep dips. They have been correlated with the Proterozoic Yavapai Series (Cheeseman, 1975), but in this area are probably better referred to as Pinal schist. Younger, Mesozoic to Tertiary dike rocks or small stocks are noted intruding the basement lithologies.

Mineralization in the area is not widespread, and based on population or density of occurrences, would not be considered at all (see precious metals overlay to Plate 1). The demarked region does, however, contain several specific mines or prospects which we feel warrant special attention. Some of this base metal-gold-silver mineralization (i.e. Black Butte prospect) may be of Precambrian age, related to the Pinal (Yavapai ?)schist and be of volcanogenic or exhalative origin. Other occurrences appear to be epigenetic, related to intrusive activity and localization along structural zones.

Mines of Interest:

<u>Black Butte prospect</u>: (T2S, R7W, Secs. 14 & 15) Small exposures of Precambrian gneiss and schist just north of the basalt capped Black Butte exhibit considerable alteration and disperse copper-gold mineralization. Mineralization is related to numerous veins, stockworks and "blowouts" of quartz and barite which appear concentrated along contacts between basic dikes and gneisses or granitic rocks. Better mineralization is also noted at the contact between Tertiary

volcanics and basement. The area has received attention as a copper prospect with extensive sampling and drilling. Surface sampling yields numerous values ⊳1 opt in gold, with copper ranging from 0.007 to 6.4%. Of seven holes drilled on the prospect, #4 ran from a trace to 0.59 opt Au; #7 encountered intervals assaying trace to 5.7 opt Au with Cu ⊳1%. In hole #7, 59 ft ran from 0.03 to 0.54 opt Au with several percentages of Cu. The best mineralization was encountered along a steeply dipping structural zone which may be conformable to foliation in the metamorphic host rocks. Currently the property is held by Rhyolite Resources, 301-1285 W. Pender Street, Vancouver, B.C., VBA 422, or Box 31, Black Point Road, Powell River, B.C., Canada.

Buckeye mine: (Sec. 28, T2S, R6W) Mineralization is concentrated along a highly sheared contact between foliate granodiorite and altered Pinal Series metamorphic rocks including quartz-sericite, magnetite, pyritic, schists, quartzite, amphibolite, metarhyolite and meta-andesitic tuffaceous rocks. The magnetite-quartz-muscovite schist unit with interbeds of marble and calc-silicate rock occurs stratigraphically just below one of the metarhyolite horizons and is the principal host rock for mineralization at the Buckeye copper mine. Note that some of the schist is tourmaline bearing.

Mineralization occurs as silicates and carbonates of copper with some sulfides at depth. These minerals occur in disseminations, small lenses, streaks and pockets along foliation planes in the schist and associated with strong quartz-tourmaline veining along the sheared, N10°E to N35°W-trending contact zone. Pyrite and chalcopyrite with minor bornite-chalcocite are the chief sulfide minerals. The contact zone yields several percent copper. No gold assays are reported but precious metals are present (CRIB data). The deposit may have volcanogenic origins with superimposed mineralization due to later intrusion.

Yellow Medicine Butte (Pumpkin Glow) Prospect: (T2S, R9W, Secs. 30 & 31) Mineralization is concentrated in a granitic breccia cemented by iron oxides which is localized along a major structural zone between granite gneiss and limestone. The structure strikes N75°W, dips 80° south and is from 20 to 100 ft wide. It is exposed intermittently over a strike length of at least 1,800 ft. Argentiferous galena is reported from the zone and a number of samples run from 1 to 4 oz in Ag. Gold values vary from less than 0.02 to as high as 0.13 opt. Black calcite veinlets permeate the zone. The property is currently held by a Jim Weatherby (602) 939-3961.

References:

Arizona Dept Mineral Resources, file data; Cheeseman, 1974.

STATE OF ARIZONA)
) ss.
COUNTY OF Maricopa

I do hereby certify that the within instrument was filed and recorded at the request of Del Tierra Engineering & Mining Corp on ______ A.D. 19 83, at ______ o'clock ____.m., Book ______ Official Records, page ______, Records of Maricopa County, Arizona.
WITNESS my hand and official seal the day and year first above written.

County Recorder By: Deputy

NOTICE OF MINING LOCATION
LODE CLAIM

NOTICE IS HEREBY GIVEN THAT
James E. Bond II, and Jim Roy Weatherby citizens of the United States, hereby claims the land hereinafter described as a Lode Mining Claim, under and pursuant to the laws of the United States of America and the State of Arizona, and, in making such claim and for the purpose of establishing its right thereto, hereby certifies: THAT ON the 30 day of Jan., 1985, the undersigned discovered a lode, vein or deposit of valuable minerals within the limits of this claim as hereinafter established.

THAT THE NAME of this claim is Pumpkin Glow # 17A

THIS CLAIM so located, being 1500 feet in length and 600 feet along the surface in width, claiming 300 feet on each side of the centerline; said claim measures lengthwise of the claim 1499 feet in a west direction and 1 foot in an east direction from the location monument, at which a copy of this notice is posted; said location monument being offset 1 foot from the S.E. corner of this claim. The general course of the claim is East to West.

THE UNDERSIGNED has distinctly marked the said location on the ground, so that its surface boundaries may be readily traced, by six substantial posts 2" x 2" x 4'6", one at each corner and one at each end center, each so marked or inscribed as to indicate the intended location.

SAID CLAIM is situated in the Webb Mining District, Maricopa County, State of Arizona, and is more particularly described as follows:

BEGINNING AT the Northeast corner monument, which is located north, 1451 ft. and east, 457 ft. from the B. M. 1225 in unsurveyed Section 30, Township 2 North.,

Range 9 West., G.& S.R.M.; thence,

300 feet S. 15 W. to the East end center ; thence
300 feet S. 15 W. to the SE corner ; thence
1500 feet N. 75 W. to the SW corner ; thence
300 feet N. 15 E. to the West end center ; thence
300 feet N. 15 E. to the NW corner ; thence
1500 feet S. 75 E. to the point and place of beginning.

Said claim is located in the:
S.E. 1/4 of Sec. 30, Twp. 2 North, Range 9 West.
S.W. 1/4 of Sec. 30, Twp. 2 North, Range 9 West.
______ 1/4 of Sec. ____, Twp. 2 North, Range ___ East.
______ 1/4 of Sec. ____, Twp. 2 North, Range ___ East.
Gila & Salt River Meridian.

DATED and posted on the ground this 30 day of Jan., 1985.

Locator: James E. Bond II and Jim Roy Weatherby
P. O. Box 948
Welch, WV 24801

By: [signature]
Agent

4-12-85

Gila Bend Mtns.

· Black Butte mine

– massive qtz veins 1-2' wide w/ trace Cu Ox stain assoc/ w/ siliceous dikes. Sericite ± clay adjacent to veins but only for 1-2'. Country rock essentially unaltered mafic flows

NICOR MINERAL VENTURES

One of the NICOR basic energy companies

Suite 12 2341 South Friebus Avenue Tucson, Arizona 85713 602-881-8871

April 1, 1985

Mr. J.A. Stewart
Rhyolite Resources, Inc.
RR #1, Box 31
Black Point Road
Powell River, B.C.
V8A 4Z2

Dear Mr. Stewart:

NICOR Mineral Ventures, Inc. is actively exploring for precious metals in western Arizona and throughout the continental U.S. with offices in Tucson, Reno, Denver, Spokane, Missoula and Charlotte. NICOR Mineral Ventures, Inc., is a wholly owned subsidiary of NICOR Inc., a diversified energy company listed on the N.Y.S.E.

It has come to our attention that your firm controls the Black Butte Property in the Gila Bend Mtns, Maricopa County, Arizona. We would be most interested in obtaining more information on this property, particularly the results of any drilling which you have done. Is Sunatco Development Corporation still your partner on this property?

If this property meets our requirements we may be interested in possible joint venture participation which might ultimately lead to production. Thank you in advance for your consideration in this matter.

Sincerely,

Gary A. Parkison
Senior Geologist

GAP:psp

ROCOCCO RESOURCES LTD. (RCO-V)

[redacted] have agreed to acquire from Northwest Scientific International of [redacted]

Bukaye -

804 - 837 W Hastings

R 6W

T 25

13 12
24 25

Webb mining
Moncoqua

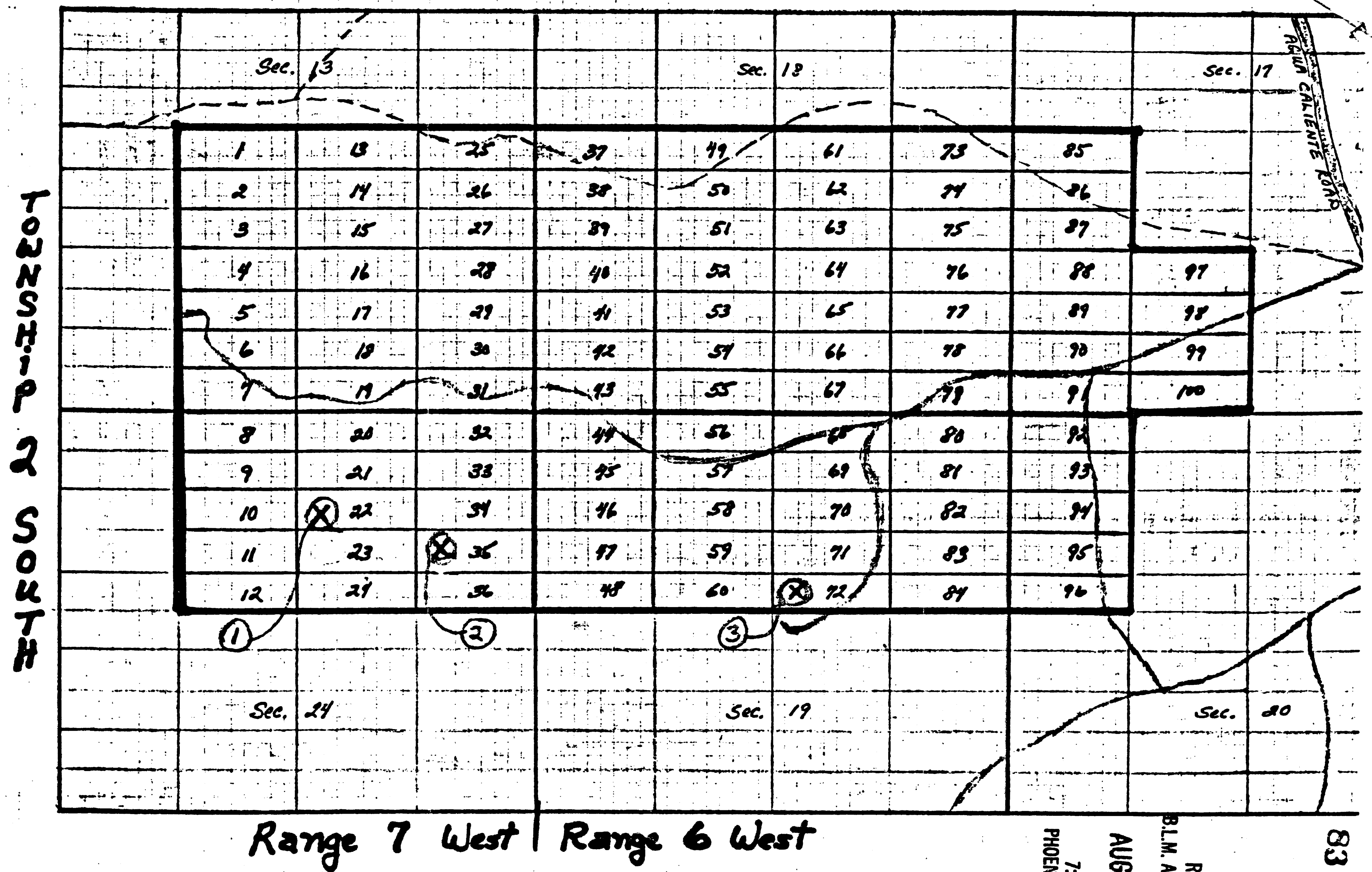
Gary

Area next to Jack Lovelocks land - owned by Webb Mining?

Jack E. Lovelock
PRESIDENT

Permian Resources Ltd.
203 - 1285 West Pender Street,
Vancouver, B.C. V6E 4B1
Telephone (604) 687-4297

Exhibit "A"



Maricopa County
Webb District

B-J Claims

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B.L.M. AZ STATE OFFICE
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PHOENIX, ARIZONA

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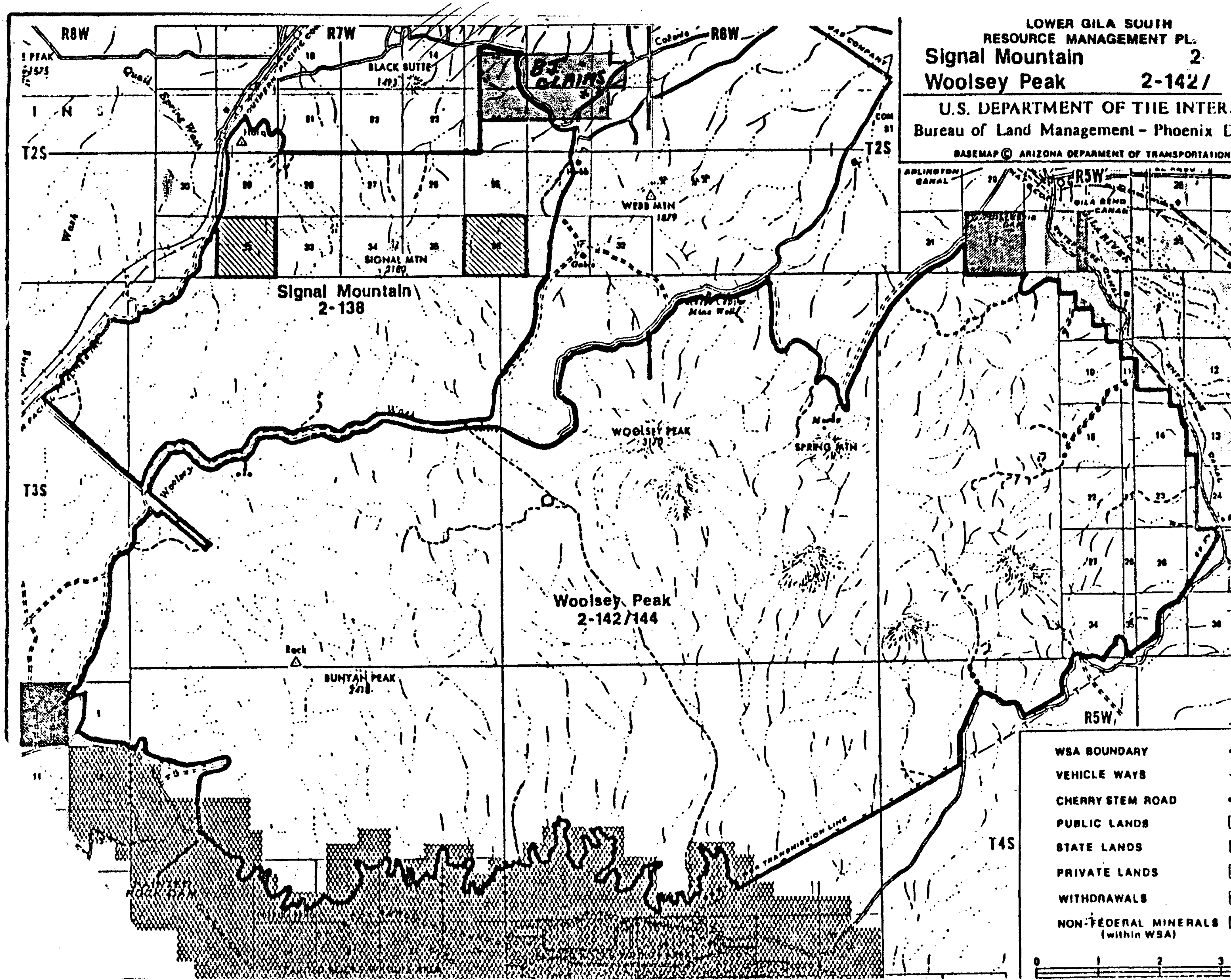
LOWER GILA SOUTH
RESOURCE MANAGEMENT PL.
Signal Mountain 2
Woolsey Peak 2-142/
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Bureau of Land Management - Phoenix D
BASEMAP © ARIZONA DEPARMENT OF TRANSPORTATION
R8W
R7W
R6W
R5W
T2S
T3S
T4S
BLACK BUTTE
BJ CLAIMS
WEBB MTN
1879
SIGNAL MTN
2180
Signal Mountain
2-138
WOOLSEY PEAK
SPRING MTN
Woolsey Peak
2-142/144
Rock
BUNYAN PEAK
ARLINGTON CANAL
GILA BEND CANAL
TRANSMISSION LINE
WSA BOUNDARY
VEHICLE WAYS
CHERRY STEM ROAD
PUBLIC LANDS
STATE LANDS
PRIVATE LANDS
WITHDRAWALS
NON-FEDERAL MINERALS
(within WSA)
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THE GEOLOGY OF THE WEBB MOUNTAIN DISTRICT,
GILA BEND MOUNTAINS, MARICOPA COUNTY,
SOUTHWESTERN ARIZONA

A Thesis in Geology

in Partial Fulfillment

of the Requirements for the Degree

Master of Science

(Geology)

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by

Raymond J. Cheeseman

Approved:

Richard F. Holm

Charles W. Barnes

David S. Brumbaugh

Research Committee

North Az Univ.

Date: January 21, 1975

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LIST OF ILLUSTRATIONS

ACKNOWLEDGEMENTS

~~This writer~~ I would like to extend thanks for the generous assistance given by ~~the~~ my thesis committee, Drs. Charles Barnes and David Brumbaugh. Thanks are also due to Mr. Glenn Walker of the Arizona Department of Mineral Resources and Dr. Richard Moore of the Arizona Bureau of Mines for background material and research suggestions.

Much gratitude is due to my advisor, Dr. Richard F. Holm, without whose excellent technical advice this thesis might never have been completed. Finally, thanks are due to my wife, Valerie, for her patience, and to my typist, Mrs. Lynda Sowers, and my illustrator, Mrs. Sue Alley Davis, for their assistance.

INTRODUCTION

Purpose and Scope

A study of the igneous, metamorphic and volcanic rocks in the Webb Mountain District was undertaken to determine the petrology, structural history and economic geology of the area. The mapped area includes almost ten square miles near the town of Arlington, Arizona, 6 miles west of Gillespie Dam.

Rocks Studied

Precambrian metamorphic and plutonic rocks, Mesozoic(?) plutonic rocks, and Cretaceous and Cenozoic volcanic rocks were studied. Portions of the metamorphic rock unit may be correlated with the Yavapai Series of Older Precambrian age. The metamorphic rocks include quartzite, mica schist, metarhyolite, and amphibolite.

A granodiorite body was emplaced in the metamorphic rocks, and also may be Older Precambrian. It is not entirely clear whether this pluton has intrusive or fault contacts with the metamorphic rocks.

Intrusive into the granodiorite ~~is~~ A quartz monzonite stock is and a quartz diorite stock intrudes both the granodiorite and quartz monzonite. Dikes and plugs of a younger, mineralized ~~younger~~ quartz monzonite intrude the quartz diorite. ~~The age of the mineralization is that of the younger quartz monzonite or slightly younger.~~ The age ~~is~~ of the younger qtz mon bracketed by the Older Precambrian and Late Cretaceous. Late Cretaceous to Early Tertiary volcanic rocks, from andesite to dacite, occur at the western boundary of the area. Quaternary basalt is also present.

Field and Laboratory Work

Approximately two months were spent in the field collecting samples and mapping. Field work was initiated in the fall of 1973 and was conducted periodically until the summer of 1974. Field data were recorded on a 1:24,000 orthophotoquad ~~obtained from the Arizona Resources Information System~~. Laboratory work consisted mainly of petrographic examination of thin sections, and compilation of structural measurements.

Location and Accessibility

The Webb Mountain mining district is located in Woolsey Peak Quadrangle in the Gila Bend Mountains, Maricopa County, southwestern Arizona. The approximate coordinates of the mapped area are 112° 50' W. and 33° 14' N. Access from the east ~~to the mapped area~~ is by Buckeye Road to Hassayampa, Old U.S. 80 to Arlington, and through the El Paso Natural Gas plant "Certified Free Area" (6.5 miles Southeast of Arlington on Old U.S. 80) (Figure 1).

The Buckeye Copper Mine, abandoned since about October, 1929, is in the approximate center of the area. The Buckeye Copper Mine well is on the southern boundary, and Webb well is on the

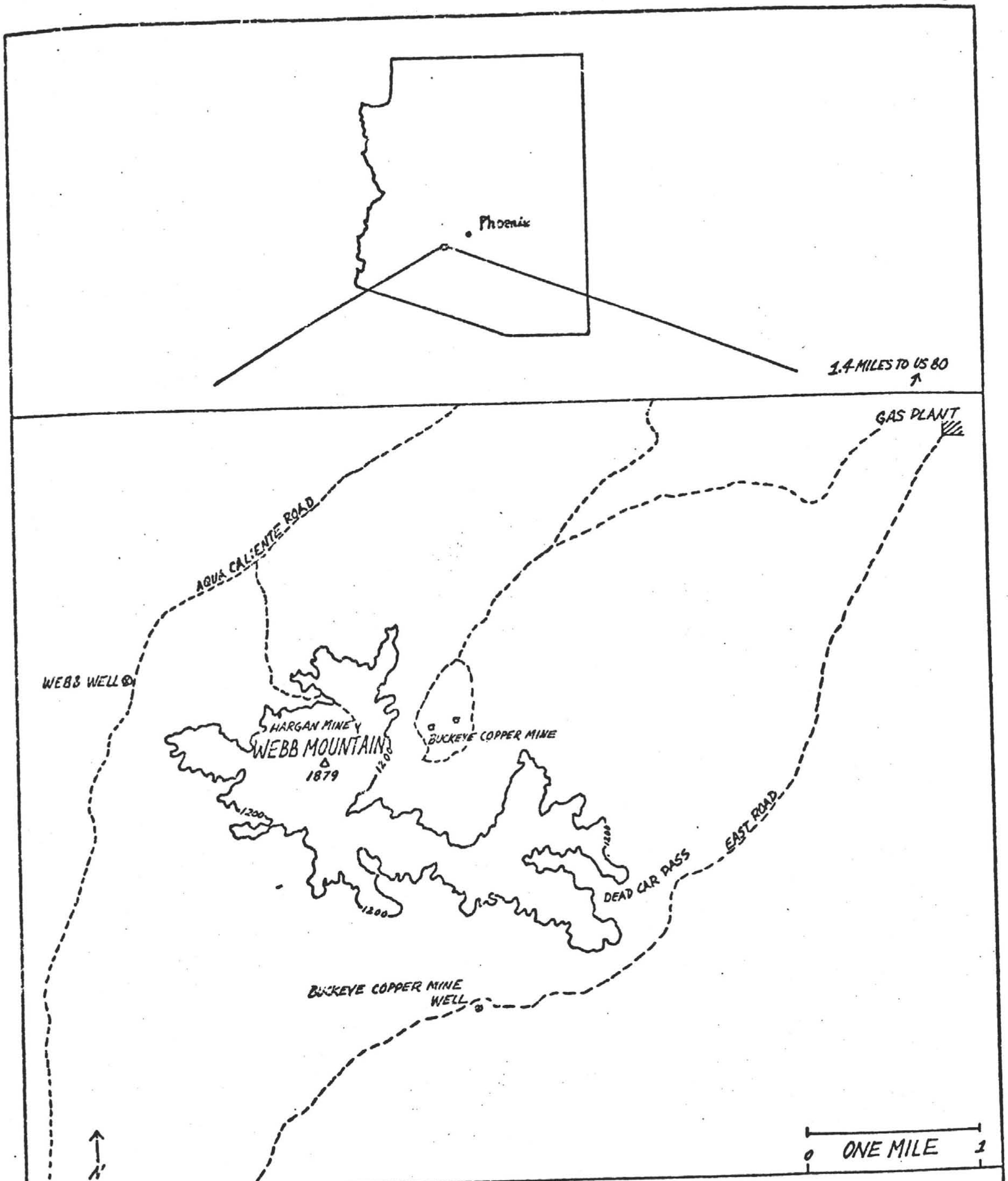

Figure 1

Index Map of Arizona showing location of Webb Mountain western boundary. The Dead Car Pass marks the eastern boundary and the Agua Caliente Road is at the north boundary.

Previous Investigations

Prior to this study, virtually no detailed geological work and no petrographic work had been done in the area immediately southwest of Phoenix and Buckeye. The only investigations in the area were those of the Arizona Bureau of Mines (Moore, ~~R. T.,~~ 1957) and by the Buckeye Copper Company, Inc. in 1925 to 1927. ~~Dr. Moore's work resulted in a contribution to the compilation of the Geologic Map of Maricopa County, as well as that of Arizona.~~ With reference to the Buckeye Copper Company, Inc., all that seems to be available is a one-half page report in the Mines Handbook of 1926. No detailed mapping of this area is extant, and possibly none was ever done.

REGIONAL SETTING

The Gila Bend Mountains form a west-northwest trending physiographic unit approximately thirty-five miles long in the Basin and Range province of southern Arizona. In southern Arizona the ranges are fault block mountains bounded by normal faults. The ranges are composed of Precambrian schists and gneisses capped with Cretaceous and Cenozoic volcanic rocks (Figure 2).

Basin and Range Province

The Webb Mountain area lies within the Desert Region of the Basin and Range Province of Arizona (Wilson, 1962, fig. 13, p. 86). According to Anderson (1966), the Basin and Range normal faults have a regional north to north-northwest trend, but in southwestern Arizona the trend locally is west-northwest.

The basins and ranges are twenty to thirty-five miles long, parallel, and consist of fault blocks that commonly are tilted. The Basin and Range orogeny extended from early or middle Miocene into Pliocene time (Lance, 1960, p. 155-159).

Gila Bend Mountains

The Gila Bend Mountains are fault block mountains capped with volcanic rocks. Within the Gila Bend Mountains, the most common topographic feature is the volcanic peak. The topographic quadrangle is named for Woolsey Peak and this unusually shaped mountain of Quaternary basalt dominates the landscape (Figure 3).

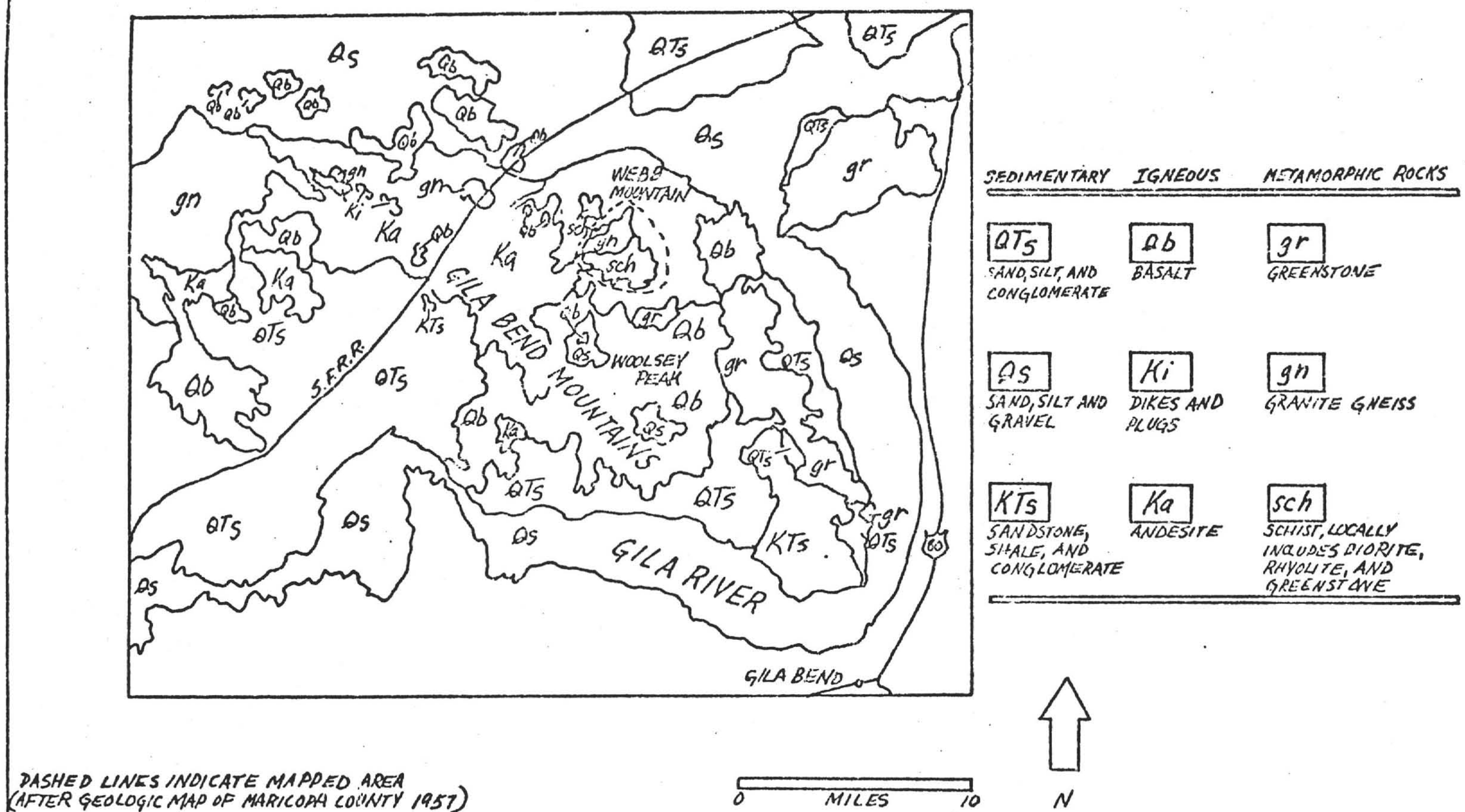

Figure 2

Geologic Map of Gila Bend Mountains showing location of Webb Mountain and Woolsey Peak

Figure 3

Woolsey Peak, at left. (View is to South)

Isolated exposures of Precambrian schist and gneissic plutonic rock are surrounded by Cretaceous and Cenozoic volcanic rocks. The most prominent and angular peaks generally are composed of Quaternary basalt. The more subdued hills tend to be Cretaceous andesitic, and rhyolitic, dikes and plugs. Older Precambrian granitic gneiss occurs on the far northwest end of the range, and granite of younger Precambrian age occurs to the southeast near the town of Gila Bend.

A drill hole in Quaternary alluvium in the plains just to the east of Dead Car Pass was extended more than a thousand feet without reaching bedrock. This drill hole was made for the siting of the alternate site of the Arizona Nuclear Power Plant (Fugro, Inc., 1974, oral comm.).

METAMORPHIC ROCKS

The oldest rocks in the area are ~~the~~ a metamorphic series of ~~These metamorphosed~~ Precambrian rocks, which include a mafic intrusion and at least two rhyolitic lava flows. They are exposed throughout the eastern half of the area. These metamorphic rocks correspond with the southeast area labeled schist by Moore (1957) on the Maricopa County geologic map.

The top of the sequence is a metarhyolite flow, termed Flow A in this ~~paper.~~ circular. Flow A crops out mainly near Dead Car Pass, in a small area three and ~~a~~ one-half miles southwest of the El Paso Natural Gas Compressor Station on the east road. Another metarhyolite, termed Flow B, crops out in the south-central part of the area.

A quartzite, which occurs just below ~~the metarhyolite~~ (Flow A), is exposed further west along the pass. The quartzite, about 200 feet ~~in thickness,~~ thick, includes a conglomerate bed which ranges from 2 to 14 feet in thickness with quartz pebbles from 1/8 inch to one inch in diameter. Graded bedding in this unit demonstrates that the top is to the east.

Two amphibolite layers are next lower in the section and occur between the quartzite and a mica schist. The schist is the dominant rock in the series, and crops out for more than 2 square miles in the south and southeastern part of the area. Crenulated sericite schist occurs within this mica schist in the central area.

The metamorphic history began with a regional metamorphism in the epidote-amphibolite facies. Structures formed in the crenulated sericite schist include the S_1 original sericite foliation, accompanied by aligned quartz, biotite and tourmaline. After the granodiorite intrusion, a shearing and recrystallizing event affected the metamorphic rocks and the intrusion. This later event formed S_2 structures such as axial planes of the crenulations, and the strain-slip cleavage, which is parallel to the axial planes of the crenulations. Tourmaline crystals were bent at this time.

Metarhyolite

Field Relationships. Approximately 5 percent of the eastern half of the study area is metarhyolite. It occurs in two flows, termed A and B in this paper. Flow A crops out mainly in Dead Car Pass and composes two small hills on either side of the pass.

Flow B occurs in the south-central part of the area, near the contact of the gneissic rocks with the mica schist. Flow B is in most places a lens-shaped bed which ranges from 16 to 70 feet in thickness (Figure 4a). Two quarries have been excavated at the site of the maximum exposure of Flow B.

Flow B is actually a composite unit made up of four different flows, although metarhyolite constitutes about two-thirds of the volume. Other lithologies included are two very siliceous flows, one pale green and one white, and a thin meta-andesite layer.

Figure 4a

Metarhyolite, Flow B, at top right and middle left.

Metamorphic andesitic tuffaceous rocks intertongue with the Flow B metarhyolite. Andesitic metamorphic rocks are dark green with abundant chlorite and biotite. A layer of metamorphosed andesitic rock about 2 feet thick is exposed above the prospect pit about a half-mile northeast of the Buckeye Copper Mine.

In hand specimen, the rhyolitic rocks are light beige to white in color, and have a porphyroclastic texture. Flow A tends to be brown on the weathered surface, whereas Flow B is a very light pink or white.

Flow A, Petrography. Petrographic examination confirms the porphyroclastic appearance, though original flow structure predominates over cataclastic texture. Large potassium feldspar and quartz grains appear within a fine-grained matrix of quartz, potassium feldspar, and sericite. Chlorite, tourmaline, and rutile are accessory minerals.

Flow B, Petrography. Flow B consists of albite, muscovite, potassium feldspar, quartz, and tourmaline, with secondary chlorite, hematite, and accessory rutile. It is much finer-grained than Flow A and also has a schistose texture. Tourmaline appears only in a few layers associated with muscovite and chlorite. Tourmaline grains are much coarser than the other constituents, measuring from 0.25 mm to 0.5 mm across, whereas other crystals are 0.1 mm or less across.

Quartzite

Field Relationships. Approximately 10 percent of the metasedimentary rocks exposed ~~on~~ the eastern half of the Webb Mountain district ~~are~~ quartzite. ~~This is~~ a light-brown ~~rock~~, highly vitreous ~~in appearance.~~ The quartzite occurs on both sides of ~~the~~ Dead Car Pass and strikes north by northeast for about three quarters of a mile.

Petrography. Quartz is the major constituent, although microcline, plagioclase, and carbonate also occur. The quartz grains are well-rounded and sorted, and have been stretched to form a well-developed lineation. Carbonate, which may be dolomite, occurs in interstitial blebs. Accessories include rutile, chlorite, magnetite, and ilmenite.

Amphibolite

Field Relationships. Amphibolite is exposed immediately to the west of the quartzite, where it makes up 20 percent of the metamorphic rocks. It strikes in the same general direction as the quartzite, but dips more steeply. The amphibolite is very dark green to black in color and weathers less angularly than the neighboring schist or quartzite.

Petrography. The amphibolite consists of hornblende (50-75 percent), plagioclase (10 percent), with minor epidote minerals

(10 percent), biotite, chlorite, carbonate, and accessory magnetite, rutile, and quartz. The usual epidote group mineral is clinozoisite, although zoisite is sometimes present. This mineral assemblage conforms to the epidote-amphibolite facies.

Petrographic examination indicates that the amphibolite has porphyroblastic and relict diabasic texture. A fine-grained network of elongate hornblende crystals defines a foliation. Amphibolite exhibits a uniform texture throughout although some difference in grain size occurs.

Hornblende varies in type and amounts, from 50 percent green hornblende at the quartzite contact to 70 percent green hornblende and 5 percent blue-green hornblende at the schist contact.

The anorthite content of plagioclase rims is An_{28-34}. These feldspar crystals have been filled with clinozoisite and zoisite. The plagioclase forms are relict phenocrysts, and the texture is blastoporphyritic with a vague foliation. Apparently the diabasic parent rock was recrystallized but was not highly sheared.

Schist

Field Relationships. Approximately 60 percent of the metamorphic rocks are magnetite-quartz-muscovite schist, which crops out from the southern boundary at Buckeye Copper Mine well, to the north and east boundaries. Schist is the host rock to much of the mineralization at the Buckeye Copper Mine. The schist is blue to slate-gray to silvery-gray in hand specimen. A layer of white marble and a green calc-silicate rock, each about 2 feet thick, occur in the mica schist, stratigraphically just below the meta-rhyolite Flow B, and is exposed in the prospect pit 1/2 miles northeast of the Buckeye Copper Mine.

Petrography. The schist is very fine-grained; individual grains range 0.1 mm to 0.5 mm in diameter. Magnetite, quartz and muscovite make up 90 percent of the rock. There is a very good foliation formed by muscovite, which composes more than 20 percent of the rock. Quartz grains are elongated parallel with the foliation. Magnetite, which makes up 5 percent of the rock, occurs in porphyroblasts up to 0.5 mm, and are idioblastic octahedrons. Accessory minerals include chlorite and sericite.

Considering the large percentage of quartz in this rock, the parent rock may have been a shaley ferruginous sandstone. shaley

Crenulated Sericite Schist

Field Relationships. Sericite schist is fine-grained, with a perfect schistosity and a glossy sheen on the surfaces of splitting. Sericite schist forms a lens-shaped body near the plutonic igneous-metasedimentary rock contact, and is surrounded by the magnetite-quartz-muscovite schist. The lens crops out at the base of the West Buckeye Copper Mine hill and continues along strike, N25°E, for about two hundred yards. The outcrop has a conspicuous shiny white appearance. Sericite flakes are thin, with a wavy, crenulated or corrugated arrangement. Harker (1939, p. 211) called similar rocks sericite-phyllites. However, the texture of this particular rock ~~would seem to~~ warrants the name schist.

<u>Petrography</u>. Sericite schist consists of sericite (65 percent), quartz (about 20 percent), rutile (2 percent), albite (1 percent), and chlorite (1 percent), with secondary leucoxene and limonite, and accessory ilmenite, sphene, tourmaline, and zircon. Some of the yellow-to-red high relief mineral may be baddelyite rather than rutile. There are many ghosts of a brown ~~platy~~ plate-like mineral, which probably was biotite. This biotite had been formed by the original metamorphic event which had formed a sericite foliation, S_1. The sericite recrystallization was mainly post-kinematic, as the crenulations are formed mainly of mica with straight discontinuous plates, rather than by bent plates. Crenulations are made up of sericite and quartz that form sharp chevrons in the crowded centers of folds; the folds have more rounded peaks where space is available. Tourmaline, apparently an original constituent of the argillaceous parent rock, has been bent by the deforming event that created the folds. The mica forms polygonal arcs where recrystallized, and the bent, randomly-oriented mica crystals may remain, due to a lag of recrystallization energy (Misch, 1969). Strain-slip cleavage occurs and seems associated with the tight

plate-like

chevron folding. The folding was therefore strong enough to produce a new s-surface, an s_2 strain-slip cleavage. The cleavage is parallel to the axial plane of the crenulation folds.

This schist is the product of metamorphosed argillaceous rock, perhaps a clay-rich lake deposit. Tourmaline may have formed a lineation in the rock during metamorphism. The clay became sericite. Rutile and zircon seem pre-tectonic, and may have been of volcanic origin. The second deforming event produced the bent tourmaline, the crenulations and strain-slip cleavage. Strain-slip cleavage sometimes forms discrete fractures which affect the sericite layers and occur so that heavy minerals are often in crests of folds.

Petrogenesis of the Metamorphic Rocks

The argillaceous, quartzitic and mafic metamorphic rocks of the Dead Car Pass area have undergone regional dynamothermal metamorphism in the epidote-amphibolite facies. This facies interpretation is suggested by the epidote-hornblende-oligoclase association in the amphibolite. This mineral assemblage conforms to the oligoclase-epidote-amphibolite subfacies of the epidote-amphibolite facies (Barth, 1962, p. 323).

Portions of the metamorphic rock unit may be correlated with the Yavapai Series of Older Precambrian age, ~~This Series~~ which developed in a geosynclinal trough. The Yavapai Series was probably underlain by igneous rocks in southern Arizona. The trough was several hundred miles wide and had been formed by regional warping and faulting (Wilson, 1962). Regional metamorphism produced the Yavapai Series from a sandy, silty, shaley and volcanic sequence that had been deposited and lithified in this basin.

The Yavapai Schist, later renamed the Yavapai Series (Wilson, 1939), contains schist and phyllite, amphibolite, quartzite, and volcanic rocks, as does the Webb Mountain metamorphic sequence. The most abundant rock type in the Yavapai Series is "an argillaceous phyllite varying to slate, mica schist and chlorite-schist", according to Jagger and Palache (1905), the original workers. The most abundant rock type in the study area is a similarly varying argillaceous rock, generally segregated and recrystallized enough to term schist. Jagger and Palache describe a finely-foliated, blue or silvery schist consisting chiefly of quartz and muscovite, which is a good description of the Webb Mountain schist. Mica schist in the study area has in addition a few percent of magnetite. More recent workers (Anderson, C. A., and Creasey, S. C., 1958, Blacet, P. M., 1966) do not follow the metamorphic terminology of Jagger and Palache but instead use volcanic and sedimentary parent rock names.

The Big Bug Group of the Yavapai Series, previously termed the Alder Group in some areas, contains a unit named the Spud Mountain Volcanics (see Figure 4b). The Spud Mountain Volcanics has recently (Anderson and Blacet, 1972) been divided into nine

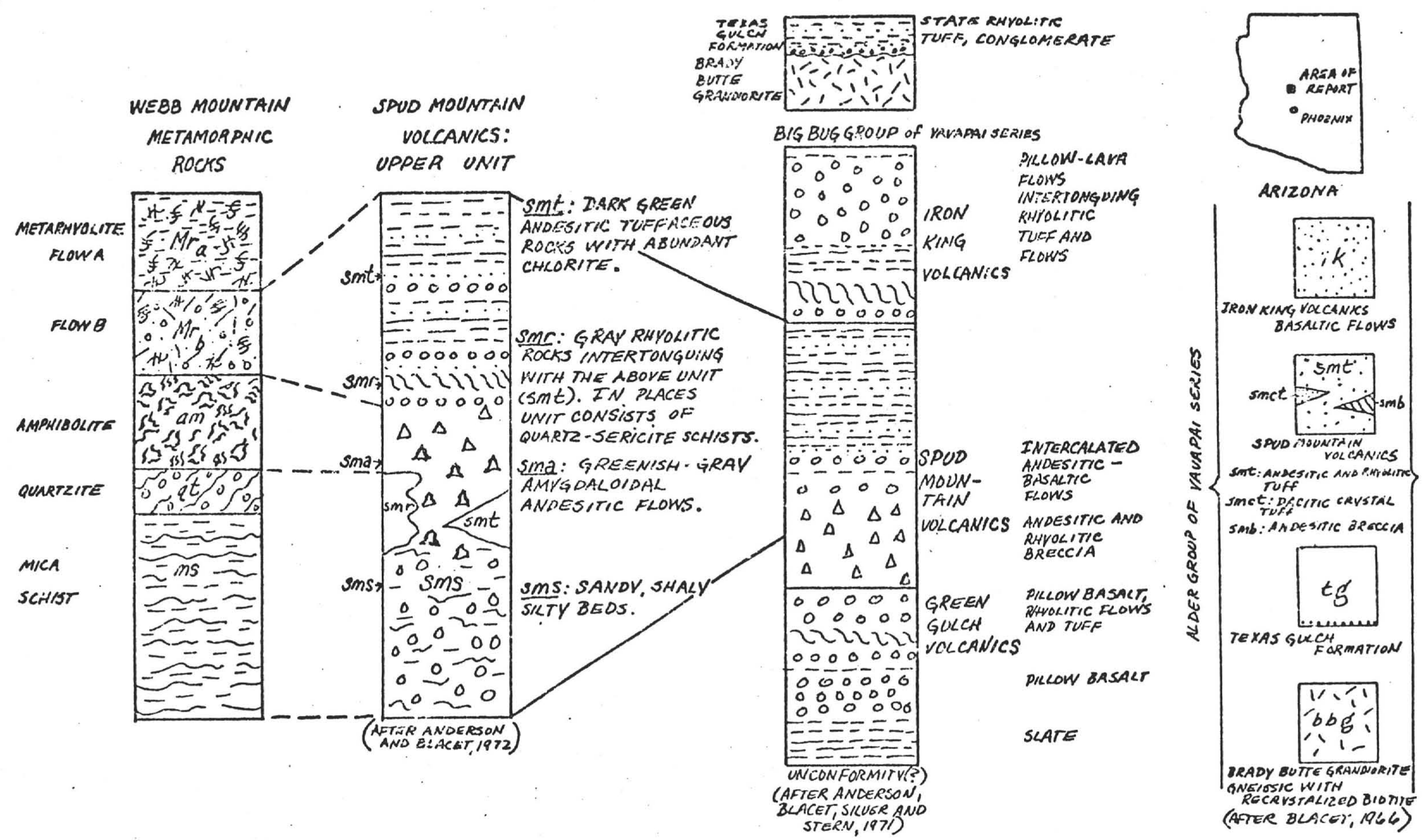

Figure 4b

Proposed correlation of Webb Mountain Metamorphic Rocks with Upper Spud Mountain Volcanics parts, and appears to correlate, in three parts ("smr", "smt" and "sms") of the four-part upper unit, with the metavolcanic and metasedimentary rocks of Webb Mountain. Metavolcanic rocks "smt" and "smr" correspond with portions of metarhyolite Flow B, while "sms" and part of "smr" correspond with the quartz-sericite-schist. The unit termed "sma" does not exactly match the description of the Webb Mountain amphibolite, but is of a similarly mafic composition.

According to Anderson and Creasey (1958, p. 33), the environment of deposition for the Yavapai Series may have been either marine or non-marine or a combination of both, and evidence is available for both environments, although clearly terrigenous sediments are found only in the Texas Gulch Formation.

The Texas Gulch Formation has been removed from the Yavapai Series because it is separated from the rocks of the Big Bug Group (a sub-division of the Yavapai Series) by a period of plutonism, represented by the Brady Butte granodiorite, and subsequent erosion (Anderson, Blacet, Silver and Stern, 1971). Anderson _et al._ (1971) used a date on the Brady Butte granodiorite of 1770 $\pm$10 m.y. as the younger limit of the Yavapai Series. This restriction, in addition to the upper limit of the Ash Creek Group (the other subdivision of the Yavapai Series) dated at 1820+ ? m.y. (Anderson _et al._, 1971, p. C15), makes it possible to use the term Yavapai Series as a time-stratigraphic term.

Another similarity exists between the Webb Mountain area and the Yavapai Series rocks. In the Webb Mountain study area, the second most abundant rock type is a sheared granodiorite. The description of the Brady Butte granodiorite as gneissic with much recrystallized biotite (Blacet, 1966 and Anderson and Blacet, 1972), corresponds with the Webb Mountain granodiorite, and may strengthen the correlation with the Yavapai Series.

PLUTONIC IGNEOUS ROCKS

Plutonic igneous rocks include sheared granodiorite, quartz monzonite, two varieties of diorite, younger quartz monzonite, aplite, mafic dikes and quartz-tourmaline veins. The first rock, and possibly the quartz monzonite and quartz diorite as well, were involved in a postmagmatic event of shearing and partial recrystallization. Part of the gneissic structure, however, is protoclastic. The shearing event which caused the postmagmatic cataclastic textures in the sheared granodiorite can probably be correlated with that event which produced the S_2 structures and recrystallization in the crenulated sericite schist. The sheared granodiorite is mainly in contact with the metamorphic rocks. The nature of this boundary is a problem and is discussed from two points of view.

(1). The pattern of foliation dips of the metamorphic rocks near the Buckeye Copper Mine suggests a local dome structure that may have been formed by intrusion (Plate 1). This points to an intrusive contact, with the quartz monzonite or the sheared granodiorite, or both, continuing under the schist. The Buckeye Mine fault, which occurs at this point, and the change in strike of the metasedimentary rocks are in support of this theory (Figure 5). The granodiorite foliation is partially parallel to the contact and aligned grains without mortar appear in thin section view. Although the above criteria seem to indicate origin by protoclastic deformation, (Waters and Krauskopf, 1941; Snook, 1965) the

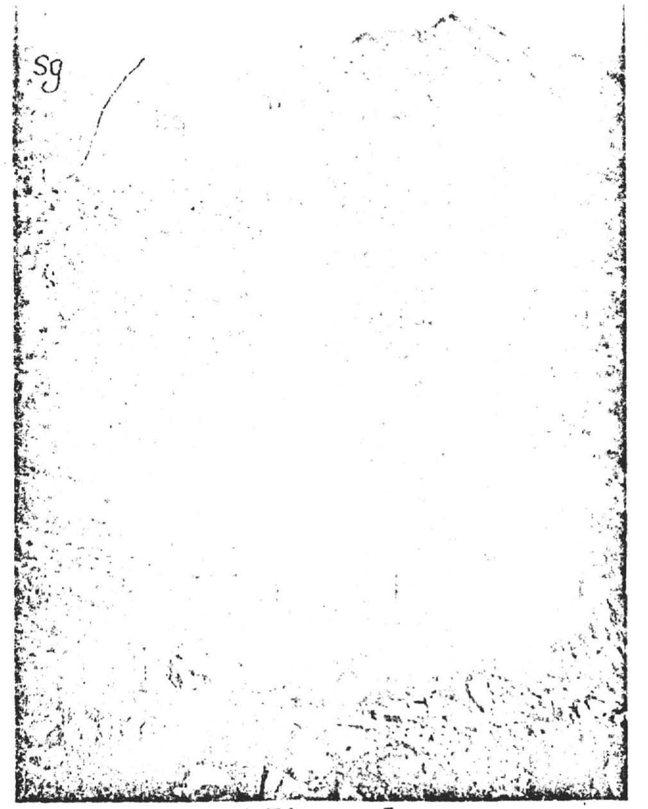

Figure 5

Steepening of dip of metamorphic rock layers approaching intrusions. View is from South to North. Symbols same as Plate I.

similarity of orientation of foliation in the metamorphic rocks and the igneous rocks indicates a common origin. Metamorphism after the intrusive event explains the common facies of metamorphism of both rock groups, and the concordance of the contact with foliation. The concordance of foliation is exhibited in those parts of the sheared granodiorite where foliation is near N25°E. The contact itself trends mostly N25°E, and throughout the metamorphic rocks the foliation strikes close to N25°E.

(2). On the other hand, the contact may be a fault. Some of the sheared granodiorite is mylonitized at the contact, and the sericite schist crenulations demonstrate a sense of movement from east to west. The metamorphic rocks may have been thrust westward on the igneous rocks, which do not crop out east of the contact. Direction of yielding demonstrated by small-scale, passive folds is consistent with thrusting from east to west. Further, post-intrusion tectonism is necessary to explain cataclastic texture in the granodiorite.

Although the latest event may have been a thrust fault, the original nature of this contact is still unknown. This contact forms a slightly curved lineation for its entire length across the area.

Besides the two points of view discussed above, two other origins are possible. This contact could be, an unconformity, or a brittle fault. In the case of the unconformity, there is only negative evidence, since an erosional surface cannot be found.

Breccia and crush zones of a possible brittle fault are also absent, as ~~well as~~ are slickensides and fault gouge. Dikes, veins and hydrothermal alteration abound in the vicinity of the contact, but these only indicate a zone of weakness in the rocks, not the nature of it.

Sheared Granodiorite

Field Relationships. Sheared granodiorite forms 55 percent of the igneous rocks exposed in the western section of the study area. The granodiorite is the oldest plutonic rock. In hand specimen, this rock is dark greenish-gray, and clots of biotite are apparent. Biotite forms a lineation and the shearing has produced a well-developed foliation. Granodiorite seems more resistant to erosion than the other gneissic rocks; it forms the central peak of the area (Figures 6a and b).

Petrography. Petrographic examination of granodiorite samples collected far apart on Webb Mountain demonstrates an overall similarity in mineralogy, despite diversity of grain size, and textures due to shearing and hydrothermal alteration. This mineralogical uniformity suggests that most of Webb Mountain is made up of one rock unit.

All of the samples examined are highly sheared and altered, and optical measurements were difficult to obtain. The granodiorite

Figure 6a

Metarhyolite Flow B in foreground; Webb Mountain sheared granodiorite forms peak in the distance.

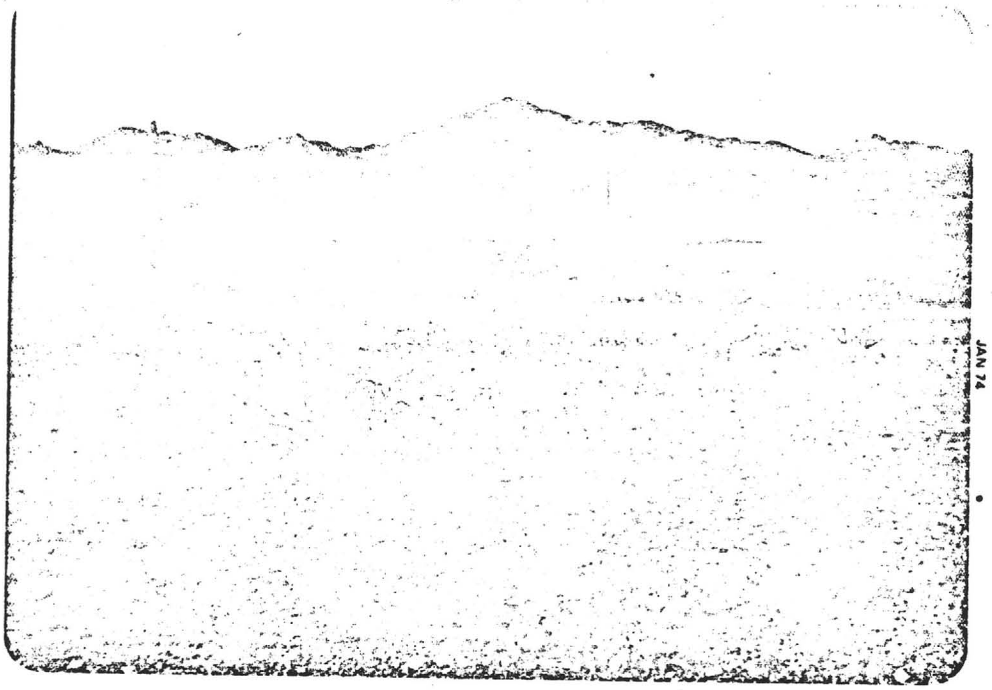

Figure 6b

View of study area from the North.
Webb Mountain is in the center of
photo.

consists of plagioclase feldspar (An_{43-48}), orthoclase, quartz and secondary biotite, sphene, epidote, tourmaline, chlorite, calcite, and accessory apatite. Many plagioclase crystals exhibit alteration to more sodic compositions (An_{35}) and epidote.

Textures show that quartz and biotite may have been modified by hydrothermal solutions. Quartz is in its original interstitial position, but it seems changed in size and shape.

In several places, the quartz is unusually large, up to 2.0 mm across. A polygonal mosaic of quartz masks the original igneous texture. Quartz grains form an alignment and appear annealed. The extinction is not undulose in most grains.

Biotite forms subidioblastic porphyroblasts, up to 3.0 mm across. Biotite appears to be metamorphic, as it has very straight extinction, is enlarged, and lies parallel to the shear planes.

Postmagmatic cataclasis has occurred, producing various types of mylonitic textures. Some parts of Webb Mountain granodiorite exhibit a grade of shearing which corresponds to the protomylonite of Higgins (1971, p. 7-9). These samples contain mostly large rotated crystals accompanied by a lesser amount of fine-grained material, which is mortar. This is granulation, with wispy muscovite trains, and bent, unrecrystallized plagioclase feldspar (Figure 7). Partial mylonitization has also taken place, as is demonstrated by the large augen broken down and mortar well developed (Figure 8).

? Dr Moore

Figure 7

Unrecrystallized plagioclase in sheared granodiorite. (3.2x, x-nicols)

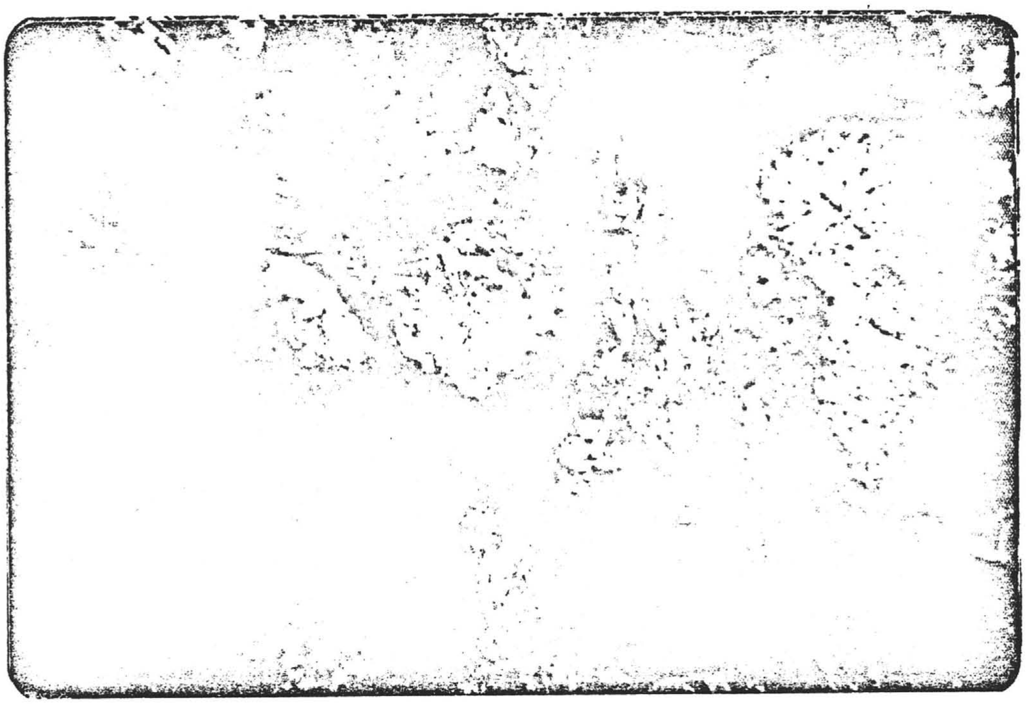

Figure 8

Partial mylonitization of sheared granodiorite. (3.2x, x-nicols)

Hastingsitic hornblende occurs in the sheared granodiorite at intrusive contacts. Frequently, copper minerals and tourmaline occur in this rock, and in adjoining quartz veins, where this bluish hornblende is found. This blue-green amphibole is post-kinematic in relation to the cataclastic event. Clusters of amphibole crystals are elongated in a direction nearly normal to, and cut across, the foliation (Figure 9). Locally, the amphibole crystals are bent so as to appear partially synkinematic as well. These amphibole crystals may have grown as a result of the hydrothermal solutions associated with the copper mineralization, hence the mineralization appears to be post-kinematic. The facies of metamorphism involved is epidote-amphibolite facies.

The metamorphic rocks at Webb Mountain show evidence of polymetamorphism, in the crenulated sericite schist, and the sheared granodiorite demonstrates both protoclastic and regional metamorphic effects. The two younger igneous rocks, the quartz diorite and the quartz monzonite, may have suffered only protoclasis. Two metamorphic pulses may be indicated, one associated with or previous to, the granodiorite intrusion, and another event which occurred post-intrusion, but before emplacement of the two later plutonic igneous rocks.

Quartz Monzonite

Field Relationships. Quartz monzonite forms about 10 percent of the gneissic Precambrian rocks. The quartz monzonite

Figure 9

Post-kinematic amphiboles in sheared granodiorite near schist-granodiorite contact. (10x, plane light) occurs along the Hargan Mine road, between quartz diorite and sheared granodiorite. Xenoliths of quartz monzonite within quartz diorite, and intrusive relations of the quartz monzonite with the granodiorite, indicate that quartz monzonite is intermediate in age between the granodiorite and the quartz diorite. The quartz monzonite is granitic in appearance and possesses fine, hypidiomorphic-granular texture in the center of the outcrop area but is distinctly foliated at contacts with the quartz diorite and granodiorite. Diorite dikes and aplitic dikes intrude this rock unit; in addition it exhibits strong hydrothermal alteration.

In hand specimen the rocks are gneissic with augen of quartz and feldspar, giving a spotted gray and white appearance. The rock contains few mafic minerals and is light-colored.

Petrography. Quartz monzonite consists of plagioclase feldspar and microcline in approximately equal amounts, plus quartz, muscovite, and biotite, with secondary epidote group minerals, tourmaline, hornblende, chlorite, calcite, and accessory ilmenite. Tourmaline is a hydrothermal addition associated with amphibole. Calcite occurs due to the breakdown of calcic plagioclase. At some contacts the rock assumes greenish color due to alteration of mafic minerals to epidote and chlorite. Primary plagioclase (An_{40}) is rare, as most specimens exhibit alteration to more sodic compositions (An_{26-32}) and epidote (Figure 10a).

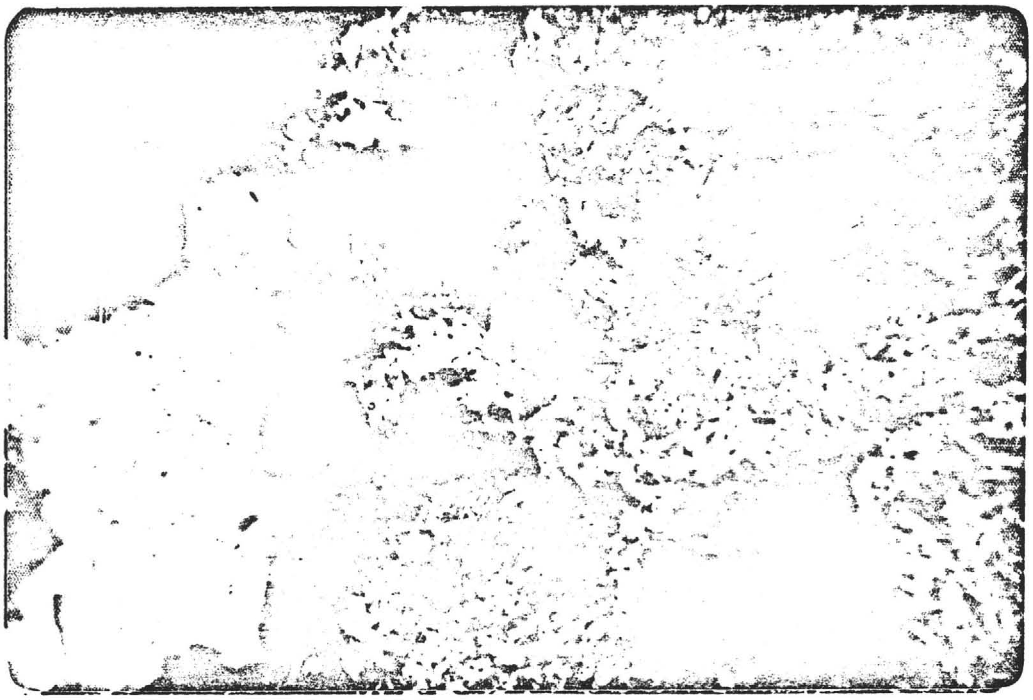

Figure 10a

Alteration of plagioclase feldspar to sericite, epidote and oligoclase in quartz monzonite. (3.2x, x-nicols)

Crystals of primary plagioclase and quartz exhibit relict hypidiomorphic granular texture, associated with a recrystallized cataclastic texture in most places. Hypidiomorphic granular texture, with quartz occupying interstices around plagioclase and biotite, is most prominent near the center of the body (Figure 10b). Near contacts, the fabric of this rock gradually assumes a distinct foliation, which can be demonstrated on the basis of twenty samples taken across the body.

Quartz, plagioclase and potassium feldspar porphyroclasts demonstrates a high degree of shearing. According to Higgins, 1971, p. 60) this texture is set in a biotite-sericite-quartz matrix. Small biotite flakes with straight extinction define a foliation and together with annealed quartz indicate recrystallization (Figure 10c). This rock was sheared and recrystallized under conditions of epidote-amphibolite facies with biotite, epidote and sodic plagioclase as stable phases.

Quartz Diorite

Field Relationships. Quartz diorite forms approximately 30 percent of the gneissic rocks. The quartz diorite is the youngest of the three major plutons, and on weathered surfaces is similar in appearance to the sheared granodiorite. Compared to the sheared granodiorite, quartz diorite is slightly darker, grayish black instead of greenish black, and on a fresh surface

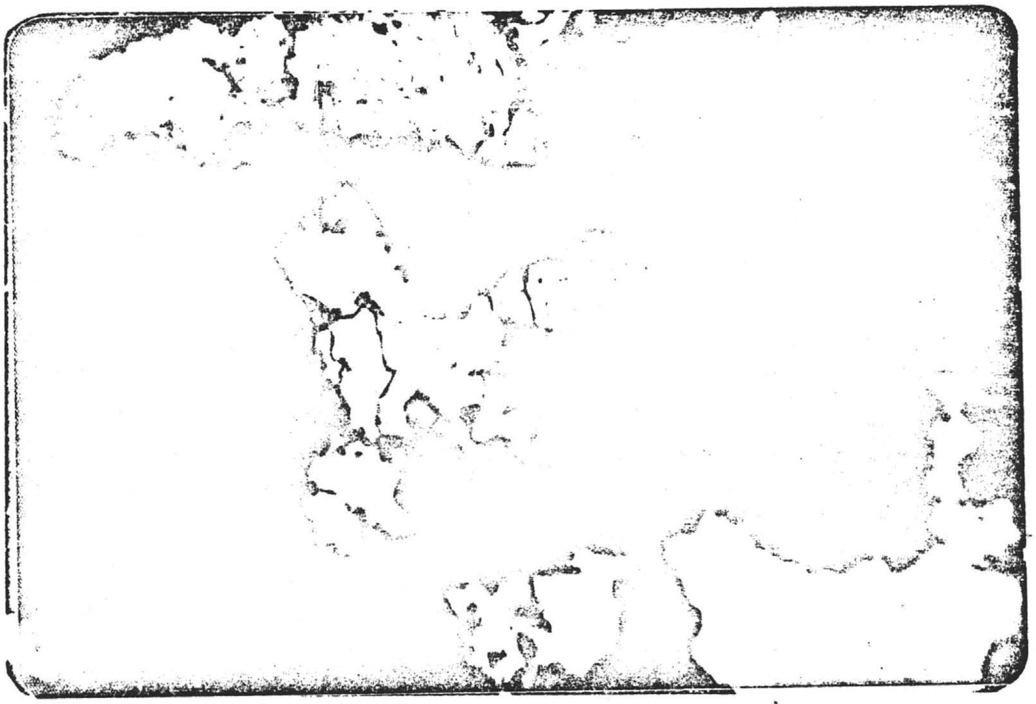

Figure 10b

Hypidiomorphic granular texture with quartz occupying interstices in sample from near center of quartz monzonite body (3.2x, x-nicols)

Figure 10c

Small biotite flakes with straight extinction define a foliation and together with annealed quartz indicate recrystallization of quartz monzonite specimen from near margin of body (3.2x, x-nicols) displays its igneous texture much more distinctly. The intrusion crops out on the northwestern edge of Webb Mountain. Aplite dikes and younger quartz monzonite dikes and pods occur within the diorite near contacts.

Petrography. Petrographic examination of the quartz diorite discloses an altered and mineralized rock. Quartz diorite consists of plagioclase feldspar (An_{50}, 40-45 percent), biotite (20-25 percent), quartz (20 percent), and hornblende (10 percent), with secondary chlorite and epidote group minerals, accessory apatite, sphene, magnetite, rutile, ilmenite, pyrite and zircon.

Primary unaltered plagioclase crystals (An_{50}) are rare, as most specimens exhibit alteration to more sodic compositions (An_{33}-An_{37}) and epidote group minerals. In specimens from an intrusive contact, plagioclase crystals are fairly strongly aligned and hornblende has been completely replaced by biotite. This local absence of hornblende is probably a result of complete replacement in a protoclastic border. The biotite has replaced hornblende to a lesser extent in other samples, due to late magmatic and deuteric reaction. Quartz has been stressed and recrystallized.

Younger Quartz Monzonite

Field Relationships. Younger quartz monzonite occurs in dikes and plugs in several places in the northwestern part of the area. The largest of these bodies is at the southeast contact of the quartz diorite pluton. Other quartz monzonite bodies are dikes that occur around the edges of the quartz diorite intrusion (Figure 11).

Petrography. Quartz monzonite consists of plagioclase feldspar (20 percent), orthoclase (15 percent), microcline (2-5 percent), biotite (4 percent), and quartz (10-15 percent), with secondary zoisite, chlorite, chrysocolla and malachite, and accessory apatite and rutile. Plagioclase crystals measure up to 3.0 mm across, and have sodic compositions (An_{5-12}) as a result of saussuritization. Plagioclase crystals have euhedral form, whereas orthoclase and microcline are generally anhedral. Potassium feldspar grains are altered to clay. Quartz is anhedral and interstitial. Texture is hypidiomorphic granular, but subhedral to anhedral forms are further modified by deuteric mineralization.

Figure 11

Small dike of mineralized younger quartz monzonite intrudes quartz diorite.

DIKE ROCKS

Aplite

Field Relationships. Aplite dikes constitute about 1 percent of the igneous rocks and occur in the northern part of the study area. The dikes intrude gneissic granodiorite, quartz monzonite, quartz diorite and mica schist. Dikes are generally 1 foot to 3 feet wide, and about 100 feet long in outcrop. Aplite is a white to gray rock, with a very vitreous lustre and few mafic minerals.

Petrography. Aplite consists of quartz, sodic plagioclase feldspar, microcline, orthoclase, and biotite, with secondary epidote, sericite, and chlorite, and accessory zircon and apatite. Quartz composes between 20 and 30 percent of this rock, and the texture is hypidiomorphic granular, obscured by a hydrothermal overprint. Plagioclase feldspar is saussurized and has an albite to oligoclase composition. Biotite contains considerable zircon with pleochroic haloes.

Diorite

Field Relationships. Diorite dikes make up less than 1 percent of the igneous rocks. This rock is dense, green to black in color and fine-grained. Diorite intrudes the quartz monzonite and the quartz diorite, and cuts aplite dikes. Xenoliths of aplite and younger quartz monzonite are found in the diorite dikes (Figure 12a). The dikes are from two to five feet in width and up to 200 feet long.

Petrography. Diorite consists of plagioclase feldspar (mostly altered andesine), green hornblende (35-45 percent) and quartz (5 percent), with secondary zoisite, clinozoisite, and limonite, and accessory zircon, magnetite and sphene.

Texture is poikilitic, with slightly fibrous, elongated, green hornblende crystals surrounding saussuritized plagioclase feldspar. Quartz is interstitial.

Quartz Veins and Chert

Quartz veins occur throughout the area, apparently emplaced in two events, one of which preceded and one of which followed the medium grade metamorphic recrystallization. In the metamorphic section of Webb Mountain, both ages of quartz veins occur. In the gneissic rocks, only veins of the latter type occur.

Earlier quartz veins have been deformed, and occur as boudins and twisted pods, which are microfractured throughout. These pre-tectonic, or possibly synkinematic, quartz veins are two to six inches wide.

Later quartz veins are massive, coarsely crystalline, and exhibit few fractures. The younger quartz crops out in areas up to 40 feet in diameter; some of these veins contain traces of copper minerals.

Figure 12a

Xenoliths (x) of aplite and younger quartz monzonite are found in this diorite dike (Dd) in the quartz diorite pluton (Dp).

In the sheared granodiorite, chert occurs as veins, which are about a foot wide and ten feet long.

Tourmaline and Quartz Veins

In the quartz veins, acicular tourmaline (schorl) occurs as large, black aggregates, and is concentrated near the sheared granodiorite-schist contact and the granodiorite-quartz monzonite contact (Figure 12b). In addition, tourmaline is abundant as individual grains and as aggregates in the granodiorite, quartz monzonite, younger quartz monzonite, and both metarhyolite flows. The tourmaline-quartz veins are later than the younger quartz monzonite dikes and plugs into which they intrude. Tourmaline in the earlier plutonic igneous rocks commonly appears to be a late~~, as a~~ hydrothermal addition, and may have been added to these rocks at the time the quartz veins were injected. This hypothesis places the tourmaline event sometime after the intrusion of the younger quartz monzonite.

Diabase Dike

A pyroxene-rich dike occurs in the schist near the granodiorite contact in the two westernmost Buckeye Copper mine shafts, but does not crop out.

Diabase consists of augite, plagioclase feldspar (An_{53} to An_{57}), and magnetite, with secondary clays, biotite, and accessory hematite. Iddingsite and magnetite form pseudomorphs after

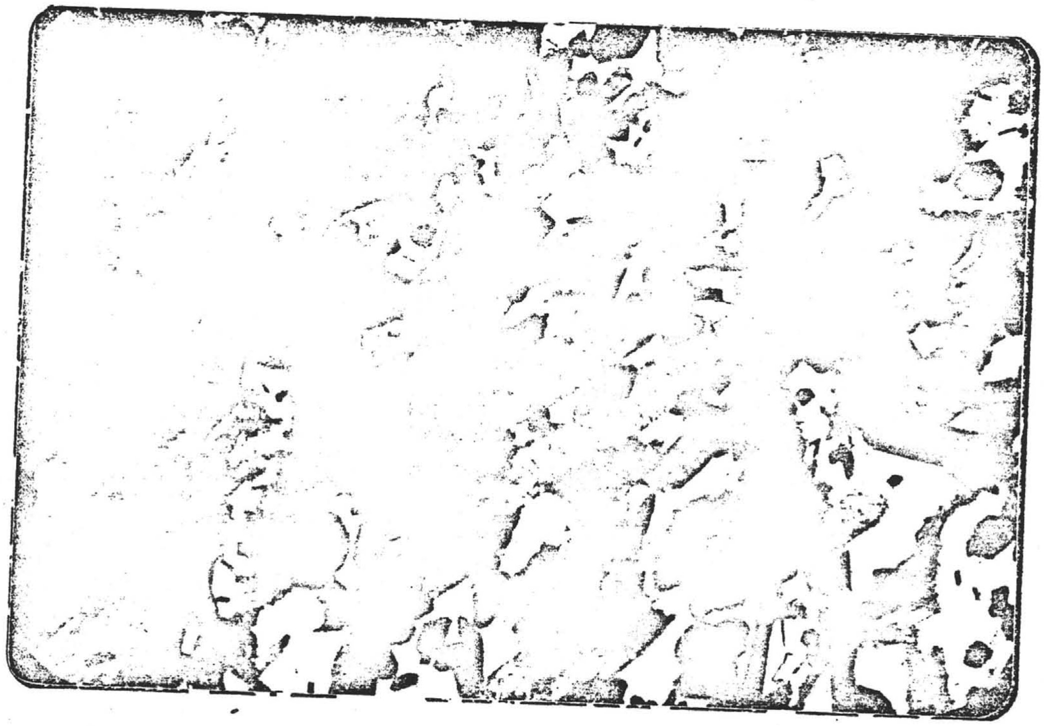

Figure 12b

Tourmaline and quartz from a massive later quartz vein in the sheared granodiorite 1/2 mile west of the Buckeye Copper Mine. (10x, x-nicols) olivine. The texture is porphyritic, with phenocrysts of augite and labradorite in a matrix of randomly oriented magnetite, plagioclase laths, and clays. Some samples of this mafic rock contain secondary chalcedony.

VOLCANIC ROCKS

Approximately 5 percent of the igneous rocks are Quaternary basalt, Cretaceous andesite and dacite. The various volcanic types have not been mapped separately in this study.

The volcanic rocks occur in the western part of the study area.

Dacite

Dacite consists of sanidine, oligoclase (An_{20-28}), quartz (15 percent), biotite and hornblende, with secondary sericite and limonite and accessory zircon, rutile and magnetite. Plagioclase phenocrysts are considerably more abundant than sanidine phenocrysts. Most minerals are clear and free of alteration, except where hornblende has been replaced by magnetite. The phenocrysts are set in a glassy matrix and make up about one-third to one-half of the rock. Phenocrysts vary in size, and measure from 0.25 mm to 2.5 mm across. Feldspar forms the largest crystals, which are 2.5 x 1.5 mm across.

Andesite

Andesite consists of plagioclase feldspar (An_{30}-An_{35}, 40 percent), oxyhornblende (10 percent), and biotite (10 percent), with secondary limonite, and accessory magnetite and rutile. Texture is porphyritic.

Basalt

Basalt consists of plagioclase feldspar (45 percent), augite (15 percent), olivine (5 percent), oxyhornblende (10 percent), and biotite (5 percent), with secondary iddingsite (10 percent) and limonite and accessory magnetite. Texture is porphyritic and intergranular, with a plagioclase lath matrix.

Origin

These volcanic rocks were produced by Cretaceous eruptions (andesite to rhyolite) to the west and Quaternary eruptions (basalt) to the south and east (Figure 2) (Moore, 1957).

STRUCTURE

Doming and Faulting of the Metamorphic Rocks

The most apparent structure in the study area is the homoclinal nature of the metamorphic rocks. This feature is formed by the eastward dip of the foliation; the resulting structure resembles one limb of an anticline.

Near the intrusions, the dip of the homoclinal structure steepens from 10° to 75°, and the strike of the foliation turns from northeast to nearly east-west. The foliation dips at the Buckeye Copper mine suggest a local dome structure. The foliation strike is N25W north of the mine and N30E south of the mine. Apparently the granodiorite intrusion tilted up these layers. The contact of the intrusion with the schist trends N25E, which is the average strike of the metamorphic rock foliation. The N25E direction of weakness controls many intrusive contacts and late quartz vein injections.

As is indicated by its very crushed and foliated borders, the quartz monzonite may have forcefully intruded. If this is true, and if the quartz monzonite continues under the schist and granodiorite in the Buckeye Copper mine area, the intrusion of this later body may have caused the east-west trending Buckeye Copper mine fault. This is a normal fault which has a displacement of about twelve feet. The quartz monzonite intrusion may have stressed the schist beyond its yield point, forming the fault. Noble (1952, p. 53) used similar evidence, the doming of nearly horizontal Paleozoic strata, and peripheral faults, to support the concept that the intrusive bodies in the Homestake Mine and the Black Hills in South Dakota were forcibly injected.

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Open Folds

Folds in the metamorphic rocks range from broad open flexures to small-scale tight folds. The mica schist was deformed into open, gentle folds with wavelengths of several hundred feet (Figure 13a). The few tight folds found are very small (Figure 13b), and these are confined to the southernmost area.

Low amplitude flexural-slip folds (Donath and Parker, 1964) occur in the mica schist, which in turn affects the amphibolite and Flow B metarhyolite, one mile west of Dead Car Pass. The folds have their axial planes at approximately N60°E, and dip 35° to the east. Fold wavelengths range from 50 to 150 feet.

Broad open flexures are possibly one of the latest structural developments in the study area. These open folds formed are post-metamorphism.

Tight, Small-Scale Folds

Tight, small-scale folds are found only in the schist three-quarters of a mile north of the Buckeye Copper mine well.

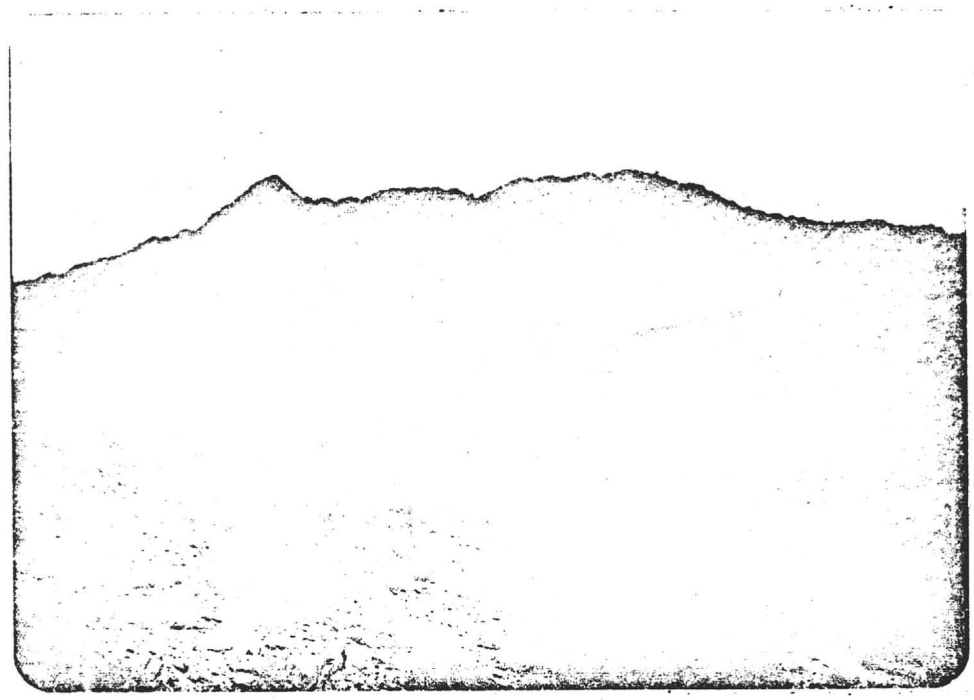

Figure 13a

Open gentle folds with wavelengths of several hundred feet

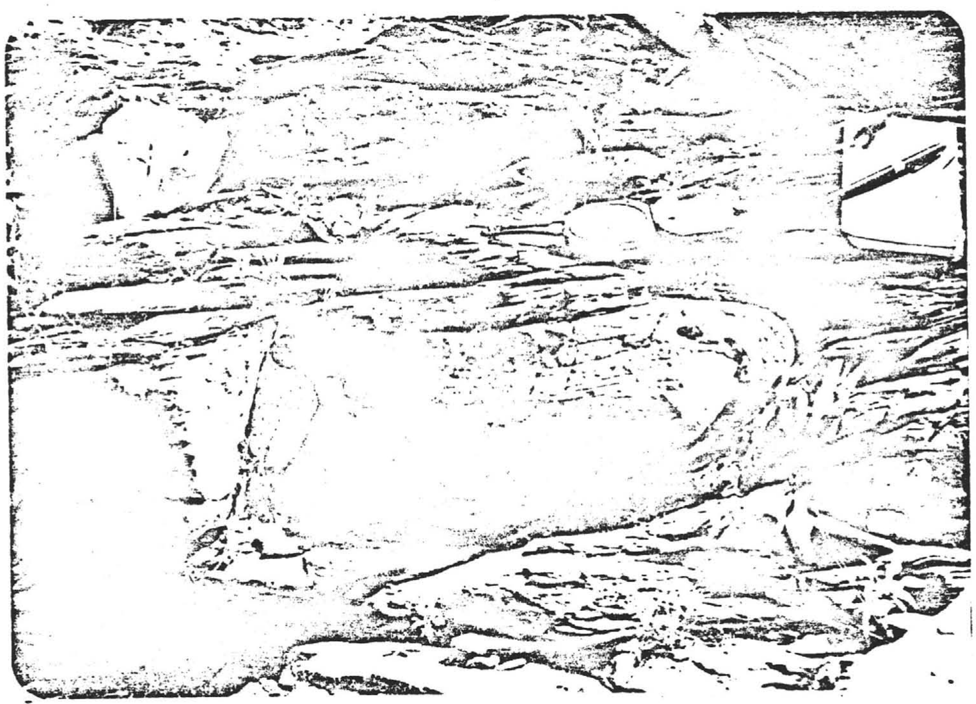

Figure 13b

Tight, small-scale passive fold in the mica schist.

The axial planes of these folds strike N40°E and dip between 30° and 37° to the east.

The folds are passive (Donath and Parker, 1964, p. 58). Folds measure from 6 inches to a foot in amplitude. Crest thicknesses are approximately three times the limbs; measurements are perpendicular to layering (Figure 13b). Ten folds of this type were found in the schist within a square mile just north of Buckeye Copper mine well. Although only 10 folds were measured, their uniform trend to the northeast suggests that they originated by northwest-southeast compression. The north-northeast structural trend is dominant throughout the metamorphic rocks of the area.

It would appear that these folds are not related to the intrusions. The direction of yielding and shape of these folds are incongruent with the hypothesis that the contact is due to simple intrusion (Figure 13c). Folds throughout the area seem to show a sense of movement of the whole schist from east to west or a yielding to the northwest. This orientation would be consistent with a thrusting of the mica schist over the pluton.

Boudinage

Older quartz veins and pods exhibit boudins that are especially well developed in the quartz veins in the blue green, brown-weathering schist (Figure 13d).

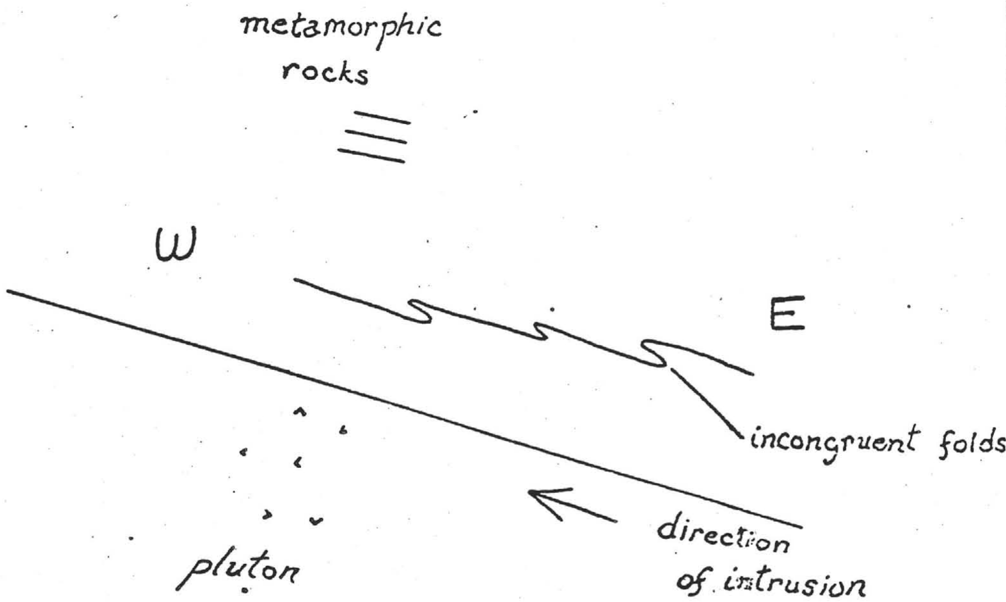

Figure 13c

Field sketch of fold orientation with respect to the granodiorite intrusion.

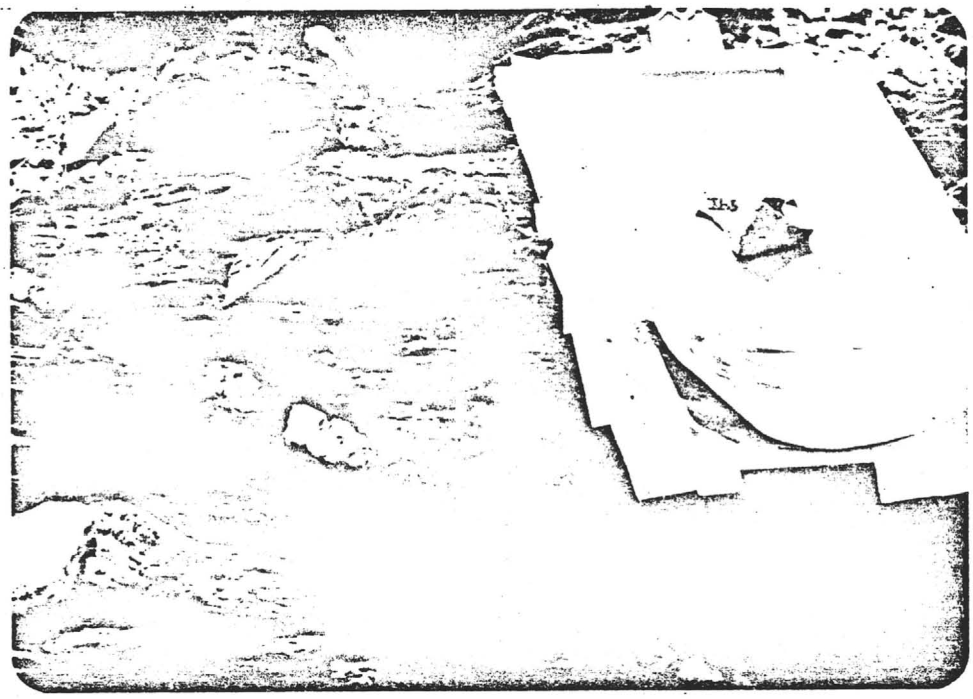

Figure 13d

Older quartz vein exhibiting boudinage
in mica schist

Boudinage at Webb Mountain is found in pinch and swell quartz veins, with the boudins themselves consisting of quartz. The boudins are not completely separated.

These boudins formed during northwest-southeast compression which produced the folds; their long direction is parallel to the geometric axes of the small-scale folds. Compression which was perpendicular to the long axes of the quartz veins, caused attenuation of this more competent material and flow of the enclosing mica schist into neck zones. Cross-jointing is well-developed throughout the older quartz veins.

The boudins are in the same area as the tight, small-scale folds.

Origin of the Small-Scale Structures

Boudinage and tight, small-scale folds may have originated during regional metamorphism, when load pressure, temperature, and, therefore, ductility, were high.

Joints

Ten joints were measured at each of ten stations in the metamorphic rocks and at each of eight stations in the plutonic igneous rocks. Joints were measured at random, although some bias may be expected in favor of the straighter and better-developed fractures.

In the metamorphic rock unit, joint stations were selected by commencing at the eastern end of Dead Car Pass and then proceeding west to the metarhyolite quarry, which was joint station six, and south from there, to the Buckeye Copper mine well.

In the plutonic igneous rocks, eight stations were chosen, beginning near the Hargan Mine road, where it meets the quartz diorite-volcanic rock contact, continuing eastward toward the Buckeye Copper mine.

Joints in the Metamorphic Rocks. Joints are well developed in the metamorphic rocks. Joints at north-south, near east-west, and N55W are prominent (Figure 14).

Joints in the Igneous Rocks. Three joint trends which appear to be related to the cooling histories of the plutons are important in the igneous rocks (Figure 15). The strongest joint trends in the igneous rocks are confined to the plutonic rock units, and are not repeated in the metamorphic rocks. In the two oldest plutonic igneous rocks, quartz monzonite and sheared granodiorite, the most important trends are N85E and N10W. The quartz diorite contains a joint trend along north-south and another along N70E. Dikes follow the N10W trends in the quartz monzonite and granodiorite and the north-south trend in the quartz diorite. The joints which are east-west and N10W trending are probably the oldest, as these trends are confined to the older plutons. The N70E joint trend is youngest.

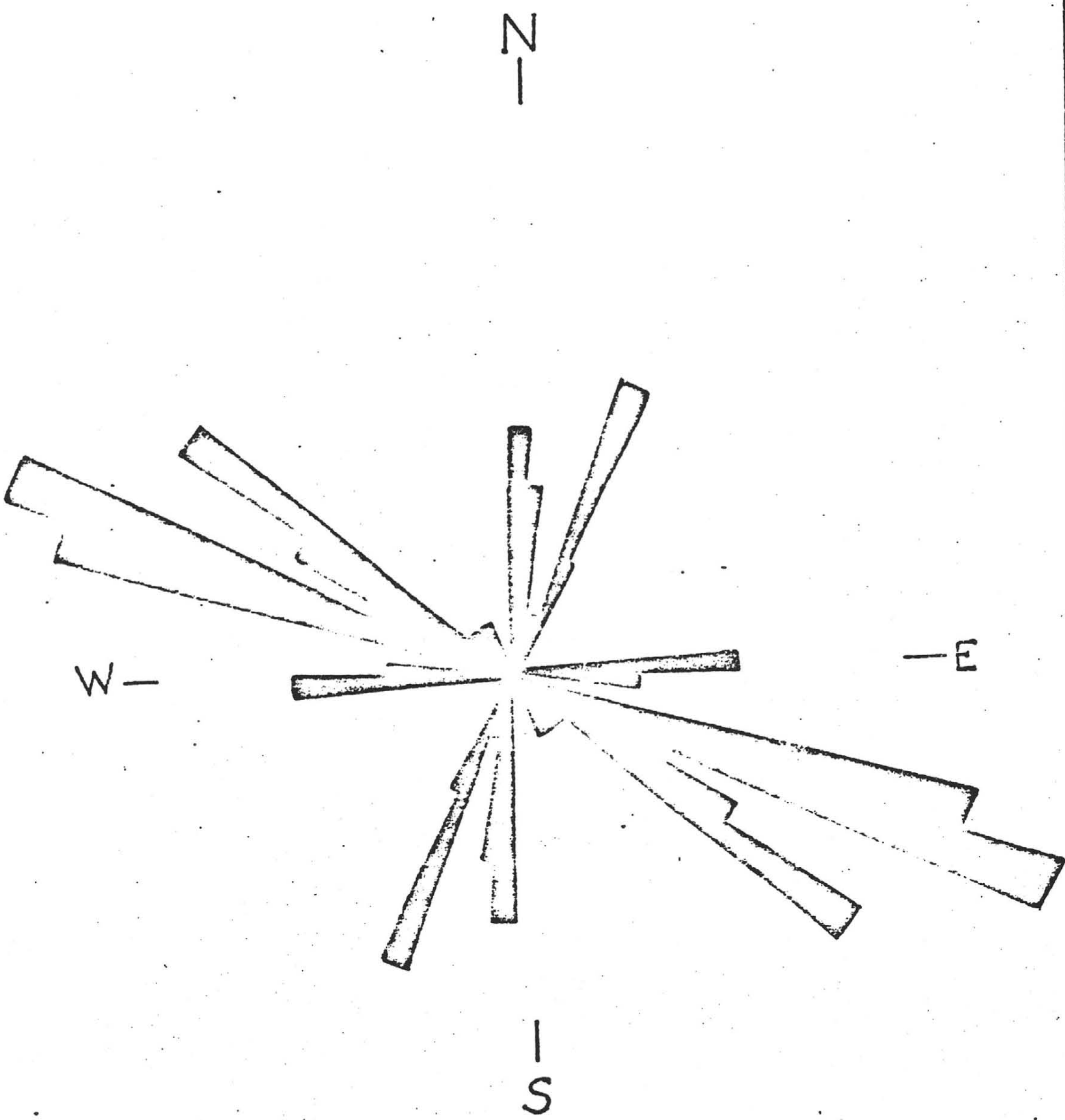

Figure 14

Rose diagram of 100 joints in the metamorphic rocks

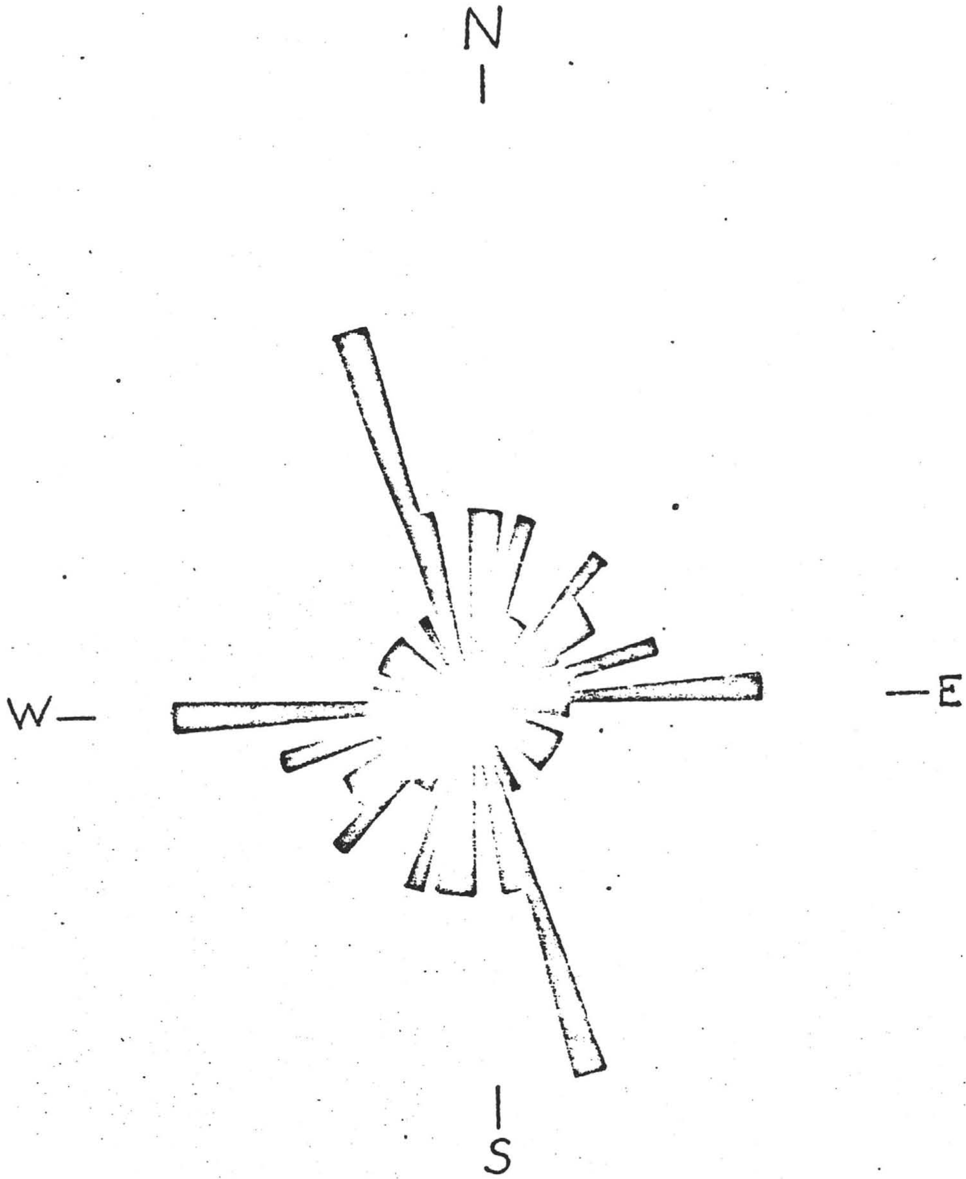

Figure 15

Rose diagram of 80 joints in the igneous rocks.

<u>Regional Joints.</u> The joint trends show a similarity to some regional patterns. This is especially true of the igneous rocks. Rehrig and Heidrick (1972, p. 198) measured joint sets, veins, dikes and faults in eleven stocks of Laramide age in the Basin and Range Province of Arizona. Orthogonal fractures striking east northeast ±20° and north northwest ±20° are a systematically oriented pattern, with only one other important regional fracture set recognized, which is west northwest.

The N85E joint trend and the N10W trend in the two older plutons at Webb Mountain are within the east northeast ±20° and north northwest ±20° direction. The N70E trend in the quartz diorite body is not regional, although it is almost exactly east northeast. The N70E joint trend seems parallel to the flow direction of the pluton and may be the rift joint (Balk, 1937).

Similarly, the joint trends of the older plutons may be due to cooling histories. The intervals chosen by Rehrig and Heidrick cover 80 degrees of the compass, or nearly 25 percent, and the similarity of the Webb Mountain fracture pattern may be simply coincidental.

The most widespread joint trends are north-south and east-west. Occurring in both the plutonic igneous and the metamorphic rocks, these directions seem regional.

ECONOMIC GEOLOGY

Copper

The copper minerals are silicate and carbonate ore, with some sulfides. Chysocolla, cuprite and malachite occur in pockets along the laminae of the schist, ~~and they~~ also occur in quartz veins.

Mineralized quartz occurs in veins in the intensely hydrothermally-altered zone near the schist-granodiorite contact. Quartz most often contains only chysocolla, which is the most widespread copper mineral. These are the younger, massive quartz veins, and they are 2 to 3 feet wide at maximum. Trend of the quartz veins is between N10E and N35W.

Bornite is minor, as is chalcocite, while pyrite and chalcopyrite occur rather densely in the schist in the west Buckeye Copper Mine mineshaft. It is estimated that in these richest zones, copper percentages may reach one or two percent (Appendix I), but the copper ore is probably not concentrated over a mineable areal extent.

The copper mineralization seems similar to the porphyry type of mesothermal epigenetic deposit common to southern Arizona. However, the deposit did not reach the ore tenor overall because of the limited size and scattered location of the younger quartz monzonite dikes and the late quartz-tourmaline veins.

The possibility of a volcanogenic origin of the copper minerals should not be overlooked. Massive sulfide deposits are associated with volcanism, and typically the extrusive rocks have accumulated in a eugeosyncline (Anderson, 1969, p. 129). Sulfides occur in either silicic or mafic volcanic host rocks, or they occur in tuffaceous sedimentary rocks interbedded with volcanics. Flow B is a metamorphosed silicic volcanic rock and may have been the end product of a volcanic center.

The volcanogenic theory is not probable for origin of the copper mineralization in the Webb Mountain area. The basic evidence against volcanogenic origin is that petrographic examination indicates a connection between the late copper minerals and late epigenetic amphibole and tourmaline. In addition, field relationships demonstrate that most copper at Webb Mountain is closely associated with the younger quartz monzonite dikes and late quartz-tourmaline veins~~, not~~ rather than with the older metavolcanic rocks. Mineralogically, most copper occurs as disseminated carbonate and silicate ore rather than massive sulfide ore.

However, if this copper deposit could be proven to be ~~a~~ volcanogenic, rather ~~than a~~ porphyry, ~~copper deposit,~~ there may be undiscovered ore in the Flow B metarhyolite.

Sericite

Sericite schist occurs parallel to the schist-granodiorite contact, and crops out for about a quarter-mile. This schist consists of very pure-looking, glossy white, crenulated fine-grained muscovite, which according to the Buckeye Mica Co. (Glenn Walker, oral comm.) contains too much limonite to be usable.

Onyx and Metarhyolite

Metarhyolite Flow B has been quarried in two places for building stone. Flow B is accompanied in a small area by a layer of onyx. Onyx occurs at the more northerly excavation, in the central part of the area.

Chalcedony

Chalcedony occurs in a mafic volcanic scree atop the west Buckeye Copper mineshaft dump. The west shaft extends over a hundred feet in depth. The mafic rock does not outcrop. Chalcedony is amygdaloidal.

Accessibility to Exploitation

This area is easily accessible. The main highway turns away at Hassayampa, 15 miles distance and the old highway, Old U.S. 80, passes within six miles of the property. The railroad can be reached at either Gila Bend or Hassayampa.

GEOLOGIC HISTORY

Precambrian

1. The early Precambrian history of the Webb district is similar to that recorded for much of southern Arizona. Sometime in the older Precambrian, perhaps as much as two billion years ago, a geosynclinal trough developed. Regional faulting and warping formed this trough in the earth's crust, which at that time consisted primarily of igneous rocks in the southern Arizona area (Wilson, 1962). Cooper and Silver (1954, p. 1242) state that the complete extent of this trough is not known.

2. In the Webb Mountain area, a sand and mudstone series was deposited on the margins of this basin. The sediments were lithified (Figure 16).

3. A diabase sill intruded the sedimentary series.

4. Two rhyolite flows were extruded on the sedimentary series.

5. Regional metamorphism and small-scale folding deformed and recrystallized the sedimentary series, the diabase, and the rhyolite. Metarhyolite now appears as lenses in the schist and quartzite.

6. Major intrusions of granodiorite, followed by quartz monzonite and quartz diorite invaded the metasedimentary rocks. The metamorphic rocks were domed and faulted by the plutons in the vicinity of the present Buckeye Copper Mine area.

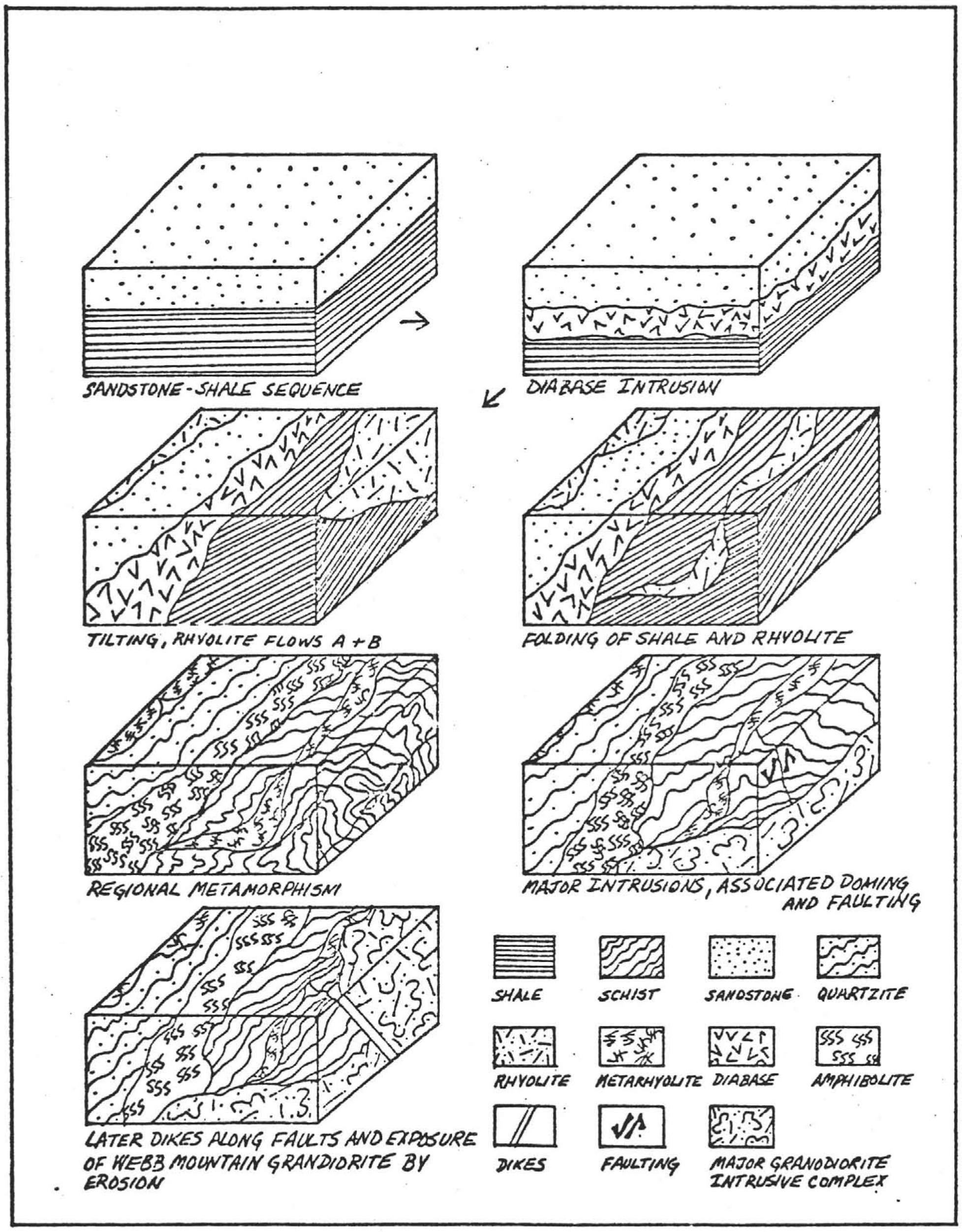

Figure 16

Sequence of events which occurred in the Webb Mountain area.

7. Post-magmatic shearing and partial recrystallization of the plutons produced gneissic structures.

Mesozoic(?)

1. Between the invasion of the Precambrian quartz diorite and late Cretaceous volcanism, a quartz monzonite dike swarm invaded the area. These igneous bodies contain copper mineralization, which may indicate a Late Cretaceous age (Lowell and Guilbert, 1970, p. 398). Dikes of aplite and then diorite intruded the metamorphic rocks and the diorite pluton.

2. Quartz-tourmaline veins appear to be the last plutonic pulsation.

3. Cretaceous volcanism occurred in the western part of the area. Broad open flexures may have formed at this time.

Cenozoic

1. Miocene-Pliocene Basin and Range faulting occurred, exposing the Precambrian complex to erosion.

2. Quaternary basalt was extruded, partially covering the district.

IRON KING ASSAY OFFICE

ASSAY CERTIFICATE

BOX 14 — PHONE 632-7410
HUMBOLDT, ARIZONA 86329

RAY CHEESEMAN
666 Campus Hts.
Flagstaff, Ariz. 86001

Nov. 16, 1974

DESCRIPTION	oz/ton Au	oz/ton Ag		% Fe	% Pb	% Zn	% Cu
Sample So.0							1.18
" CCC							0.26
" IV-3 #2							0.07
" Cmb S 30							0.04
" IV - 3 #1							0.05
" WBS #2 SCT							0.04
" WBS Sch							0.04
" OP Sch							0.05

Appendix I

Iron King Assay Office certificate showing eight Webb Mountain copper values.

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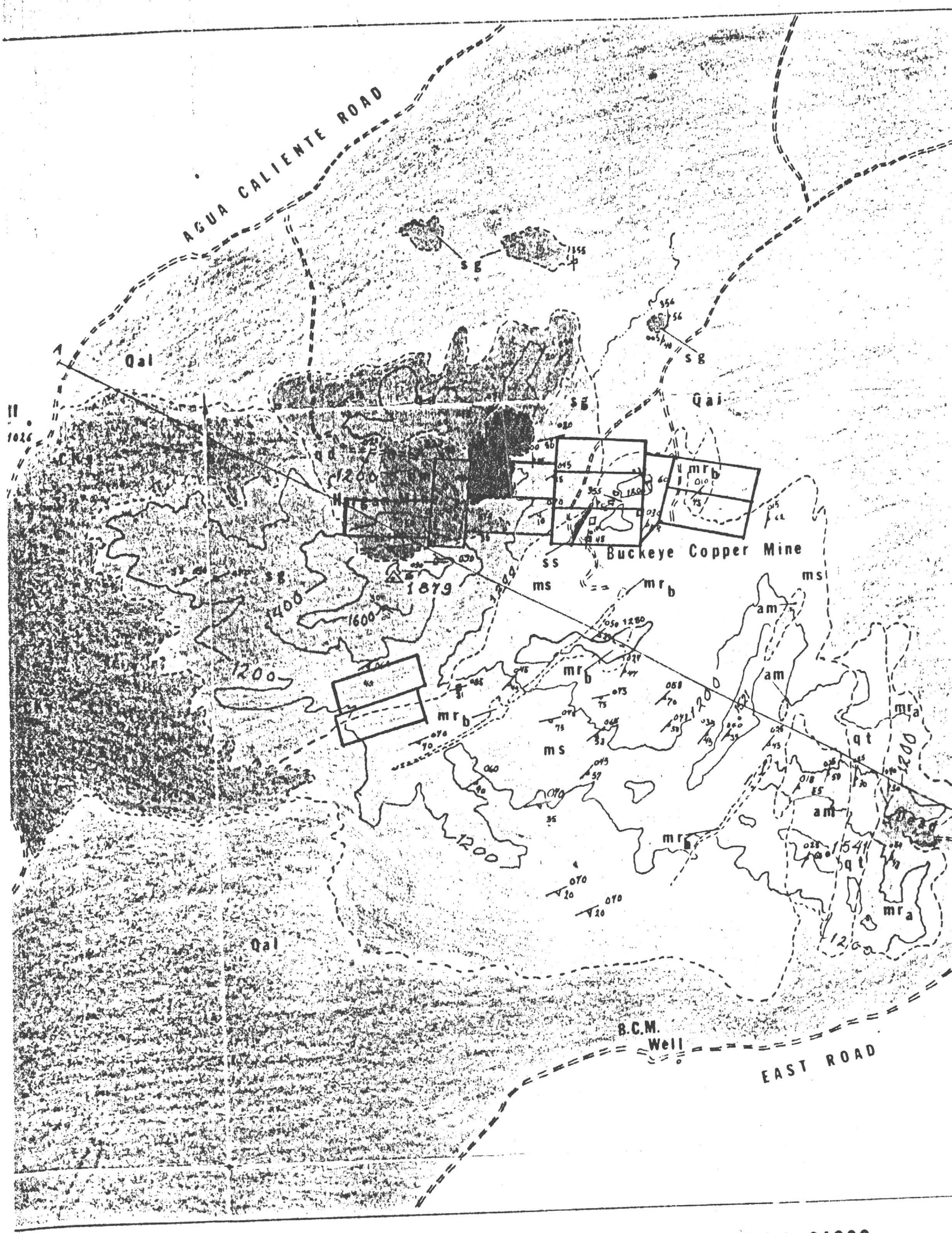
~~59-G Pan American Freeway, N.E.~~
~~lbuquerque, New Mexico 87107~~



LATE 1. GEOLOGIC MAP OF WEBB MOUNTAIN, GILA BEND MOUNTAINS, MARICOPA COUNTY, ARIZONA

By

Ray Cheeseman

1974

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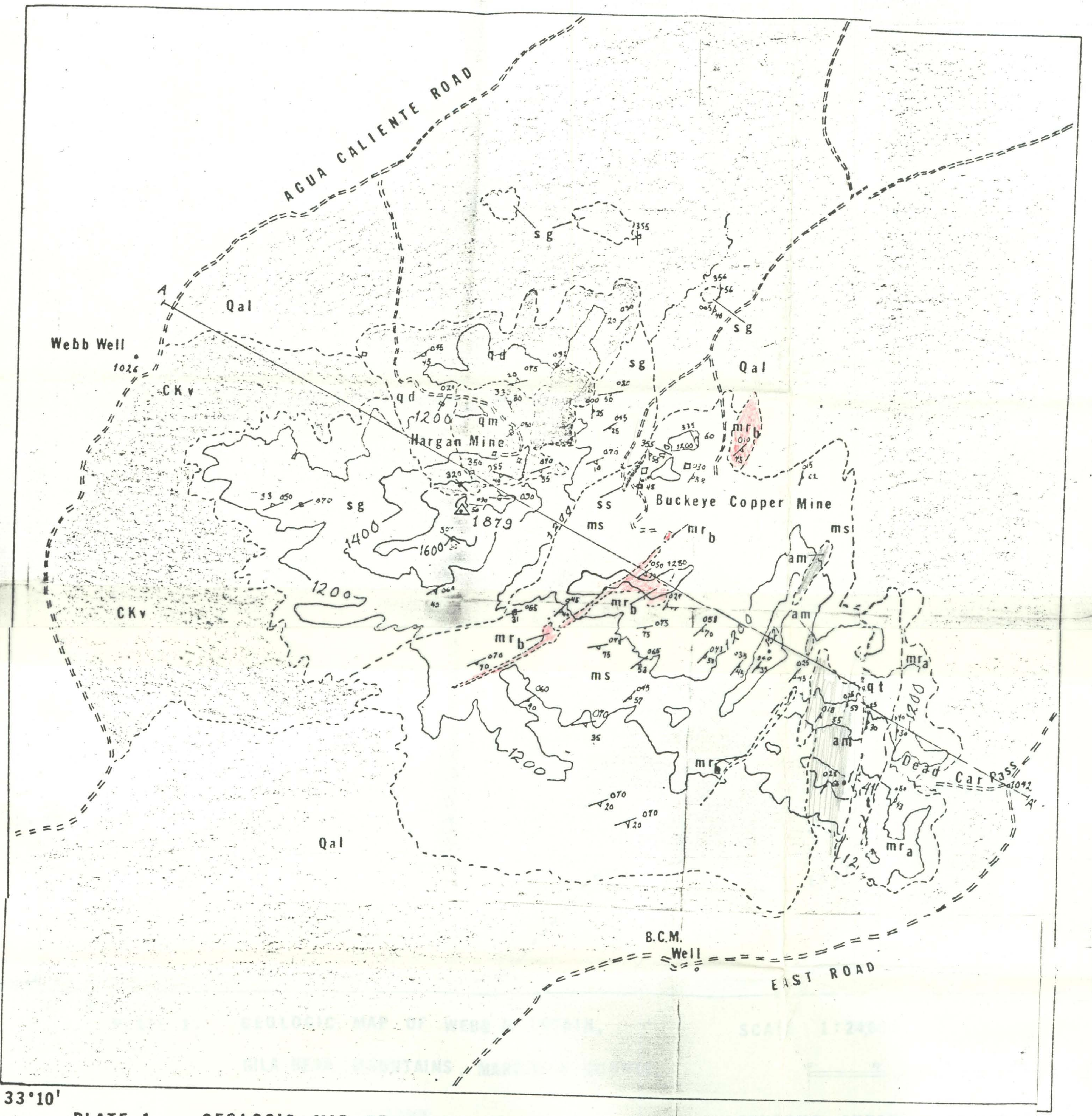
CONTOUR INTERVAL 20



112°55'
33°10'

PLATE 1. GEOLOGIC MAP OF WEBB MOUNTAIN, GILA BEND MOUNTAINS, MARICOPA COUNTY, ARIZONA

By

Ray Cheeseman

1974

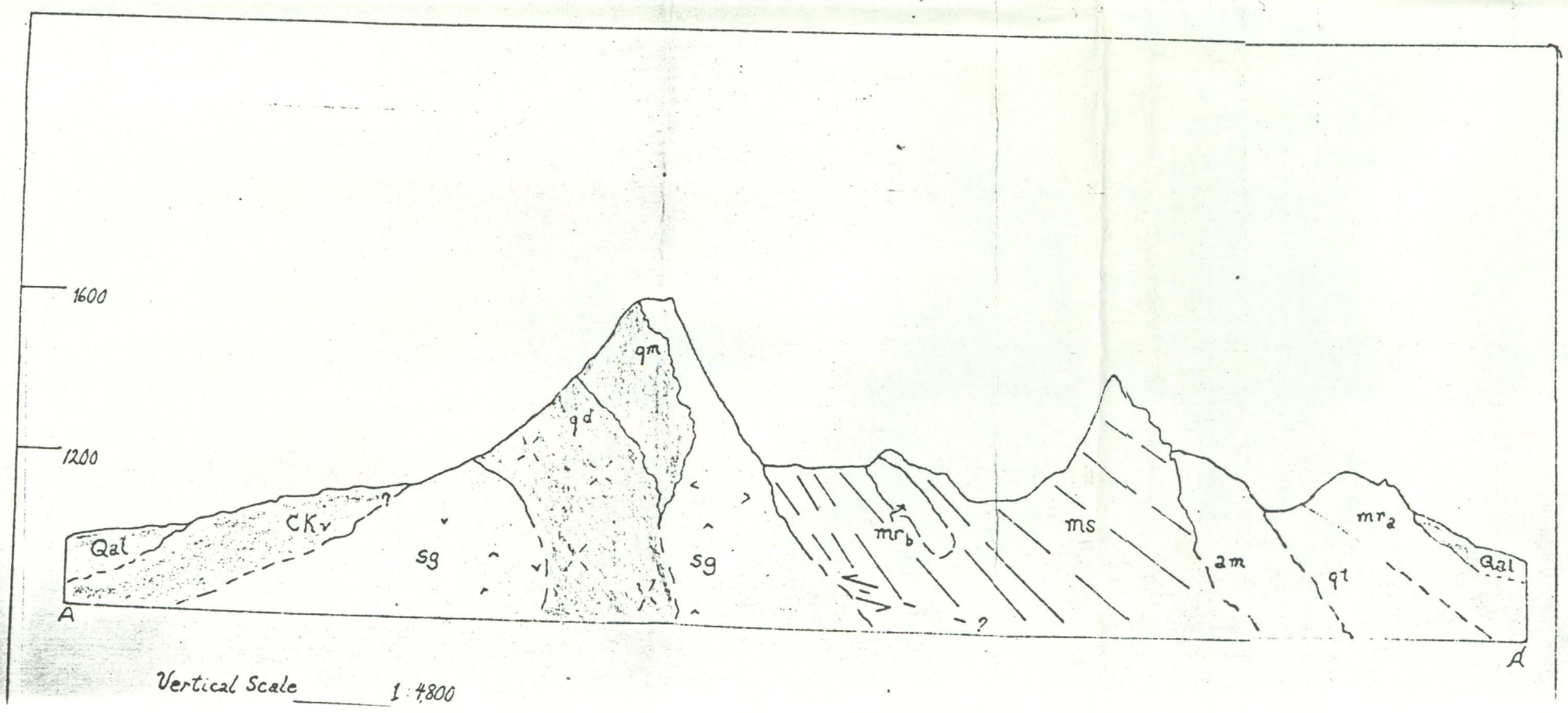
SCALE 1:24,000

0 .25 .5 .75 1 MILE

CONTOUR INTERVAL 200 FEET

EXPLANATION

- Qal — Quaternary alluvium
- CKv — Cenozoic and Cretaceous volcanic rocks
- yqm — Younger Quartz Monzonite
- qd — Quartz Diorite
- qm — Quartz Monzonite
- sg — Sheared Granodiorite
- ss — Sericite Schist
- mr$_a$ — Metarhyolite Flow A
- mr$_b$ — Metarhyolite Flow B
- am — Amphibolite
- qt — Quartzite
- ms — Mica Schist
- Fault
- Dike
- Streambed
- Adit
- Road
- Foliation strike, dip
- Contact
- 1200 — Contour



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