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

The following file is part of the

James Doyle Sell Mining Collection

ACCESS STATEMENT

These digitized collections are accessible for purposes of education and research. We have indicated what we know about copyright and rights of privacy, publicity, or trademark. Due to the nature of archival collections, we are not always able to identify this information. We are eager to hear from any rights owners, so that we may obtain accurate information. Upon request, we will remove material from public view while we address a rights issue.

CONSTRAINTS STATEMENT

The Arizona Geological Survey does not claim to control all rights for all materials in its collection. These rights include, but are not limited to: copyright, privacy rights, and cultural protection rights. The User hereby assumes all responsibility for obtaining any rights to use the material in excess of "fair use."

The Survey makes no intellectual property claims to the products created by individual authors in the manuscript collections, except when the author deeded those rights to the Survey or when those authors were employed by the State of Arizona and created intellectual products as a function of their official duties. The Survey does maintain property rights to the physical and digital representations of the works.

QUALITY STATEMENT

The Arizona Geological Survey is not responsible for the accuracy of the records, information, or opinions that may be contained in the files. The Survey collects, catalogs, and archives data on mineral properties regardless of its views of the veracity or accuracy of those data.

ASARCO

Southwestern Exploration Division

JDS

October 20, 1986

To: J.D. Sell

From: H.G. Kreis

Mesquite Mine
Imperial County, AZ

The Mesquite Mine was visited by you and me on a recent AGS field trip, and the geology is described in the attached Gold Fields' handout. The highlights of the Mesquite deposit are briefly summarized in the following paragraphs.

Blast hole assays and geologic mapping in the Mesquite open pit show the gold is very strongly controlled by northwest striking, steeply dipping faults (see Figures 3 and 5 in the attached handout). Some of these high angle faults are breccia veins with a quartz-ankerite matrix and high gold values, 0.1 to 0.9 opt. A strongly developed, low angle fault zone is present on the west side of the pit (Figure 3), and it strikes northwesterly and dips southwesterly at 25°. The low angle fault zone and its hanging wall do not host gold mineralization, and the low angle fault appears to cut the high angle, gold bearing faults.

The gold mineralization favors the middle unit of the biotite gneiss. Furthermore, the gold appears to be spacially related to a sill like mass of muscovite granite, and the possibility of a genetic relationship exists. The granite has a halo of bleaching and sericitization in the gneiss host rock.

The gold mineralization is associated with weak pyrite mineralization amounting to one to three percent. There is no substantial silicification except in the fault breccia veins. There is minor clay on fractures, but no significant clay alteration products. I took five samples to check the trace element geochemistry, and the results should be available in a couple of weeks (sample locations in Figure 3).

The Mesquite Deposit has been substantially affected by post mineral horst-grabben faulting. In the SE corner of the pit, for example, a large block of barren hornblende-biotite gneiss was uplifted 300' into the gold ore zone. Similarly, the premineral-postmineral contact has been block faulted.

New gold reserves have been discovered south of the highway. Fifteen million tons at 0.05 opt Au is present in three deposits which include the old Rainbow and Vista Mines. Rumored information said these reserves are much larger, and will support an open pit the size of Mesquite (41 million tons at 0.056 opt Au).

H. G. Kreis

HGK:mek
Att.

H. G. Kreis

cc: WL Kurtz, FR Koutz, T Dalla Vista

AK

GEOLOGY AND MINERALIZATION

OF THE MESQUITE OPEN PIT

GOLD MINE

Gearld F. Willis
Mine Geologist

Gold Fields Operating Co.-Mesquite
HCR 76 Glamis 100
Brawley, CA 92227

Presented at 10-17-86 AGS talk and followed by trip (AGS) to the Mesquite Mine.

The Mesquite orebody is located on the southwestern flank of the Chocolate Mountains of southeasternmost California. Gold mineralization occurs in rocks of the upper plate of the Chocolate Mountains thrust. This thrust is reported to have moved gneisses and intrusive rocks at least 48 kilometers to the northeast over the greenschist facies Orocopia and Pelona schists (Dillon, 1975). Various attempts have been made to correlate the upper plate gneissic rocks to similar rocks in the Picacho area, Peter Kane Mountain area, the Cargo Muchacho Mountains and Pilot Knob (Fig. 1), based on scattered radiometric age dates and similarity in appearance (Miller, 1944; Crowell, 1975; Dillon, 1975; Haxel, 1975; Morton, 1977). More recent work (Tosdal and others 1985) has indicated the rocks in the Cargo Muchacho Mountains and the Picacho Peak area are Mesozoic in age, possibly Middle to Late Jurassic, based on U-Pb zircon dates. Similar dating done on biotite gneiss from the Mesquite pit has also shown a Jurrasic age (Tosdal pers. commun., 1986).

A pseudostratigraphic sequence of rocks within the Mesquite pit has been defined through reconnaissance mapping, diamond core drilling, reverse circulation drilling and pit mapping (Fig. 2 and Fig 3). Mafic

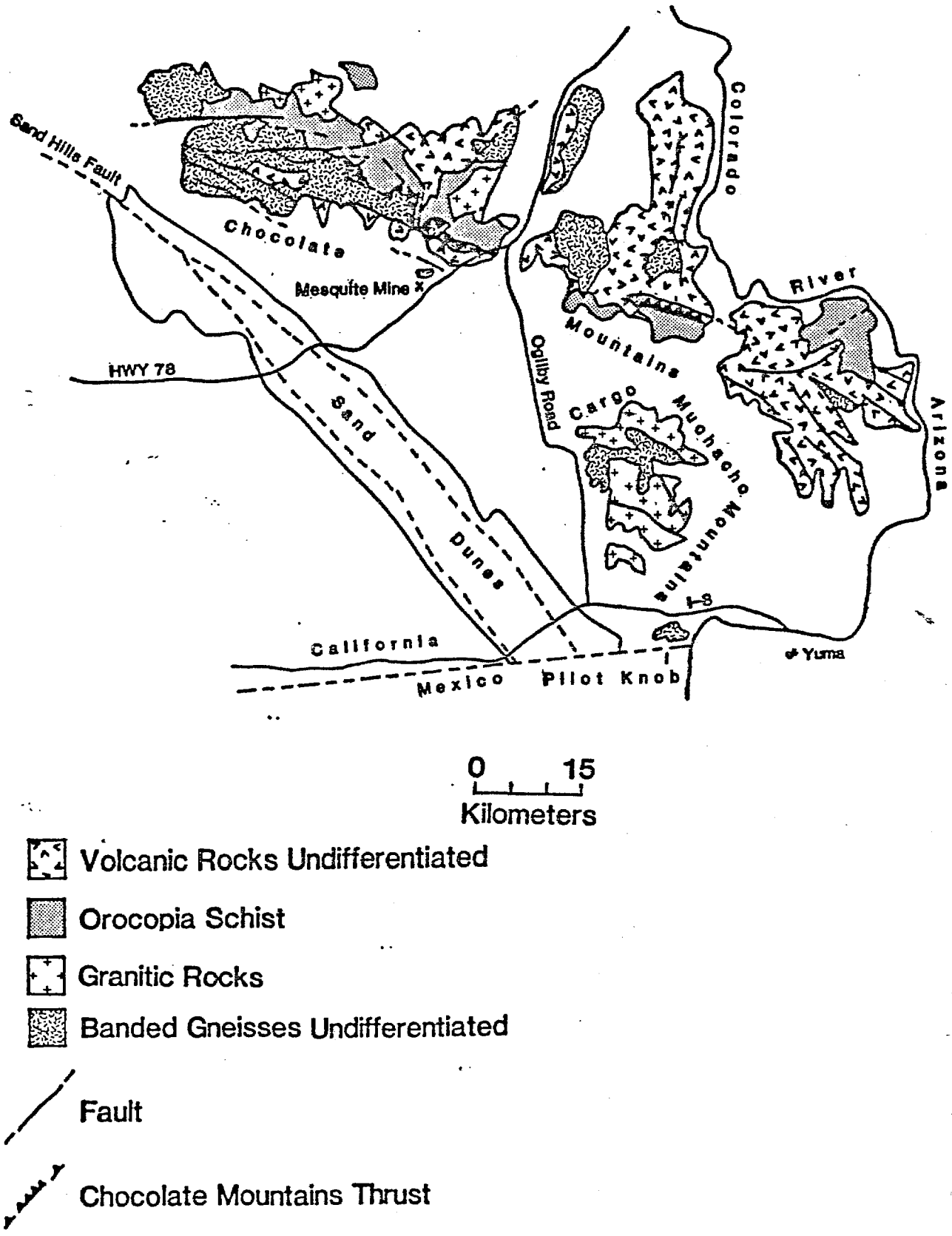


Fig. 1. Regional geologic map of southeasternmost California (adapted from Morton, 1977).

MESQUITE PIT
PSEUDO-STRATIGRAPHIC SECTION

Not to scale

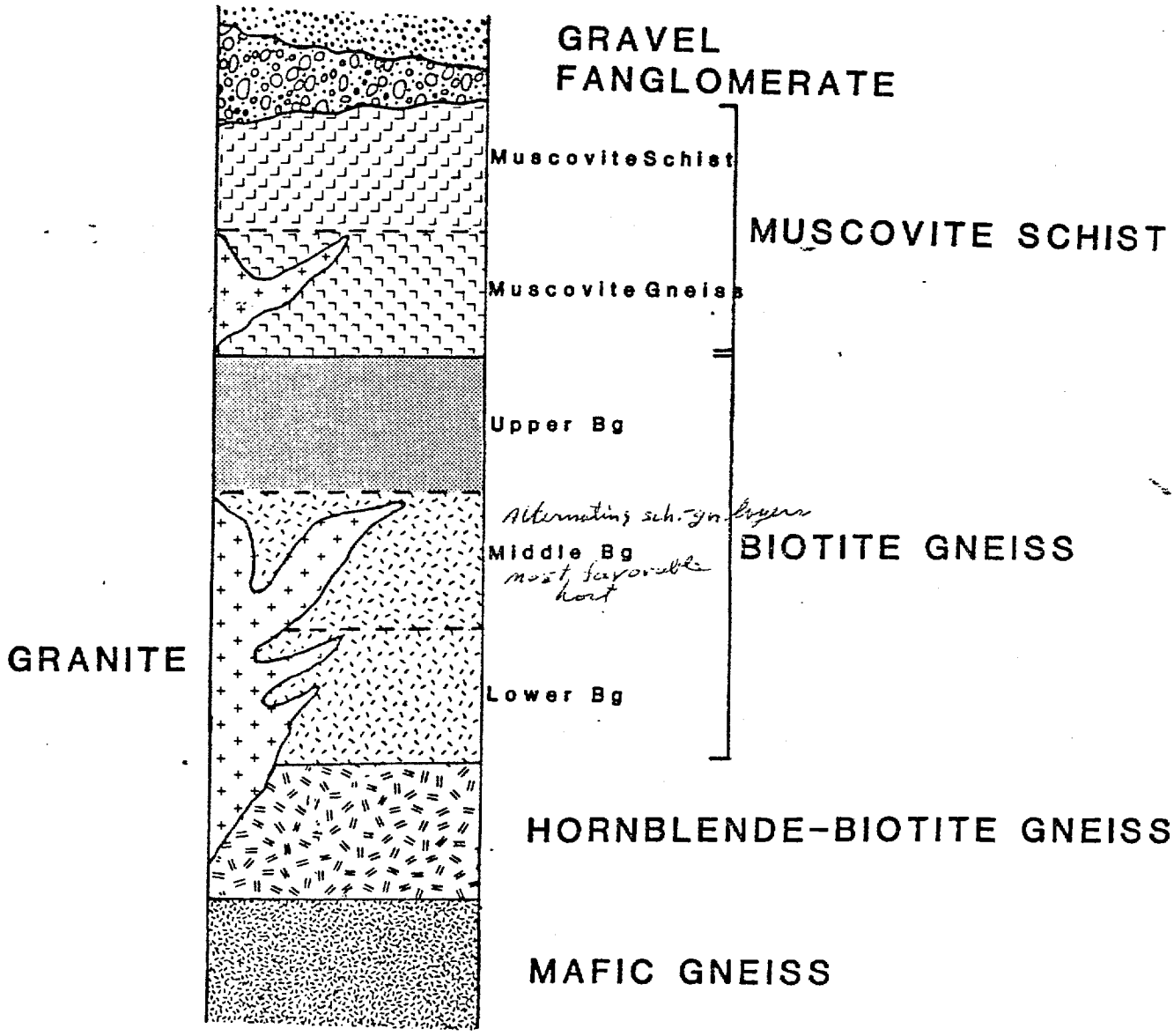


Fig. 2

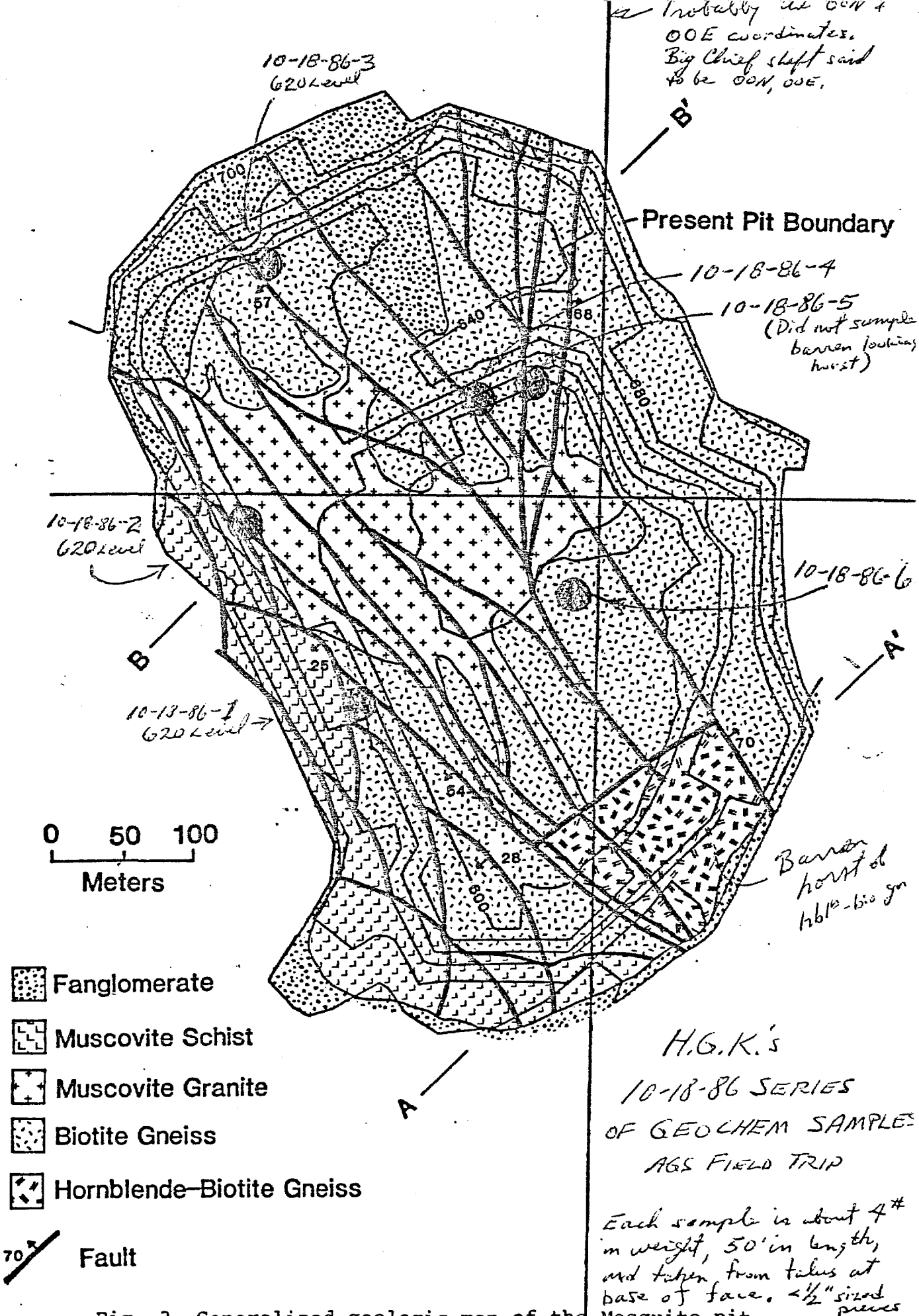


Fig. 3. Generalized geologic map of the Mesquite pit.

gneiss is the lowermost unit defined and forms the core of a northwest trending antiformal structure. The Mesquite orebody lies on the southwestern limb of this inferred structure. Moving upwards, the sequence consists of hornblende biotite gneiss, biotite gneiss, muscovite schist, Tertiary conglomeratic sediments and recent gravel cover. The biotite gneiss has been further divided into a lower salt and pepper unit, a middle unit consisting of alternating layers of salt and pepper gneiss and biotite rich layers and an upper quartzofeldspathic unit. The muscovite schist has been divided into a lower quartzofeldspathic muscovite gneiss and a very friable muscovite schist.

A coarse grained to pegmatitic muscovite bearing granite crosscuts the lower and middle units of the biotite gneiss and the muscovite gneiss. The intrusive may be sill-like, with a series of smaller dikes and sills radiating away from the main mass. Potassium-argon dating puts the age of the intrusive at around 38 m.y., but it is probable this is a reset metamorphic date.

Pit geology is dominated by two sets of major faults (Fig. 3). The first set has a strike of N. 40 to 50 W., with a split near mid-pit trending due north. This fault set has a range of dips from 55 to 80 southwest and northeast. The second major fault

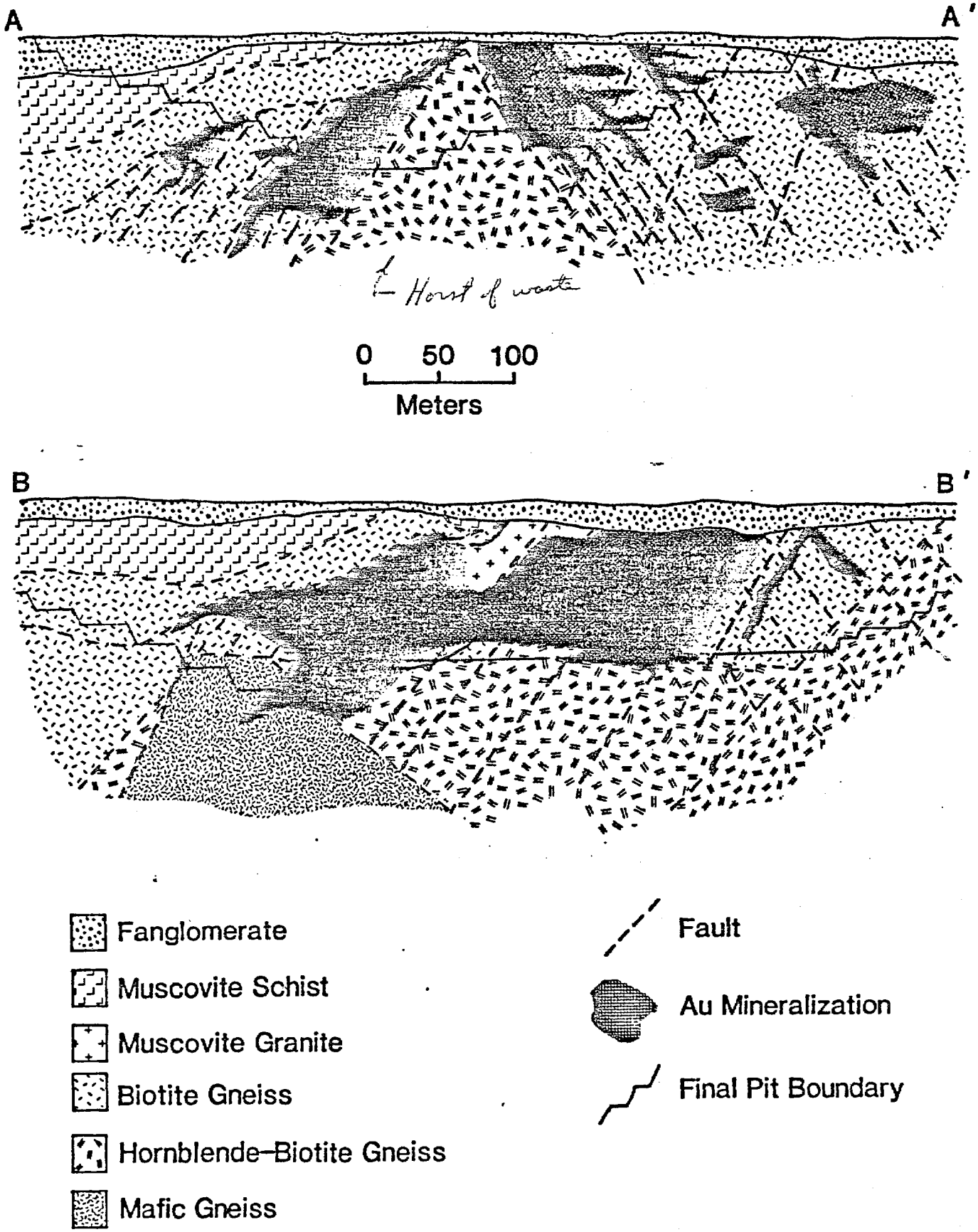


Fig. 4. Generalized geologic cross sections looking northwest through the Mesquite orebody.

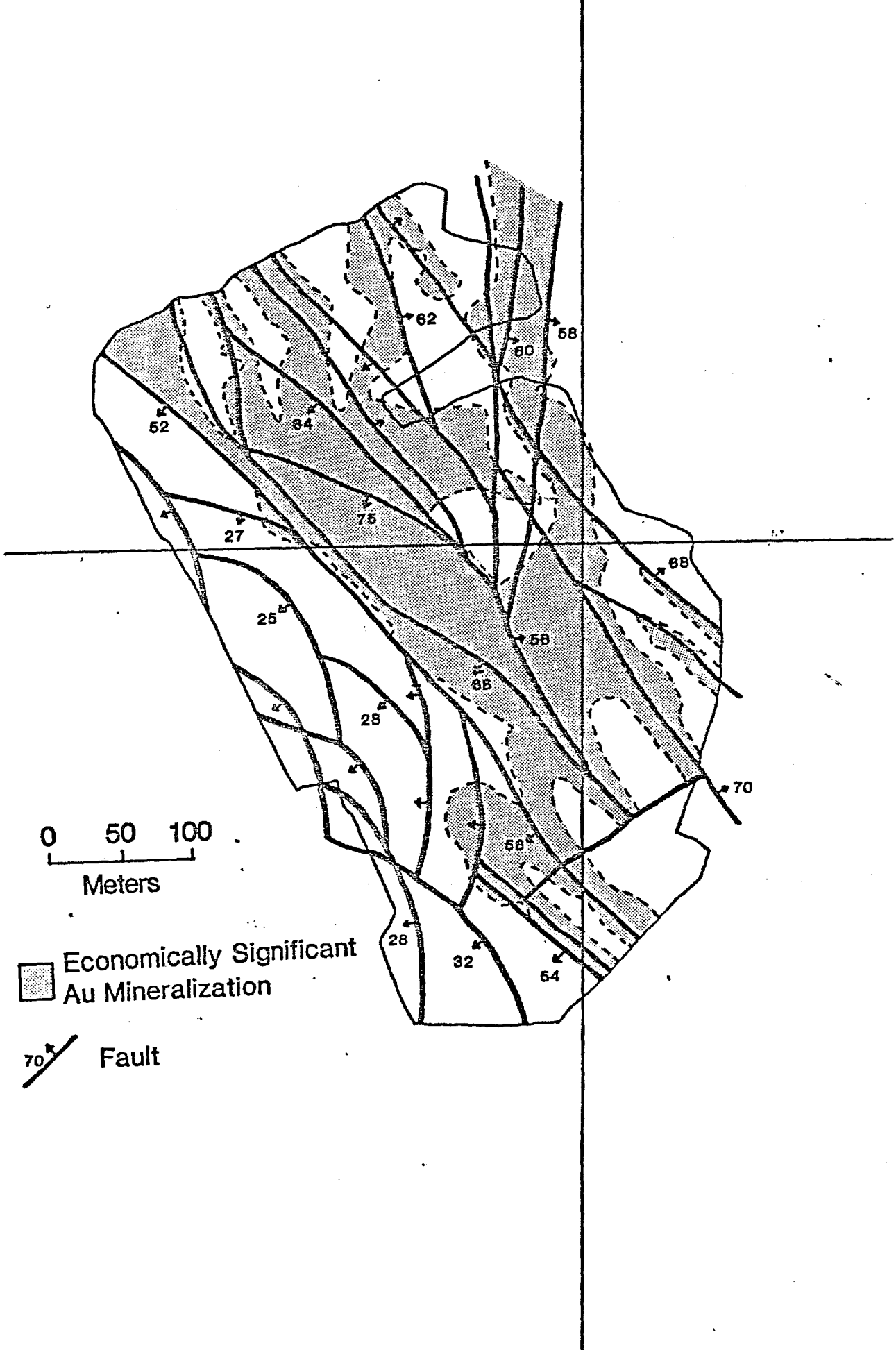


Fig. 5. Simplified fault map showing relationship of mineralization to faulting on the 640 bench.

trend dips from 20 to 40 to the southwest, with individual faults having an arcuate trace. In cross section the arcuate system has a braided appearance which may be evidence for a tensional detachment system, (Adams and others, 1983) but locally there is evidence for low angle reverse movement or thrusting.

Detailed fault mapping and blast hole sampling has shown that the majority of the gold mineralization is closely associated with, if not totally controlled by the high angle north to northwest trending fault system (Fig. 4 and 5). The low angle fault system is not mineralized and appears to have moved barren rock over the top of the high angle mineralized system often concealing it. Mineralization dies out to the northwest and southeast with higher grade zones occurring where the system is narrowest.

It is possible that the granite intrusive has played a major role in concentration of gold mineralization. The intrusive may have acted as the heat sources that brought in gold mineralization or remobilized anamalous syngenetic gold, concentrating it in the high angle structures, as well as in the receptive middle biotite gneiss.

It is also possible that the mineralization would fit into the detachment model as proposed by Drobeck and others (1986) for the Picacho Mine. In the Mesquite

instance the mineralization would be concentrated in the high angle normal faults rather than the low angle or detachment zone.

There are unanswered questions in relating gold mineralization to either of these two models. What is evident is the high angle normal faulting is very important in the Mesquite orebody. Relatively recent reactivation of many of these normal faults has complicated the picture even further and dictates the present signature of the orebody.

Adams, M.A., Hillemeyer, F.L., and Frost, E.G., 1983, Anastomosing shear zones - A geometric expansion for mid-Tertiary crustal extension in the detachment terrane of the Colorado River region, California, Arizona, and Nevada: Geological Society of America Abs w/Programs, v. 15, no. 7, p. 375.

Crowell, J.C., 1975, Geologic sketch of the Orocopia Mountains, southeastern California: California Div. Mines and Geology Spec. Rept. 118, p. 99-110.

Dillon, J.T., 1975, Geology of the Chocolate and Cargo Muchacho Mountains, southeasternmost California: Univ. Calif. Santa Barbara, Ph.D. thesis, 405 p.

Dillon, J.T., and Haxel, G.B., 1975, The Chocolate Mountain- Orocopia-Vincent thrust systems as a tectonic element of late Mesozoic California: Geol. Soc. America, Abs. with Programs, v. 7, no. 3, p. 311.

Drobeck, P.A.; Hillemeyer, F.L., Frost, E.G., Liebler, G.S., 1986, The Picacho Mine: A gold mineralized detachment in southeastern California: Arizona Geological Society Digest, v. XVI.

Haxel, G.B., 1975, The Orocopia Schist and the Chocolate Mountain thrust, Picacho-Peter Kane Mountain area, southeasternmost California: Univ. Calif. Santa Barbara, Ph.D. thesis, 277 p.

Miller, W.J., 1944, Geology of Palm Springs-Blythe strip, Riverside County, California: California Jour. Mines and Geology, v. 40, no. 1, p. 11-72.

Tosdal, R.M., Haxel, G.B., Dillon, J.T., 1985, Lithologic associations of gold deposits, southern California and southwestern Arizona: Geologic Society of America Abs. w/Programs, v. 17, no. 6, p. 414.

SKYLINE LABS, INC.
1775 W. Sahuaro Dr. • P.O. Box 50106
Tucson, Arizona 85703
(602) 622-4836

REPORT OF ANALYSIS

JOB NO. TAJ 467
November 7, 1986
10-18-86 1,2,3,4,6
PAGE 1 OF 1

ASARCO INCORPORATED
Attn: Mr. H.G. Kreis
Southwestern Exploration
P.O. Box 5747
Tucson, Arizona 85703

Analysis of 5 Rock Chip Samples

ITEM	SAMPLE NUMBER	Au (ppm)	As (ppm)	Sb (ppm)
1	10-18-86-1	.16	70.	2.
2	10-18-86-2	.52	50.	1.
3	10-18-86-3	2.60	34.	1.
4	10-18-86-4	.65	60.	2.
5	10-18-86-6	1.90	145.	3.

cc: ASARCO INCORPORATED
Attn: Mr. James D. Sell
Southwestern Exploration
P.O. Box 5747
Tucson, AZ 85703

ASARCO Incorporated
NOV 10 1986
SW Exploration

REGISTERED ASSAYER
CERTIFICATE NO.
9425
WILLIAM L.
LEHMBECK
REGISTERED
ARIZONA
11/7/86

SKYLINE LABS, INC.
1775 W. Sahuaro Dr. • P.O. Box 50106
Tucson, Arizona 85703
(602) 622-4836

REPORT OF SPECTROGRAPHIC ANALYSIS

JOB NO. TAJ 467
November 7, 1986
10-18-86 1,2,3,4,6

ASARCO INCORPORATED
Attn: Mr. H.G. Kreis
Southwestern Exploration
P.O. Box 5747
Tucson, Arizona 85703

Spectrographic Analysis of 5 Samples

The attached pages comprise this report of analysis. Values are reported in parts per million (ppm), except where otherwise noted, to the nearest number in the series 1, 1.5, 2, 3, 5, 7, 10, etc. within each order of magnitude. These numbers represent the approximate boundaries and midpoints of arbitrary ranges of concentration differing by the reciprocal of the cube root of ten. The 'accepted' value is considered to be within + or - 1 step of the range reported at the 68 % confidence level and within + or - 2 steps at the 95 % confidence level.

REGISTERED ASSAYER CERTIFICATE NO. 9425 WILLIAM L. LEHMBECK DATE SIGNED 11/7/86 Arizona

William Lehmbeck
Manager

cc: ASARCO INCORPORATED
Attn: Mr. James D. Sell
Southwestern Exploration
P.O. Box 5747
Tucson, AZ 85703

ASARCO Incorporated
NOV 10 1986
SW Exploration

SKYLINE LABS, INC.
1775 W. Sahuaro Dr. • P.O. Box 50106
Tucson, Arizona 85703
(602) 622-4836

JOB NO. TAJ 467
PAGE 2

ITEM NO.		SAMPLE NO.
1	=	10-18-86-1
2	=	10-18-86-2
3	=	10-18-86-3
4	=	10-18-86-4
5	=	10-18-86-6

ITEM	1	2	3	4	5
ELEMENT					
Fe	1.5%	.5%	1%	2%	2%
Ca	.2%	.1%	.15%	.5%	.2%
Mg	.2%	.05%	.1%	.2%	.3%
Ag	<1	<1	<1	<1	1
As	<200	<200	<200	<200	200
B	150	10	<10	30	20
Ba	700	500	100	1000	1000
Be	2	<2	<2	<2	2
Bi	<10	<10	<10	<10	<10
Cd	<50	<50	<50	<50	<50
Co	<5	<5	<5	<5	5
Cr	150	70	70	100	100
Cu	20	15	5	20	50
Ga	10	<10	<10	30	20
Ge	<20	<20	<20	<20	<20
La	50	20	20	50	50
Mn	700	200	150	300	1000
Mo	<2	<2	5	5	<2
Nb	<20	<20	<20	<20	<20
Ni	<5	<5	<5	<5	<5
Pb	30	50	<10	50	20
Sb	<100	<100	<100	<100	<100
Sc	<10	<10	<10	<10	<10
Sn	<10	<10	<10	<10	<10
Sr	100	100	<100	200	200
Ti	1500	700	1500	2000	3000
V	50	20	30	50	70
W	<50	<50	<50	<50	<50
Y	10	20	<10	20	20
Zn	<200	<200	<200	<200	<200
Zr	100	50	100	150	150

ASARCO Incorporated
NOV 1 0 1986
SW Exploration

Charles E. Thompson
Arizona Registered Assayer No. 9427

William L. Lehmbeck
Arizona Registered Assayer No. 9425

James A. Martin
Arizona Registered Assayer No. 11122

ASARCO

Southwestern Exploration Division

JDS

October 21, 1986

R.L. Brown
New York Office

Mesquite, etc., Deposit(s)
Imperial County, California

The Arizona Geological Society conducted an extremely interesting field trip on October 17-18-19. Asarco attendees included H.G. Kreis, J.H. Courtright, and J.D. Sell.

The trip included visits to the Mesquite Mine, the American Girl - Padre-Madre Property, and the Picacho Mine.

I attach a Xerox of the cover of the guidebook and also a copy of a handout by the Mesquite staff for your interest.

Of, perhaps, the biggest of surprises was that the ore at Gold Fields' Mesquite is now largely controlled by high-angled structures as they get below the low-angled structures originally thought to control the ore mineralization.

The story of Mesquite is continually being rewritten as exposures are made.

H. Kreis has collected a number of samples and his report will be forwarded upon receipt.

The guidebook proper contains 221 pages with the following titles:

Precious Metal Mineralization, Stratigraphy, and Tectonics in Southeastern California (1 p.).

First Day Road Log (25 p.).

Gneissic Host Rocks to Gold Mineralization in the Cargo Muchacho Mountains, SE Calif. (8 p.).

Second Day Road Log (10 p.).

Field Guide to the Picacho Mine and Vicinity, SE Calif. (33 p.).

(Reprint) Day Three: Picacho Basin - Picacho Mine Area; Detachment Faults and Gold Mineralization (23 p.).

(Reprint) Field Guide to the Chocolate Mountains Thrust and Orocopia Schist, Gavilan Wash Area, SE California (12 p.).

(Reprint) The Pelona-Orocopia Schist and Vincent-Chocolate Mountain Thrust System, S. California (17 p.).

(Reprint) Abstract: The Geology of the Cargo Muchacho Mountains and S. Chocolate Mountains, SE California (4 p.).

(Reprint) Tectonic Setting and Lithology of the Winterhaven Formation (22 p.).

(Reprint) Petrochemical Variations in Laramide Magmatism and their Relationship to Laramide Tectonic and Metallogenic Evolution in Arizona and Adjacent Regions (12 p.).

(Reprint) Gold Fields begins Mesquite Mine Construction.

(Reprint) The Picacho Mine: A Gold Mineralized Detachment in SE California (34 p.).

(Reprint) Geology and Mineralization of the Picacho-Gold Prospect, Imperial County, California (9 p.).

(Reprint) (Several pages of Abstracts).

James D. Sell

James D. Sell

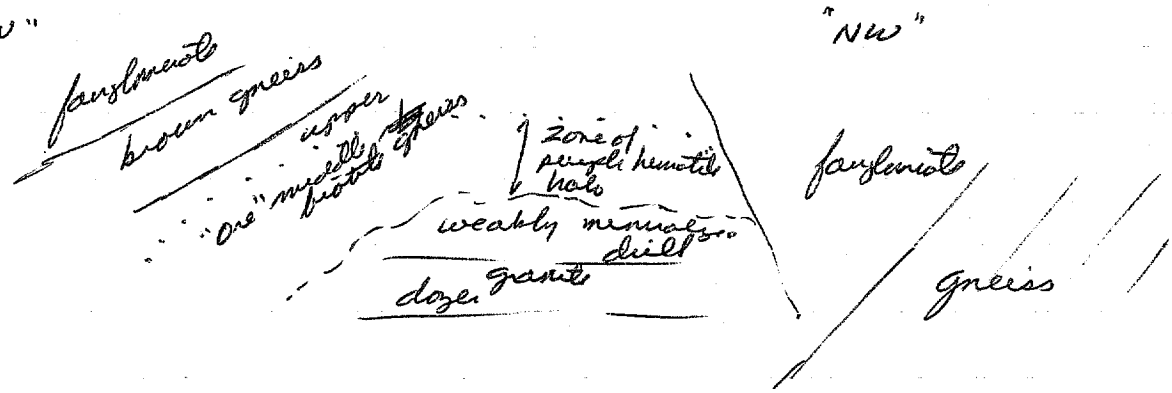
JDS:mek
attachments

cc: W. L. Kurtz

Mesquite Notes 10/18/86 AGS Fall F.T.

12,000 tpd ore with 4/1. w/o ratio, in 40,000 tpd total. Drill ends bench zones on 16' centers for blasting, all grade control determines rock moving to various piles.

NW to W Wall photo:



1-3% pyrite, Tr. Hg ; highest in high angled qtz veins.

Profound vertical ore control by structure which cuts all units (except fanglomerates). The fanglomerates are cut by lots (hundreds) vertical faults. Low dipping structures originally thought to control some mineralization are moving to SW (in plan) as pit deepens.

The middle biotite gneiss has a good affinity for gold. Oxidation to 400-500 feet in highly fractured zones, but may be only 200' deep elsewhere.

No real base metals. Very low silver ppms etc.

Big Chief Shaft in NE corner of present pit & was probably put down on high angled structure just NW of the flattest structures.

Surface at 740 feet. 40' benches.
Planned depth of 460' deep pit, is 280' elevation
Very little true clay, but abundant clay sized particles. On 3/4" crush, get 30% -200 mesh material. Much is fine sericite. Most of "ore" is highly shattered, + cut by numerous qtz + silicified zones and sericitic alteration to obliterate texture in gneisses for most part. (Stepping back 30' you can see the "texture" of gneiss banding etc, but obscure up close.)
Blast hole assays. All 0.1 ppm Au are rerun by fire-assay for control.
All ore agglomerated on belts with the high grade getting a better prewetting and stronger cyanide on the agglomerating belts.
Four stages of mineralization:
1) Late stage boiling silica and pistile breccia formation.
2) Ankerite breccia (calcite-limonite) formation
3) Brown calcite breccia formation
1→3 types contain economic gold values.
4) Late late white calcite veins, sub-economic.
Values disseminate away from veins + breccia zones
Intrusion, "dome" in x-section with ore surrounding.

Precacho Notes 10/19/86 AGS Fall Field Trip

Present mining 2 million tons per year with half being ore, the other waste

Presently recovering 60-70% of values

5 year reserves.

Head grade 0.03-0.04 opt Au

Direct cost is less than $150.00 per ounce produced

Got into production at around $3 million.

Blast control is control and 0.009 is sent to leach pads.

High grade is in flat & steep gneiss-hematite zones. Subsequent cutting of these zones by landslides has produced a mixed bag of rock & mineralized gneiss which is "ore". (based on amount of rock.).

The 4 ore zones are on the flank of a mini-gneiss dome which is cut by "veins" trending NE-SW. Veins strongest near top of dome complex & decrease towards interior.

ARIZONA GEOLOGICAL SOCIETY

Fall Field Trip 1986

Field Trip to Mesquite Mine, American Girl - Padre-Madre Properties, and Picacho Mine, Imperial County, California

led by Will Wilkinson and Clancy Wendt,
NICOR Mineral Ventures, Inc.

GEOLOGY AND MINERALIZATION

OF THE MESQUITE OPEN PIT

GOLD MINE

Gearld F. Willis
Mine Geologist

Gold Fields Operating Co.-Mesquite
HCR 76 Glamis 100
Brawley, CA 92227

The Mesquite orebody is located on the southwestern flank of the Chocolate Mountains of southeasternmost California. Gold mineralization occurs in rocks of the upper plate of the Chocolate Mountains thrust. This thrust is reported to have moved gneisses and intrusive rocks at least 48 kilometers to the northeast over the greenschist facies Orocopia and Pelona schists (Dillon, 1975). Various attempts have been made to correlate the upper plate gneissic rocks to similar rocks in the Picacho area, Peter Kane Mountain area, the Cargo Muchacho Mountains and Pilot Knob (Fig. 1), based on scattered radiometric age dates and similarity in appearance (Miller, 1944; Crowell, 1975; Dillon, 1975; Haxel, 1975; Morton, 1977). More recent work (Tosdal and others 1985) has indicated the rocks in the Cargo Muchacho Mountains and the Picacho Peak area are Mesozoic in age, possibly Middle to Late Jurassic, based on U-Pb zircon dates. Similar dating done on biotite gneiss from the Mesquite pit has also shown a Jurrasic age (Tosdal pers. commun., 1986).

A pseudostratigraphic sequence of rocks within the Mesquite pit has been defined through reconnaissance mapping, diamond core drilling, reverse circulation drilling and pit mapping (Fig. 2 and Fig 3). Mafic

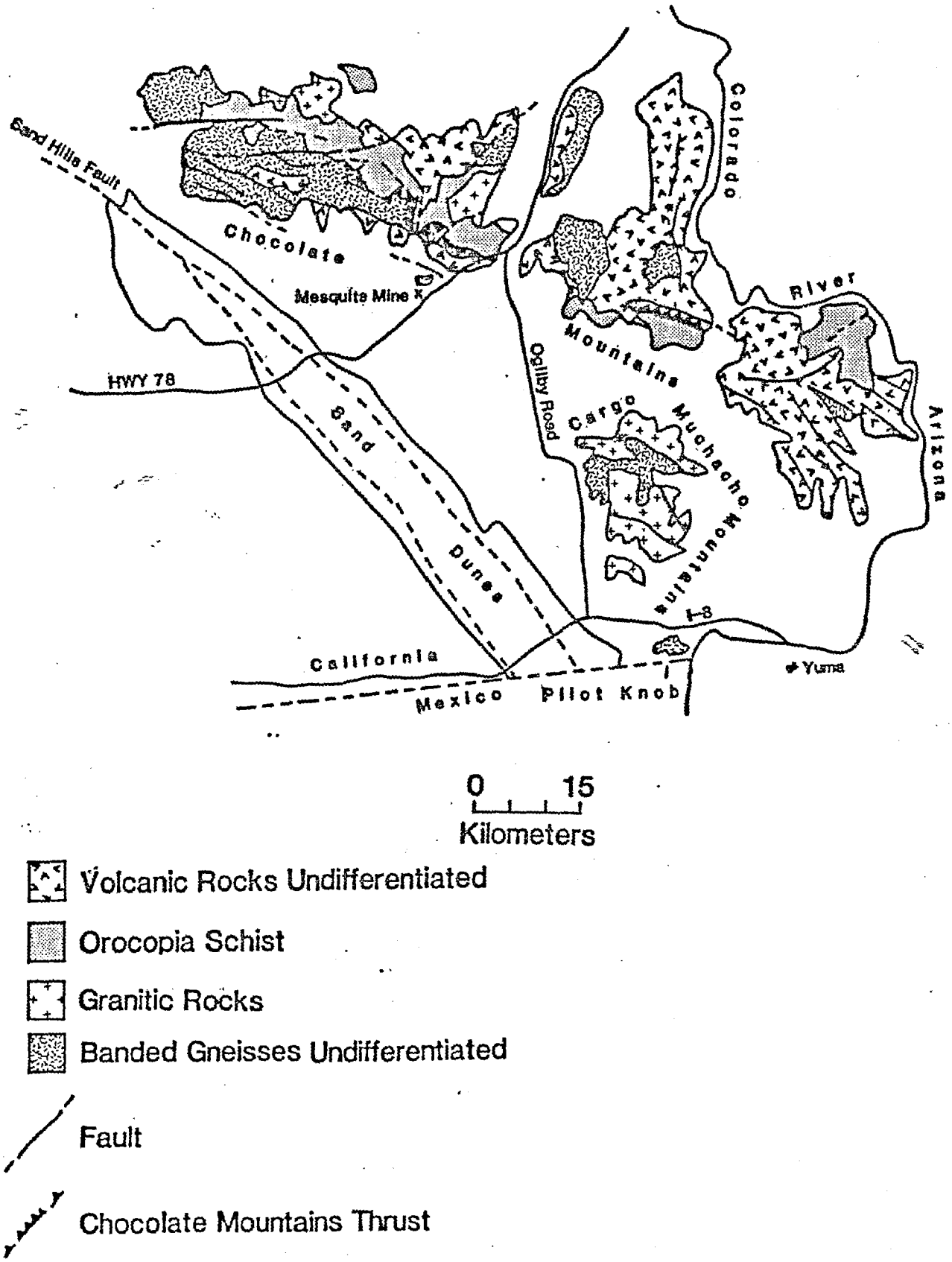


Fig. 1. Regional geologic map of southeasternmost California (adapted from Morton, 1977).

MESQUITE PIT
PSEUDO-STRATIGRAPHIC SECTION

Not to scale

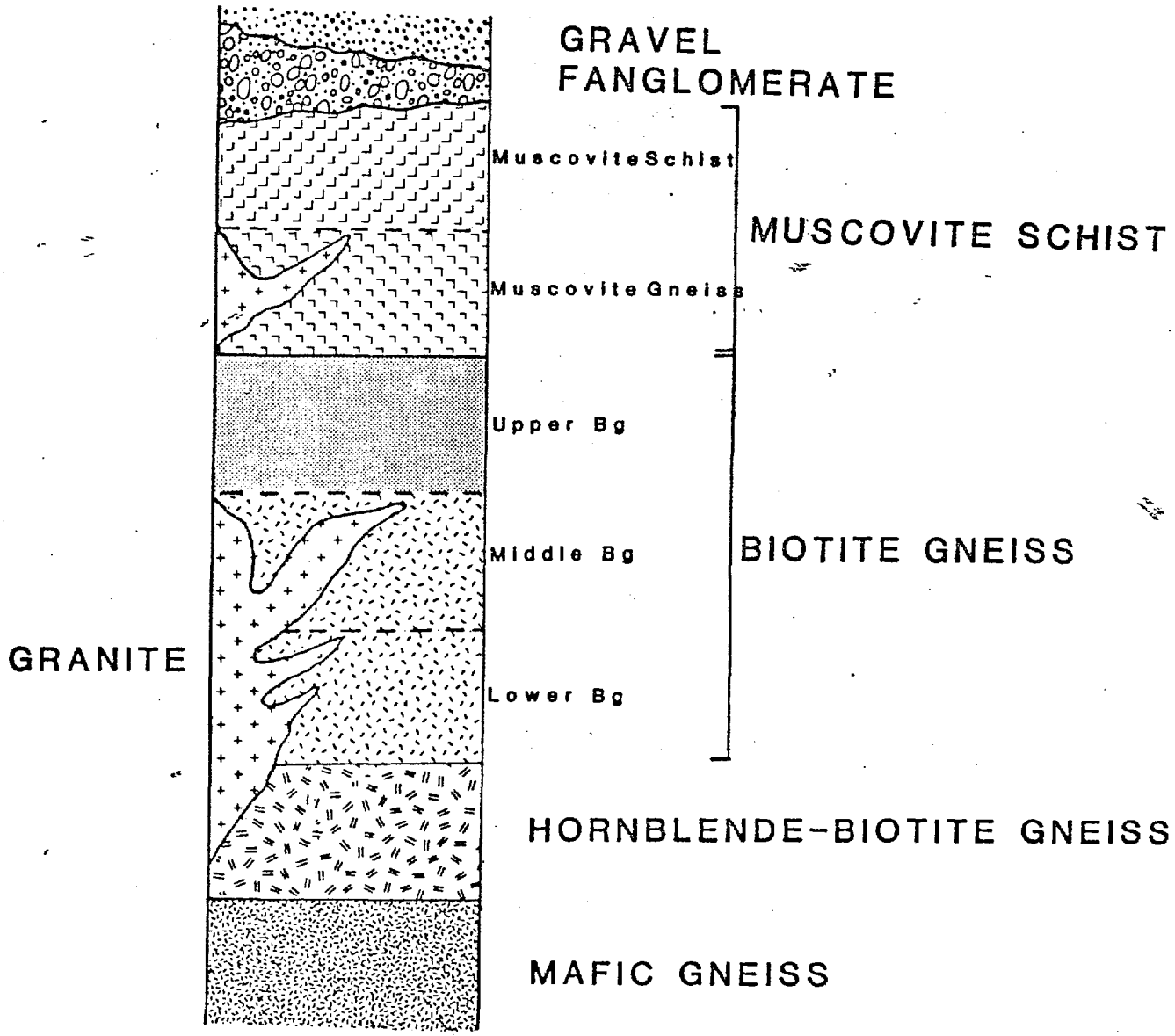


Fig. 2

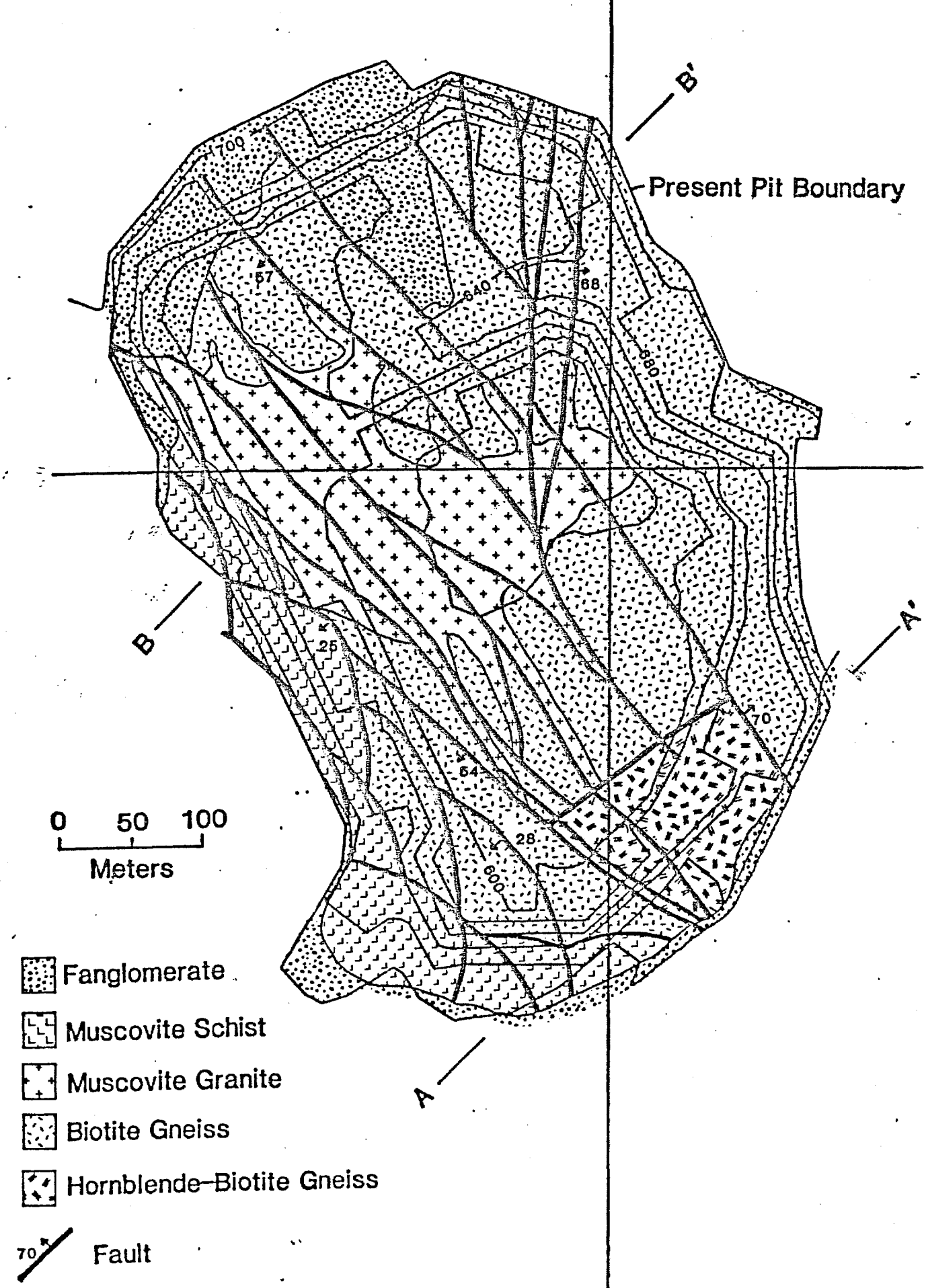


Fig. 3. Generalized geologic map of the Mesquite pit.

gneiss is the lowermost unit defined and forms the core of a northwest trending antiformal structure. The Mesquite orebody lies on the southwestern limb of this inferred structure. Moving upwards, the sequence consists of hornblende biotite gneiss, biotite gneiss, muscovite schist, Tertiary conglomeratic sediments and recent gravel cover. The biotite gneiss has been further divided into a lower salt and pepper unit, a middle unit consisting of alternating layers of salt and pepper gneiss and biotite rich layers and an upper quartzofeldspathic unit. The muscovite schist has been divided into a lower quartzofeldspathic muscovite gneiss and a very friable muscovite schist.

A coarse grained to pegmatitic muscovite bearing granite crosscuts the lower and middle units of the biotite gneiss and the muscovite gneiss. The intrusive may be sill-like, with a series of smaller dikes and sills radiating away from the main mass. Potassium-argon dating puts the age of the intrusive at around 38 m.y., but it is probable this is a reset metamorphic date.

Pit geology is dominated by two sets of major faults (Fig. 3). The first set has a strike of N. 40 to 50 W., with a split near mid-pit trending due north. This fault set has a range of dips from 55 to 80 southwest and northeast. The second major fault

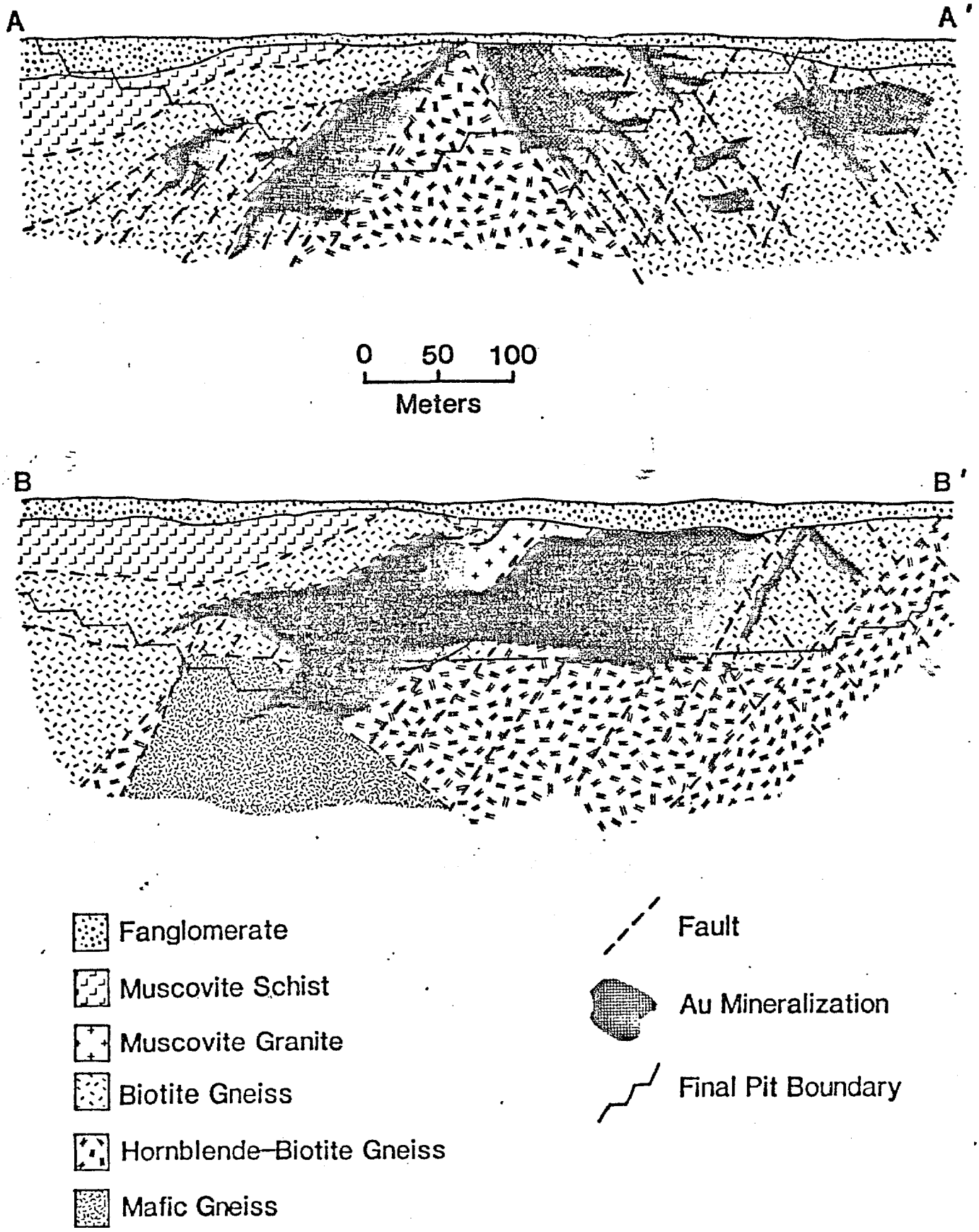


Fig. 4. Generalized geologic cross sections looking northwest through the Mesquite orebody.

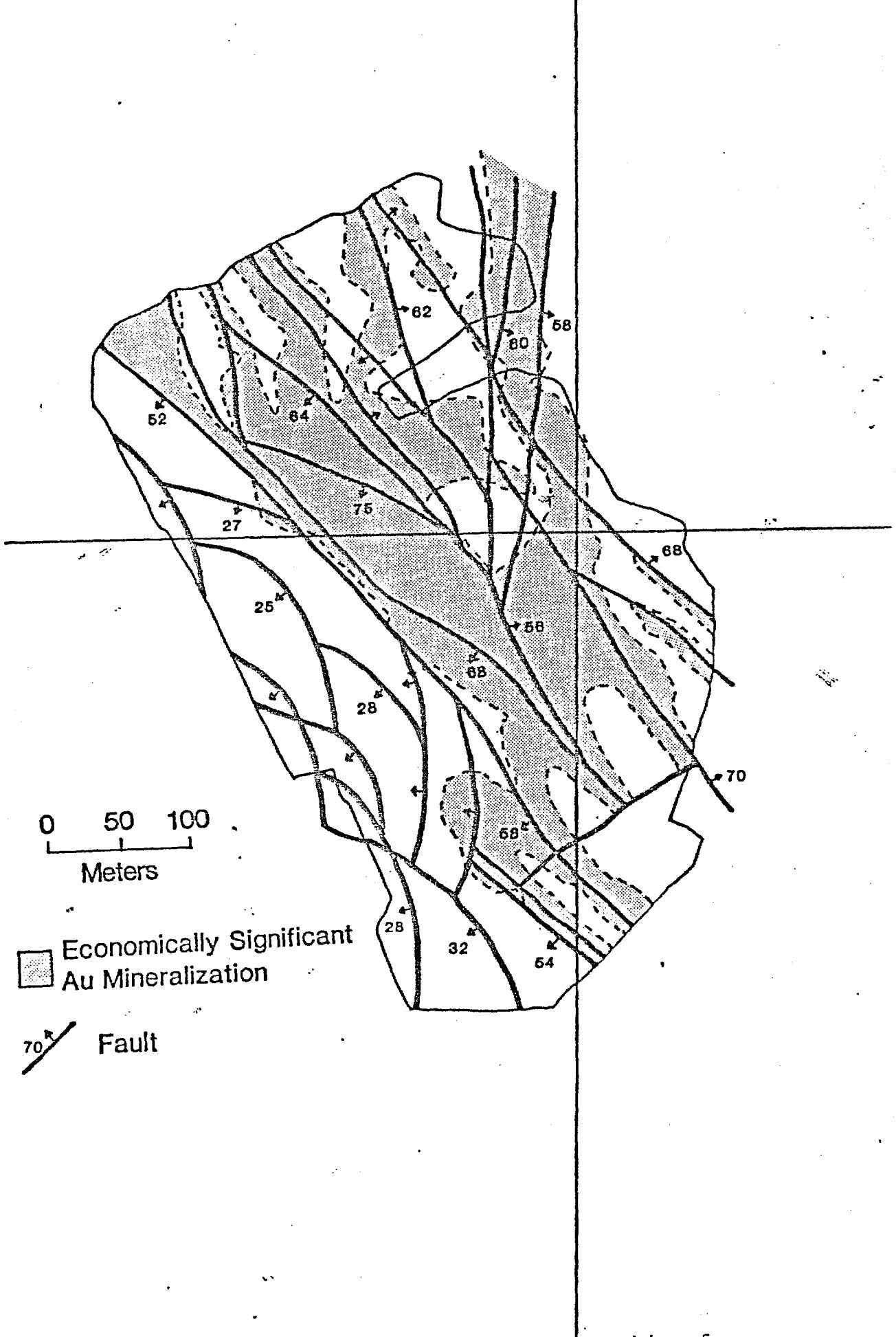


Fig. 5. Simplified fault map showing relationship of mineralization to faulting on the 640 bench.

trend dips from 20 to 40 to the southwest, with individual faults having an arcuate trace. In cross section the arcuate system has a braided appearance which may be evidence for a tensional detachment system, (Adams and others, 1983) but locally there is evidence for low angle reverse movement or thrusting.

Detailed fault mapping and blast hole sampling has shown that the majority of the gold mineralization is closely associated with, if not totally controlled by the high angle north to northwest trending fault system (Fig. 4 and 5). The low angle fault system is not mineralized and appears to have moved barren rock over the top of the high angle mineralized system often concealing it. Mineralization dies out to the northwest and southeast with higher grade zones occurring where the system is narrowest.

It is possible that the granite intrusive has played a major role in concentration of gold mineralization. The intrusive may have acted as the heat sources that brought in gold mineralization or remobilized anamalous syngenetic gold, concentrating it in the high angle structures, as well as in the receptive middle biotite gneiss.

It is also possible that the mineralization would fit into the detachment model as proposed by Drobeck and others (1986) for the Picacho Mine. In the Mesquite

instance the mineralization would be concentrated in the high angle normal faults rather than the low angle or detachment zone.

There are unanswered questions in relating gold mineralization to either of these two models. What is evident is the high angle normal faulting is very important in the Mesquite orebody. Relatively recent reactivation of many of these normal faults has complicated the picture even further and dictates the present signature of the orebody.

Adams, M.A., Hillemeyer, F.L., and Frost, E.G., 1983, Anastomosing shear zones - A geometric expansion for mid-Tertiary crustal extension in the detachment terrane of the Colorado River region, California, Arizona, and Nevada: Geological Society of America Abs w/Programs, v. 15, no. 7, p. 375.

Crowell, J.C., 1975, Geologic sketch of the Orocopia Mountains, southeastern California: California Div. Mines and Geology Spec. Rept. 118, p. 99-110.

Dillon, J.T., 1975, Geology of the Chocolate and Cargo Muchacho Mountains, southeasternmost California: Univ. Calif. Santa Barbara, Ph.D. thesis, 405 p.

Dillon, J.T., and Haxel, G.B., 1975, The Chocolate Mountain- Orocopia-Vincent thrust systems as a tectonic element of late Mesozoic California: Geol. Soc. America, Abs. with Programs, v. 7, no. 3, p. 311.

Drobeck, P.A.; Hillemeyer, F.L., Frost, E.G., Liebler, G.S., 1986, The Picacho Mine: A gold mineralized detachment in southeastern California: Arizona Geological Society Digest, v. XVI.

Haxel, G.B., 1975, The Orocopia Schist and the Chocolate Mountain thrust, Picacho-Peter Kane Mountain area, southeasternmost California: Univ. Calif. Santa Barbara, Ph.D. thesis, 277 p.

Miller, W.J., 1944, Geology of Palm Springs-Blythe strip, Riverside County, California: California Jour. Mines and Geology, v. 40, no. 1, p. 11-72.

Tosdal, R.M., Haxel, G.B., Dillon, J.T., 1985, Lithologic associations of gold deposits, southern California and southwestern Arizona: Geologic Society of America Abs. w/Programs, v. 17, no. 6, p. 414.

GEOLOGY AND MINERALIZATION

OF THE MESQUITE OPEN PIT

GOLD MINE

Gearld F. Willis
Mine Geologist

Gold Fields Operating Co.-Mesquite
HCR 76 Glamis 100
Brawley, CA 92227

Handout Oct 18, 1986
AGS Fall Field Trip

The Mesquite orebody is located on the southwestern flank of the Chocolate Mountains of southeasternmost California. Gold mineralization occurs in rocks of the upper plate of the Chocolate Mountains thrust. This thrust is reported to have moved gneisses and intrusive rocks at least 48 kilometers to the northeast over the greenschist facies Orocopia and Pelona schists (Dillon, 1975). Various attempts have been made to correlate the upper plate gneissic rocks to similar rocks in the Picacho area, Peter Kane Mountain area, the Cargo Muchacho Mountains and Pilot Knob (Fig. 1), based on scattered radiometric age dates and similarity in appearance (Miller, 1944; Crowell, 1975; Dillon, 1975; Haxel, 1975; Morton, 1977). More recent work (Tosdal and others 1985) has indicated the rocks in the Cargo Muchacho Mountains and the Picacho Peak area are Mesozoic in age, possibly Middle to Late Jurassic, based on U-Pb zircon dates. Similar dating done on biotite gneiss from the Mesquite pit has also shown a Jurrasic age (Tosdal pers. commun., 1986).

A pseudostratigraphic sequence of rocks within the Mesquite pit has been defined through reconnaissance mapping, diamond core drilling, reverse circulation drilling and pit mapping (Fig. 2 and Fig 3). Mafic

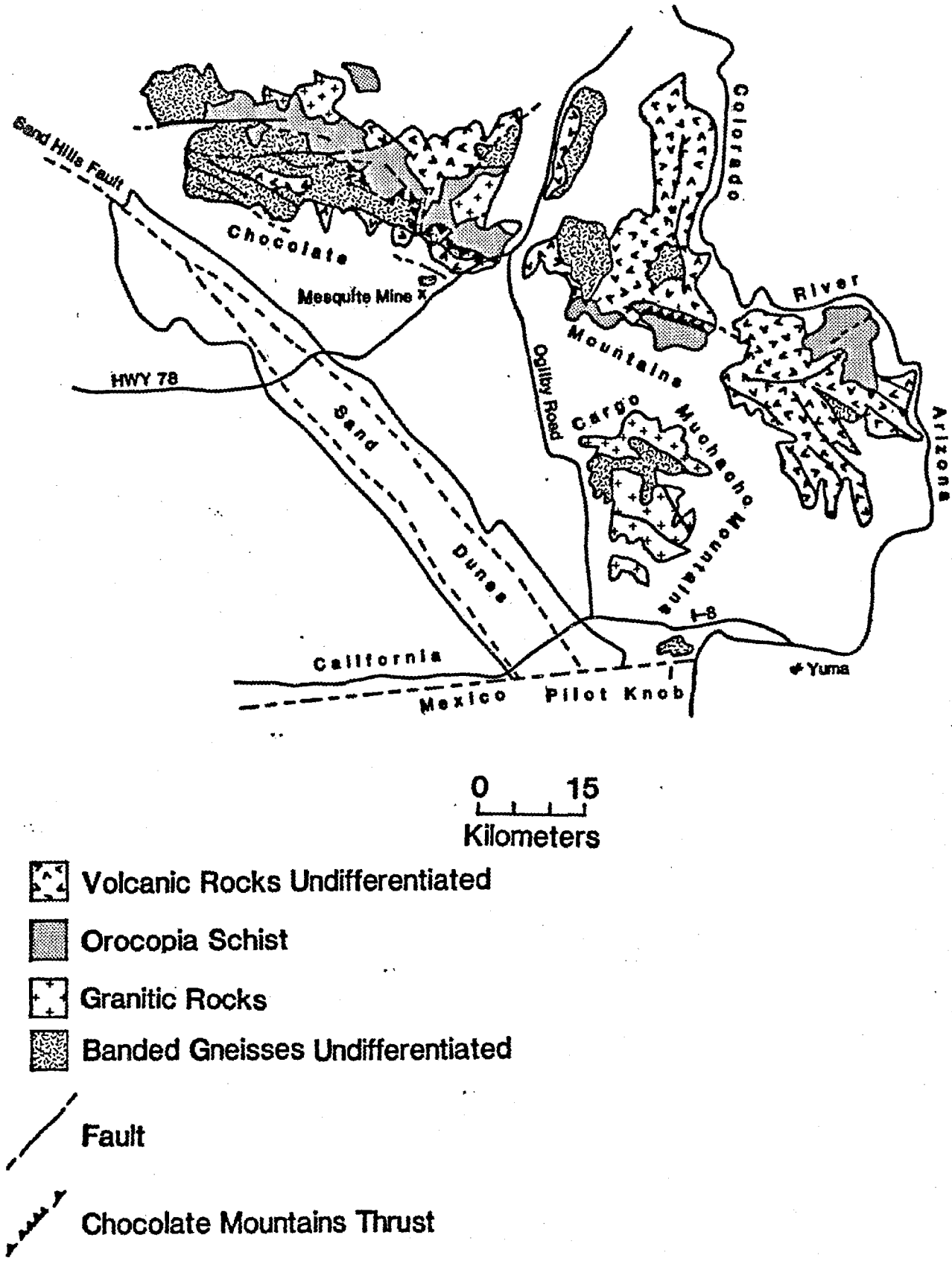


Fig. 1. Regional geologic map of southeasternmost California (adapted from Morton, 1977).

MESQUITE PIT
PSEUDO-STRATIGRAPHIC SECTION

Not to scale

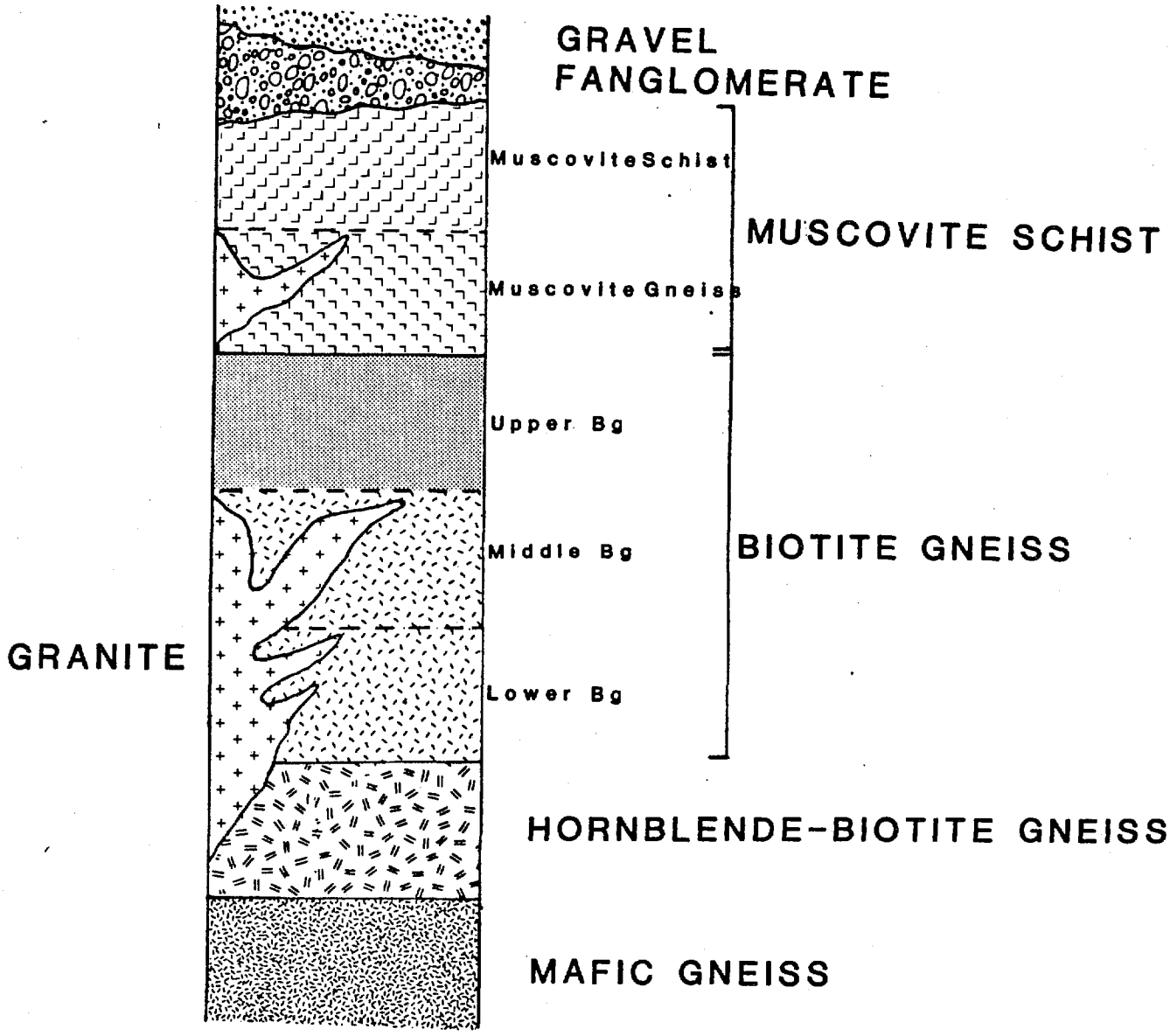


Fig. 2

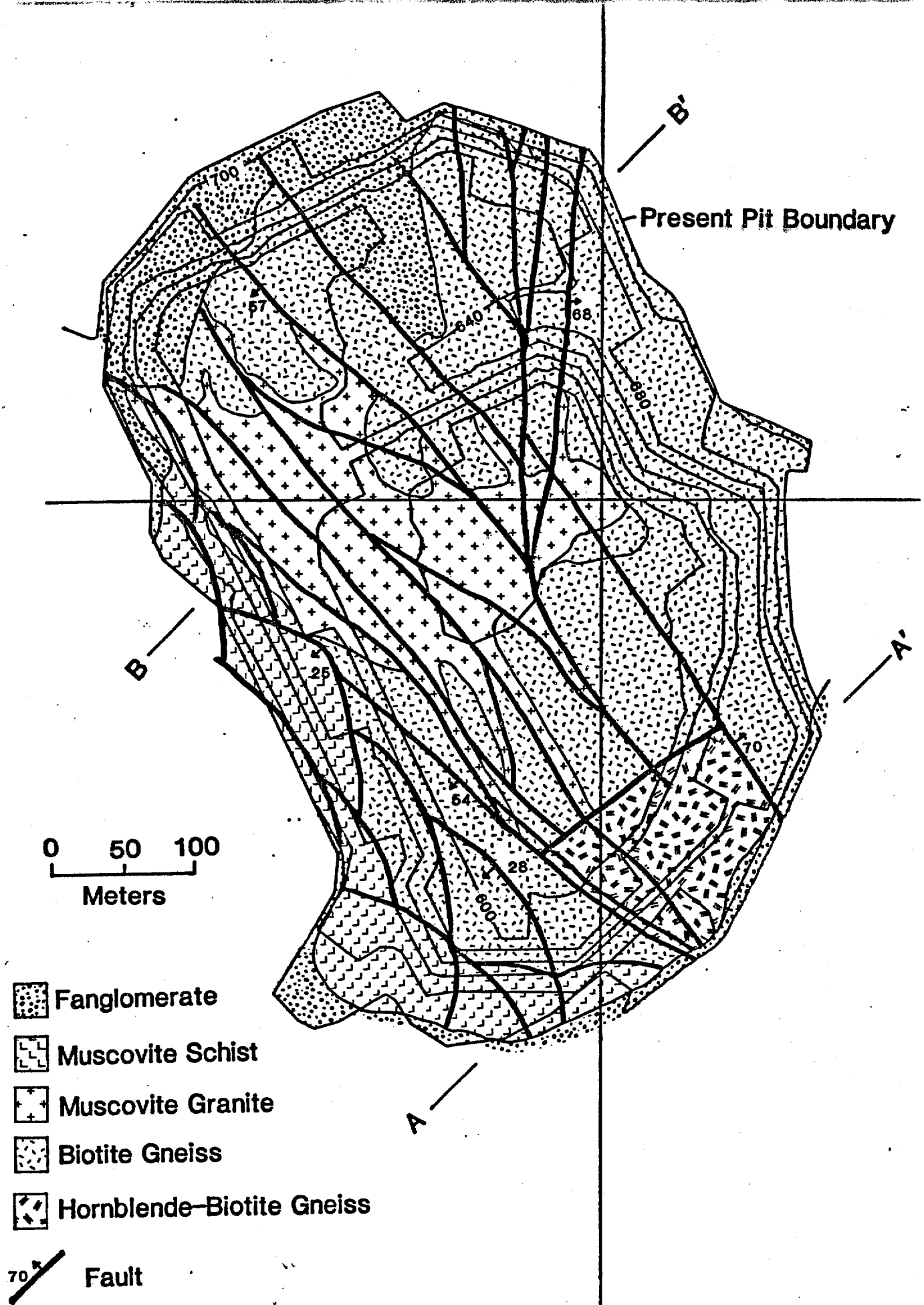


Fig. 3. Generalized geologic map of the Mesquite pit.

gneiss is the lowermost unit defined and forms the core of a northwest trending antiformal structure. The Mesquite orebody lies on the southwestern limb of this inferred structure. Moving upwards, the sequence consists of hornblende biotite gneiss, biotite gneiss, muscovite schist, Tertiary conglomeratic sediments and recent gravel cover. The biotite gneiss has been further divided into a lower salt and pepper unit, a middle unit consisting of alternating layers of salt and pepper gneiss and biotite rich layers and an upper quartzofeldspathic unit. The muscovite schist has been divided into a lower quartzofeldspathic muscovite gneiss and a very friable muscovite schist.

A coarse grained to pegmatitic muscovite bearing granite crosscuts the lower and middle units of the biotite gneiss and the muscovite gneiss. The intrusive may be sill-like, with a series of smaller dikes and sills radiating away from the main mass. Potassium-argon dating puts the age of the intrusive at around 38 m.y., but it is probable this is a reset metamorphic date.

Pit geology is dominated by two sets of major faults (Fig. 3). The first set has a strike of N. 40 to 50 W., with a split near mid-pit trending due north. This fault set has a range of dips from 55 to 80 southwest and northeast. The second major fault

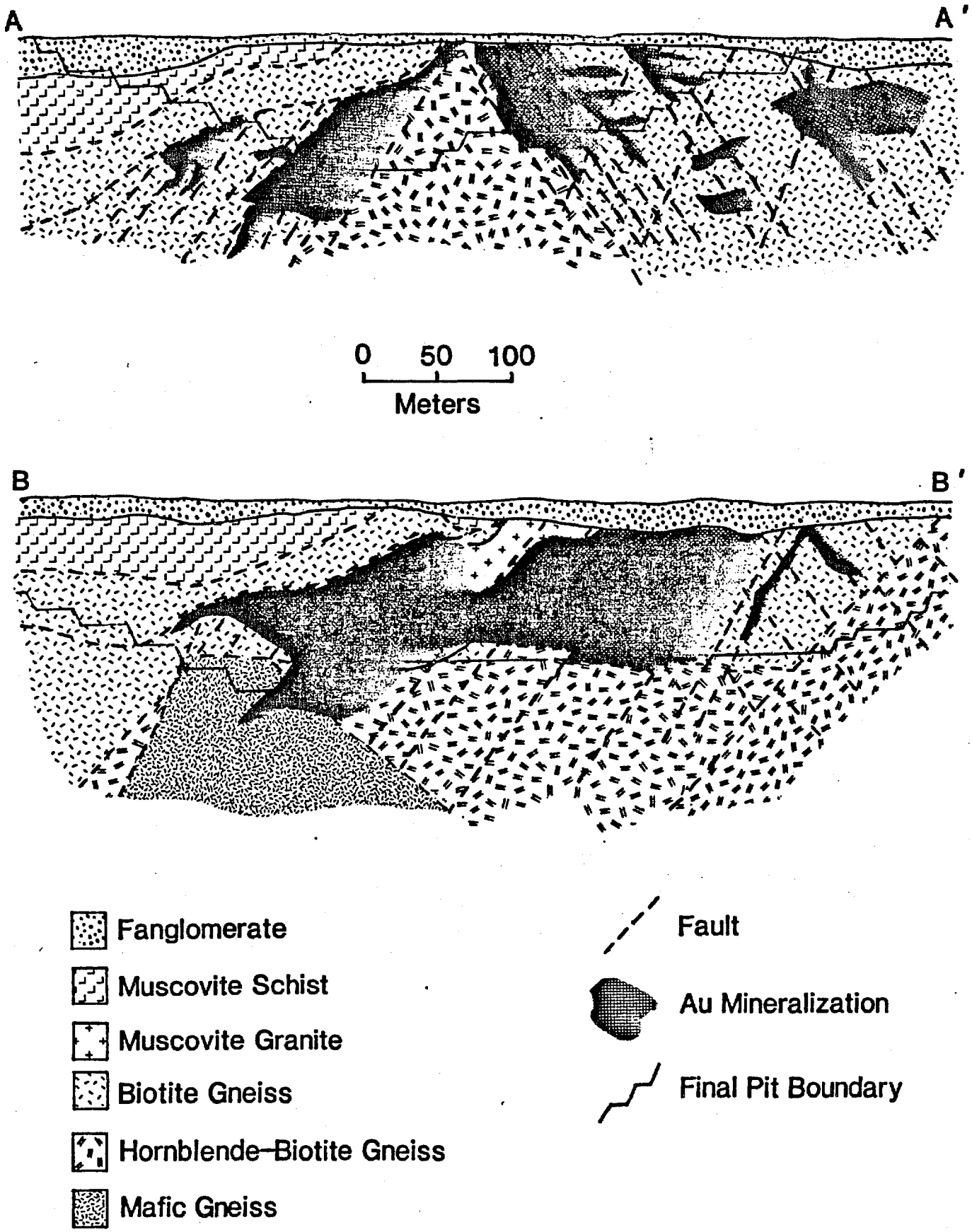


Fig. 4. Generalized geologic cross sections looking northwest through the Mesquite orebody.

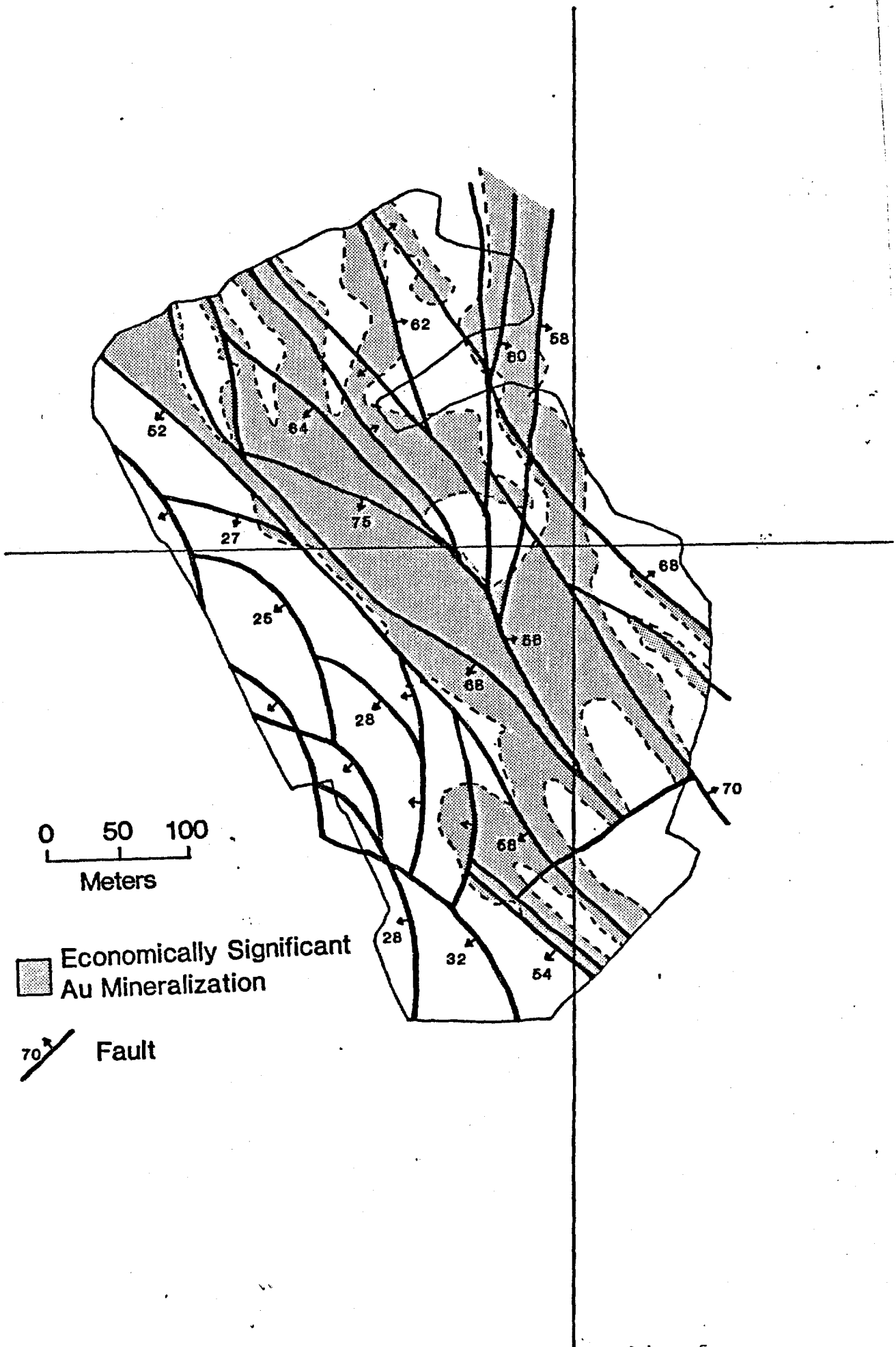


Fig. 5. Simplified fault map showing relationship of mineralization to faulting on the 640 bench.

trend dips from 20 to 40 to the southwest, with individual faults having an arcuate trace. In cross section the arcuate system has a braided appearance which may be evidence for a tensional detachment system, (Adams and others, 1983) but locally there is evidence for low angle reverse movement or thrusting.

Detailed fault mapping and blast hole sampling has shown that the majority of the gold mineralization is closely associated with, if not totally controlled by the high angle north to northwest trending fault system (Fig. 4 and 5). The low angle fault system is not mineralized and appears to have moved barren rock over the top of the high angle mineralized system often concealing it. Mineralization dies out to the northwest and southeast with higher grade zones occurring where the system is narrowest.

It is possible that the granite intrusive has played a major role in concentration of gold mineralization. The intrusive may have acted as the heat sources that brought in gold mineralization or remobilized anamalous syngenetic gold, concentrating it in the high angle structures, as well as in the receptive middle biotite gneiss.

It is also possible that the mineralization would fit into the detachment model as proposed by Drobeck and others (1986) for the Picacho Mine. In the Mesquite

instance the mineralization would be concentrated in the high angle normal faults rather than the low angle or detachment zone.

There are unanswered questions in relating gold mineralization to either of these two models. What is evident is the high angle normal faulting is very important in the Mesquite orebody. Relatively recent reactivation of many of these normal faults has complicated the picture even further and dictates the present signature of the orebody.

Adams, M.A., Hillemeyer, F.L., and Frost, E.G., 1983, Anastomosing shear zones - A geometric expansion for mid-Tertiary crustal extension in the detachment terrane of the Colorado River region, California, Arizona, and Nevada: Geological Society of America Abs w/Programs, v. 15, no. 7, p. 375.

Crowell, J.C., 1975, Geologic sketch of the Orocopia Mountains, southeastern California: California Div. Mines and Geology Spec. Rept. 118, p. 99-110.

Dillon, J.T., 1975, Geology of the Chocolate and Cargo Muchacho Mountains, southeasternmost California: Univ. Calif. Santa Barbara, Ph.D. thesis, 405 p.

Dillon, J.T., and Haxel, G.B., 1975, The Chocolate Mountain- Orocopia-Vincent thrust systems as a tectonic element of late Mesozoic California: Geol. Soc. America, Abs. with Programs, v. 7, no. 3, p. 311.

Drobeck, P.A.; Hillemeyer, F.L., Frost, E.G., Liebler, G.S., 1986, The Picacho Mine: A gold mineralized detachment in southeastern California: Arizona Geological Society Digest, v. XVI.

Haxel, G.B., 1975, The Orocopia Schist and the Chocolate Mountain thrust, Picacho-Peter Kane Mountain area, southeasternmost California: Univ. Calif. Santa Barbara, Ph.D. thesis, 277 p.

Miller, W.J., 1944, Geology of Palm Springs-Blythe strip, Riverside County, California: California Jour. Mines and Geology, v. 40, no. 1, p. 11-72.

Tosdal, R.M., Haxel, G.B., Dillon, J.T., 1985, Lithologic associations of gold deposits, southern California and southwestern Arizona: Geologic Society of America Abs. w/Programs, v. 17, no. 6, p. 414.

file — Mesquite Gold Deposit Description

WLK

ASARCO

Southwestern Exploration Division

October 27, 1986

copy for HGK done 1/22/87 mek

File Memo

Mesquite Gold Mine
Imperial County, CA

The Fall AGS Field tour convened in Yuma, Arizona, October 17, 1986. Gold Fields' open pit mine, 30 miles NE of Brawley, California, was visited the next morning. Subsequently, tours were made of two other properties, the American Girl 5 miles NE of Ogilby (where Newmont had drilled two zones of low grade gold (.03-.04) now owned by American Girl Gold Mines) and the Picacho open pit gold mine (3000 tpd, .044 oz. Au/ton) operated by Chemgold Inc. This mine-leach operation is unusually efficient, reportedly producing gold at a cost of $125.00 per ounce.

In a report dated April 18, 1984, F.R. Koutz describes in considerable detail the history of the Mesquite discovery and the nature of the ore body along with his photo's of numerous maps and sections ---- a remarkable amount of information acquired on a very brief visit (SEG-AIME) prior to the start of mining. He states that there are no outcropping ore-grade and width material, as much of the deposit is covered with gravel, and that the discovery (1980) was apparently due to the encouraging results of sampling the Big Chief shaft workings. The first hole cut ore-grade below a few tens of feet of gravel. Gold Fields was not the first to extensively examine or drill in the area. Those involved earlier were: Conoco, Cominco, Amax, Amselco, Duval, Homestake, Placer, Newmont and several uranium companies.

. . . . . .

The Mesquite ore body, based on a cutoff of .025, is a somewhat tabular mass up to 300' in thickness, averaging 170', and dipping gently SW. Reserves as of Nov. 1985 (approximate startup date): 41.5M tons at .056 oz. Au. Gravel cover on the north is thin to zero; on the south, around 100'. Prior to gravel deposition, erosion had only partially exposed ore-grade

mineralization. Submarginal grade rock over the ore ranges up to 100' or more and the overall stripping ratio is 3/1, W/O.

Mining is at a rate of 60,000 tpd (12000 tons ore) on 20' benches, using 16' blast hole spacing, 85 ton trucks and front end loaders. The ore is crushed to minus 3", agglomerated and then spread out into a 15' layer and sprinkled with a lime-cyanide solution. Reportedly, recoveries of 70-80% are achieved in a 90 day period. The pregnant solution is passed through activated carbon, precipitating the gold which is subsequently recovered by electro-winning. Reportedly, operating costs are around $6.00 per ton ore or about $155.00 per ounce of gold, assuming 70% recovery.

The deposit is situated at the SW edge of the Chocolate Mountains which, being essentially devoid of vegetation, have the appearance of a desolate, desert varnished moonscape. Principal host rocks are biotite gneiss (Precambrian or Jurassic) and intrusive biotite granite (Laramide) which lie well above the Chocolate Mountains' Thrust, a major regional structure. As exposed in the pit, the mineralized rocks show evidence of pervasive argillic and some phyllic alteration, displaying pale red-brown to light gray colors. Prior to oxidation which reaches down to 400' in part (water table at 200'), the pyrite content was 2 to 3%.

NW trending high angle faults are considered the principal control of the deposition of the gold (and pyrite), as illustrated by the pattern of ore-grade mineralization on the 640 bench map (attached). Various origins for the deposit have been postulated, but the one apparently favored by the mine staff is briefly: gold bearing solutions associated with the granite intrusive (occupying the central portion of the ore body) spread out laterally in the more favorable brecciated biotite gneiss layer (SW dip) and concentrated in the high angle fault structures.

Asarco is not included in the long list of companies (given by Koutz) that examined and sampled or drilled the Mesquite area prior to Gold Fields' entry; however, Asarco personnel were involved at least to a minor extent.

Back in 1947, Jim Gibson, placer engineer, and I drove down from Leadville to examine gold placers controlled by Desert Gold and Aluminum, located one mile SE of what is now the Mesquite Mine. The objective was also to sample bedrock for possible sources of the gold. Eleven random samples from bedrock exposures in the walls of a small placer open pit and from outcrops nearby (adjacent to the old Vista Mine diggings), ran from tr. to .03 oz. Au/ton (averaging .01). The weakly iron-stained rock contained a few thin, wide-spaced quartz stringers. It was concluded that the placer had little or no economic potential, but that "workable tonnages of low grade (lode) gold ore may be present." No specific recommendation for follow-up was made (report dated March 20, 1947).

In the fall of 1967, Barry Watson and Jim Briscoe, Tucson staff members, undertook an extensive tour of California gold prospects which was to include follow-up sampling of outcrops around the old Vista Mine. Subsequently, Watson reported (verbally) that no significant bedrock values were found. In the files here now is a report by Watson dated 6-14-68 on the Chocolate Mt. Placers SE of Glamis, wherein he mentions another block of placer claims on a pediment of the Chocolate Mts. several miles north and describes bedrock exposures as though he had examined the area where bedrock had been sampled in 1947. He concluded that this area "might be worthy of our sampling," but such work would have to await termination of the lease presently held by Gold Placers Inc. Apparently, Watson's verbal report of "no significant bedrock values" was made subsequently.

+ Report of examination by Steve Davis

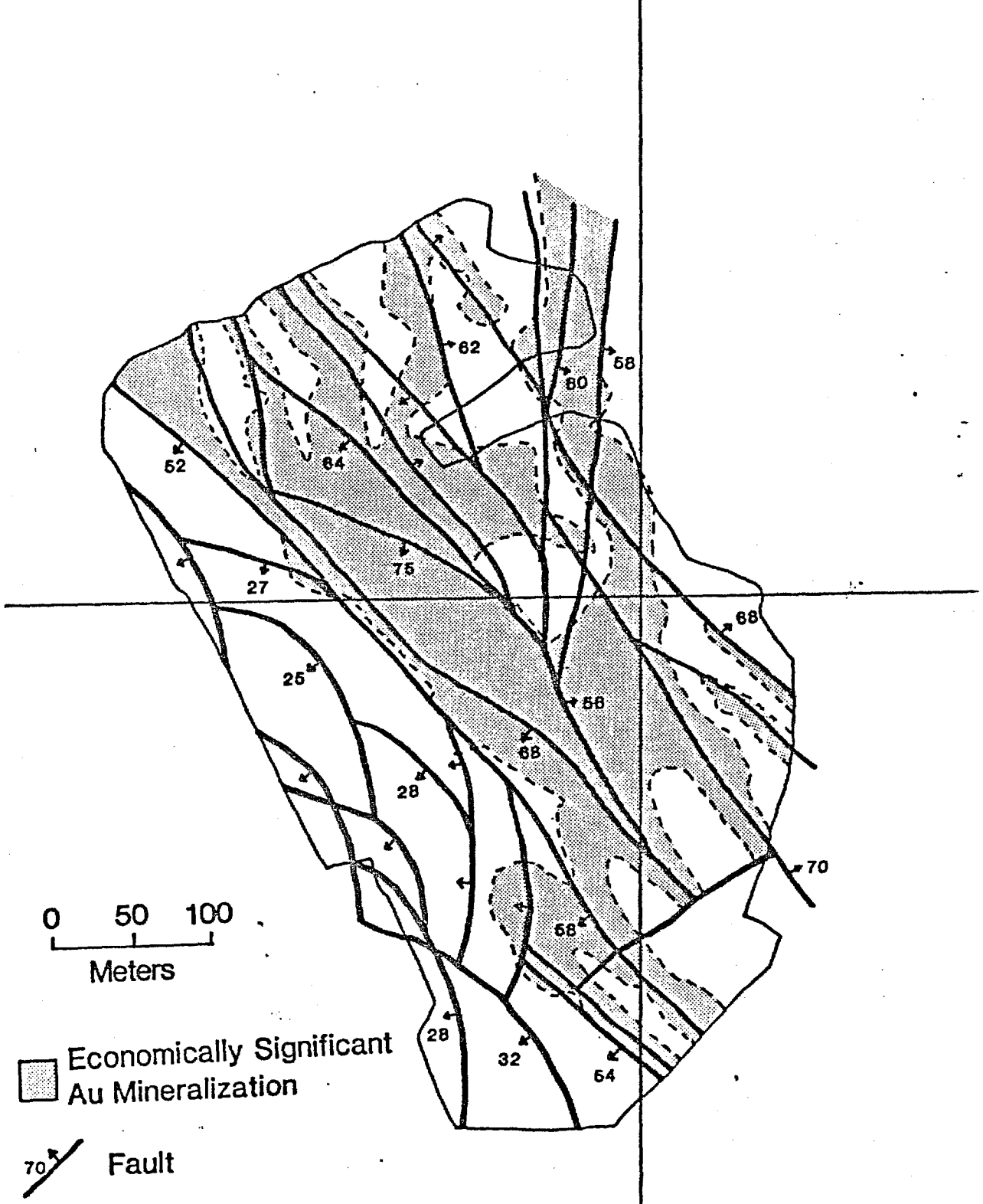
To conclude, in the AGS trip guidebook, a recent discovery of 15M tons of .05 oz. Au/ton in the vicinity of the Vista is reported. I questioned one of the guides and he replied that the tonnage was understated ---- that the new pit would be approximately equal in size to the Mesquite (1 mile to the NW). This is another example of old placer workings in the vicinity of substantial sized disseminated gold ore deposits ---- which escaped discovery until very recent times.

J. H. Courtright

JHC:mek

J. H. Courtright

cc: RL Brown, WL Kurtz, JD Sell, PG Vikre
2 extra



Att. to Rept.
by JHC 10-27-

Mesquite Mine

Fig. 5. Simplified fault map showing relationship of mineralization to faulting on the 640 bench.

ASARCO

Southwestern Exploration Division

JDS

March 10, 1988

FILE NOTE

Mesquite Mine Talk
Tucson Section AIME
Imperial County, CA

Mr. Richard Graeme, Manager, was the featured speaker for the March 9, 1988 meeting of the local AIME.

Some of the more interesting facts (other than what has been rehashed in numerous presentations) were:

Goldfields had to sign up over 800 individual land owners in their present package.

They have drilled over 1 million feet of exploration drilling, with 4 to 6 rigs constantly, and have 500,000 feet yet to go to delineate the four major zones they have now identified.

They have three geologists mapping and flagging after every blast and often a geologist directs the sorting of the ore/waste in the pit. They essentially use a 0.01 opt gold cut-off, as Graeme states, after it is on the truck and moving the rest of the costs are minor and they do recover gold which the accountants like.

They have changed from "rainbird" sprinklers to "drip" irrigation. It seems that the rain broke down the agglomerate and released fines which then caused more ponding, decreased infiltration, and increased evaporation. Drip has solved this and has 50% more infiltration input with no ponding. The secondary effect of rain and ponding is that the water attracted wildlife with subsequent failing of their health.

They now get 80% leach in 90 days, dry it out, then releach, then dry, then releach, and feel they get all they can (93 plus %). They then build another 15 foot lift and repeat. Preliminary tests show that they can go up to 80 feet with no loss on recovery. They feel the lift is "barren" when they get only 700 to 1000 ounces in the last leach period.

Richard stated that other companies (such as in copper leaching) added lifts before getting their optimum recovery, thinking that they would get the remainder as the subsequent lifts percolated through. This is true in part, but Goldfields' accountants believe it is best to get the gold in the bank and not have it tied up in recirculating, so to speak, units. Also, channeling and piping do occur and thus the underlying lifts often short circuit the solutions and thus by-pass much of the lower lift material.

The pregnant solution is 0.03-0.04 gpl in the head and 0.00X in the tails.

They recovered 180,000 ounces of gold in their first year of full production.

They are now realigning 8½ miles of county road and thus will keep environmentalists and others at arms length viewing. The amount of gold recovered from the "right of way" of the old road will be in excess of the cost of the new road.

The original reserve was 35 million tons @ +0.05. The 1988 reserve is 70 million tons at 0.047. The probable geologic now is 100 million @ 0.042. Original cost was $100 million.

Will now add $21 million on expansion/roads, etc. to mine a rate of 4½ million tons per year to leach pads.

Some 93 people attended the local meeting.

James D. Sell

JDS:mek

James D. Sell

cc: W.L. Kurtz

SOCIETY OF MINING ENGINEERS

P.O. BOX 625002, LITTLETON, COLORADO 80162-5002

PREPRINT NUMBER

88-16

GEOLOGY OF BIG CHIEF OREBODY, MESQUITE DISTRICT, IMPERIAL COUNTY, CALIFORNIA

G. F. Willis

Gold Fields Operating Company
Brawley, California

For presentation at the SME Annual Meeting
Phoenix, Arizona - January 25-28, 1988

Permission is hereby given to publish with appropriate acknowledgments, excerpts or summaries not to exceed one-fourth of the entire text of the paper. Permission to print in more extended form subsequent to publication by the Society must be obtained from the Executive Director of the Society of Mining Engineers.

If and when this paper is published by the Society of Mining Engineers, it may embody certain changes made by agreement between the Technical Publications Committee and the author, so that the form in which it appears is not necessarily that in which it may be published later.

These preprints are available for sale. Mail orders to PREPRINTS, Society of Mining Engineers, P.O. Box 625002, Littleton, Colorado 80162-5002

PREPRINT AVAILABILITY LIST IS PUBLISHED PERIODICALLY IN MINING ENGINEERING

Abstract

Gold mineralization in the Mesquite district is hosted by a series of Jurassic amphibolite grade metamorphic rocks which have been intruded by a Cretaceous leucogranite pegmatite. A series of northwest trending, high angle, normal faults have apparently acted as a structural locus for mineralized epithermal fluids and thus economic concentrations of gold in the Big Chief orebody. Late Tertiary fault reactivation has bounded the fault and fracture controlled mineralization. Popular theories of ore genesis call on, (1) Tertiary detachment faulting, (2) the Cretaceous intrusive, or (3) the opening of a dilational jog between regional dextral strike-slip faults as a source powering the gold bearing hydrothermal fluids.

General Geology

The Big Chief orebody is one of several orebodies currently in production or in the preproduction stages in the Mesquite district. The Mesquite district is located on the southwestern flank of the Chocolate Mountains, about 50 kilometers east-northeast of Brawley in southeasternmost California.

The deposit occurs in amphibolite-grade gneisses, schists and intrusives of variable composition which are part of the Chuckwalla Complex (Miller, 1944; Dillon, 1976; Morton, 1977) that have been thrust at least 48 kilometers to the northeast over the greenschist facies, Orocopia schist, along the Chocolate Mountains thrust (Dillon, 1976; Haxel and Tosdal, 1986), Phyllites and metavolcanic rocks of the Winterhaven Formation (Haxel and others, 1985) crop-out to the north and east of the mineralized area and are also hanging-wall to the thrust.

Various attempts have been made to correlate the gneissic rocks of the upper plate of the Chocolate Mountains thrust in the Mesquite district, to gneissic lithologies in the Cargo Muchacho Mountain, Picacho Peak area, the Peter Kane Mountain area and Pilot Knob, based on similarity in appearance and scattered radiometric dates (Miller, 1944; Crowell, 1975; Haxel, 1975; Dillon, 1976; Morton, 1977). More recent U-Pb radiometric dates on banded gneisses in the Cargo Muchacho Mountains, indicate these rocks and possibly those in the Picacho Peak area are of probable Middle to Late Jurassic age (Tosdal and others, 1985). Radiometric U-Pb dates from the Mesquite district gneisses also indicate a probable Jurassic age (Tosdal, 1986 unpublished; D. Frost, 1987 unpublished).

Mesquite Lithologies

Metamorphic lithologies in the Mesquite district have been placed in a pseudostratigraphic sequence that is traceable for at least 20 kilometers to the southeast along the Chocolate Mountains (Manske and others, 1987 Willis, 1987). The base of this sequence is a highly deformed package of amphibolite, biotite schist and tonalite gneiss, which is referred to collectively as the Mafic Gneiss Complex (Manske and others, 1987). The Mafic Gneiss Complex is the unit that is believed to be in direct thrust contact with the Orocopia schist.

The Mafic Gneiss Complex is overlain by hornblende-biotite gneiss, which is distinguished by its coarser-grained, light-dark banding, feldspar augen and euhedral accessory sphene. The hornblende-biotite gneiss appears to be similar to what Dillon (1976) describes as augen gneiss in the Picacho district, 40 kilometers to the southeast of Mesquite.

Biotite gneiss lies above the hornblende-biotite gneiss and in the Big Chief orebody, has been further divided into distinct, mappable subunits (Willis, 1987). A massive, fine-grained, salt and pepper, quartz-feldspar-biotite gneiss is in direct contact with the hornblende-biotite gneiss. The salt and pepper unit grades upward into alternating layers of salt and pepper gneiss and biotite schist, which in turn grades upward into a more quartzofeldspathic subunit that may contain as little as 1-2% biotite. A coarser-grained biotite gneiss has been faulted in to the salt and pepper and biotite schist bearing subunits. This subunit contains large clusters of biotite up to a centimeter across. The exact position of this rock in the pseudostratigraphy is not presently understood.

On the west side of the Big Chief pit, the biotite gneiss is overlain locally by a tourmaline bearing quartzofeldspatic gneiss (Willis, 1987). Black sooty tourmaline, with lesser muscovite is localized as thin layers along foliation. A similar tourmaline bearing rock has been noted in outcrop 1.5 kilometers northwest of the Big Chief orebody, near the boundary of the Chocolate Mountains Naval Gunnery Range.

Structurally at the top of the bedrock sequence, on the west and southwest sides of the Big Chief orebody, is a muscovite schist that contains pods, lenses and layers of muscovite bearing leucogneiss. An extreme schistosity has been developed in the muscovite schist, partially due to intense shearing along foliation. The shearing occurred as the muscovite schist was placed over the top of the other units along a low angle fault. (Willis, 1987).

The entire metamorphic package of rocks contains a series of two mica granitic pegmatites that are generally concordant to foliation. These pegmatites may be representative of the multiple episodes of granitic plutonism that have been documented in the Chocolate Mountains (Dillon, 1976).

A coarse-grained to pegmatitic, muscovite bearing granitic intrusion has been exposed in the northwest corner of the Big Chief pit (Willis, 1987). The granite occurs dominantly as a series of sills and lesser dikes, intruding the biotite gneiss and tourmaline bearing gneiss. Although this granite has been dated by U-Pb methods at 78-80 Ma. (D. Frost, 1987 unpublished data), it shows minor foliation and has undergone at least one stage of deformation (Manske and others, 1987). A larger intrusive of similar composition occurs in outcrop, along strike to the north of the Big Chief pit, on the bombing range.

The majority of the crystalline rocks in the Big Chief area are overlain by a series of conglomeratic sediments that range from silt and clay to coarse pebbles. This conglomerate has been interpreted as being Tertiary in age due to the inclusion of Tertiary volcanic clasts and the

Wyoming Gold Deposit Description

SOCIETY OF MINING ENGINEERS

CALLER NO. D, LITTLETON, COLORADO 80127

PREPRINT NUMBER

87-107

GEOLOGY OF THE MESQUITE DEPOSIT, IMPERIAL COUNTY, CALIFORNIA

S. L. Manske

Stanford University
Stanford, California

W. F. Matlack

M. W. Springett

A. E. Strakele, Jr.

S. N. Watowich

B. Yeomans

E. Yeomans

Gold Fields Mining Corporation
Lakewood, Colorado

For presentation at the SME Annual Meeting
Denver, Colorado - February 24-27, 1987

Permission is hereby given to publish with appropriate acknowledgments, excerpts or summaries not to exceed one-fourth of the entire text of the paper. Permission to print in more extended form subsequent to publication by the Society must be obtained from the Executive Director of the Society of Mining Engineers.

If and when this paper is published by the Society of Mining Engineers, it may embody certain changes made by agreement between the Technical Publications Committee and the author, so that the form in which it appears is not necessarily that in which it may be published later.

These preprints are available for sale. Mail orders to PREPRINTS, Society of Mining Engineers, Caller No. D, Littleton, Colorado 80127.

PREPRINT AVAILABILITY LIST IS PUBLISHED PERIODICALLY IN MINING ENGINEERING

Introduction

The Mesquite gold deposit is a recent discovery of Gold Fields Mining Corporation lying 65 kilometers northeast of El Centro in Imperial County, California (Figure 1). The deposit is located on the southwestern flank of the Chocolate Mountains and is a bulk-minable, low grade "disseminated" orebody. Although the host rocks of the deposit are part of a regional high-grade metamorphic terrane, abundant brittle fractures, brecciation, and open-space vein fillings indicate that Mesquite mineralization is epithermal. Faulting which postdates the hydrothermal activity has complicated the original geometry of the orebody. Alluvium effectively hides most surface expression of the mineralization, but open-pit mining is now revealing the details of Mesquite geology.

Lithology

The Mesquite deposit is hosted by a sequence of quartzofeldspathic to mafic gneisses and subordinate schist which are included in a regional unit known as the Chuckwalla Complex (Miller; 1944, 1946). The gneisses are amphibolite-grade rocks with a retrograde greenschist overprint (Dillon, 1975). Several distinct lithologies within the gneiss sequence form a pseudostratigraphy that is recognizable along the trend of the Chocolate Mountains from the Mesquite area to at least 20 kilometers to the southeast (Figure 2).

Lowest in the sequence is a highly deformed section of amphibolite, biotite schist, and tonalite gneiss which is given the field term of Mafic Gneiss Complex (MGC). Composition and relict texture suggest that the amphibolite and tonalite gneisses are meta-igneous rocks. The Mafic Gneiss Complex has been penetrated to a depth of 460 meters beneath the Mesquite deposit and forms the local basement. Elsewhere in the region, very similar mafic gneiss is in contact with the underlying Orocopia Schist along the Chocolate Mountain - Vincent Thrust.

Next higher in sequence is a hornblende - biotite gneiss (HBG) which is distinguished by its relatively coarse texture, prominent feldspar augen, and accessory mm-sized euhedral sphene. The composition of the rock ranges from tonalite to granodiorite. In appearance, the HBG is similar to an augen gneiss in the Picacho district 40 kilometers to the southeast, which has been described as a metamorphosed intrusion (Dillon, 1975). In the Mesquite district, the HBG attains an apparent thickness of up to 120 meters, but is commonly much thinner. On the southwest flank of the immediate mine area, the HBG is missing from the section entirely.

Overlying the HBG is a finer-grained and more leucocratic unit composed of a "salt-and-pepper" quartz-feldspar-biotite gneiss (BG). The biotite gneiss is the most important ore host in the Mesquite deposit. The composition of the rock ranges from granite to quartz monzonite in igneous terms, although the protolith may have been volcaniclastic or sedimentary. Several compositional and textural variants of biotite gneiss may be distinguished in the field. Fine-grained quartzofeldspathic portions of the unit have been interpreted as meta-arkose. Interlayers of chloritic biotite schist are locally present, and other minor variations in composition include muscovite-biotite schist and a fine-grained amphibole-bearing rock. The biotite gneiss varies in apparent thickness from 35 to 100 meters and rests directly on the Mafic Gneiss Complex rocks where the HBG is absent.

Capping the biotite gneiss on the southwest side of the Mesquite deposit is a muscovite bearing leucogneiss which grades upward into a muscovite schist (MS). The leucogneiss is composed of plagioclase, microcline and quartz, with accessory muscovite, biotite, epidote, and hematite-ilmenite. The mineralogy of the muscovite schist is similar with a higher proportion of mica, which imparts an excellent foliation to the rock.

The remaining significant rock types in the metamorphic sequence are meta-plutonic. Quartz-monzonite to granite pegmatites are present in the HBG, BG, and MS units. The pegmatites are generally (although not invariably) concordant to foliation and are commonly boudined or otherwise deformed. Pegmatite within the muscovite schist is muscovite bearing; similar bodies within the HBG and BG units generally contain both muscovite and biotite. Whole-rock analysis of pegmatite in the HBG outside the area of alteration or mineralization proved the rock to be peraluminous.

In addition to the pegmatites, a muscovite bearing leucogranite (Lgr) has been identified intruding the gneisses of the Mesquite deposit (Willis, 1986). The intrusion is highly faulted and its original geometry is not certain, but the leucogranite is suspected to be sill-like (G. F. Willis, 1986, pers. comm.) The intrusion varies in texture from aplitic to pegmatitic, but is most commonly medium- to coarse-grained. Microfabrics such as bent feldspar twin lamellae, kinked mica books, and strained quartz indicate that the leucogranite is a deformed rock. This presumably late-synkinematic intrusion contains virtually no mafic minerals. Accessory phases include tourmaline and uncommon garnet and epidote. The precise relationship between the leucogranite and the concordant "two-mica" pegmatites is not certain, but Dillon (1975) distinguished more than one episode of aplite-pegmatite intrusion in the southern Chocolate Mountains.

Absolute ages of the different metamorphic units are not yet well known. U-Pb dates on zircon from the biotite gneiss suggest a mid-Jurassic to early Cretaceous age for the protolith (R. M. Tosdal, 1986, pers. comm.) K-Ar dates on biotite and feldspar separates from the BG and associated pegmatites yielded ages of about 38 Ma. A similar K-Ar determination on the overlying muscovite schist gave an apparent age of approximately 55 Ma.

The metamorphic section hosting the Mesquite deposit is overlain by Tertiary sediments which exhibit both depositional and faulted contacts with the gneisses. Resting on the nonconformity is a moderately-indurated conglomerate containing subangular clasts of the metamorphic rock suite. This conglomerate includes mineralized fragments. Similar heterolithic conglomerates occur regionally and have been correlated to the Miocene Bear Canyon fanglomerate elsewhere in the district (Dillon, 1975).

The conglomerate is overlain with a series of weakly consolidated silty, sandy, and clayey sediments. Pebbly layers within this sequence contain rounded clasts of Tertiary volcanics,

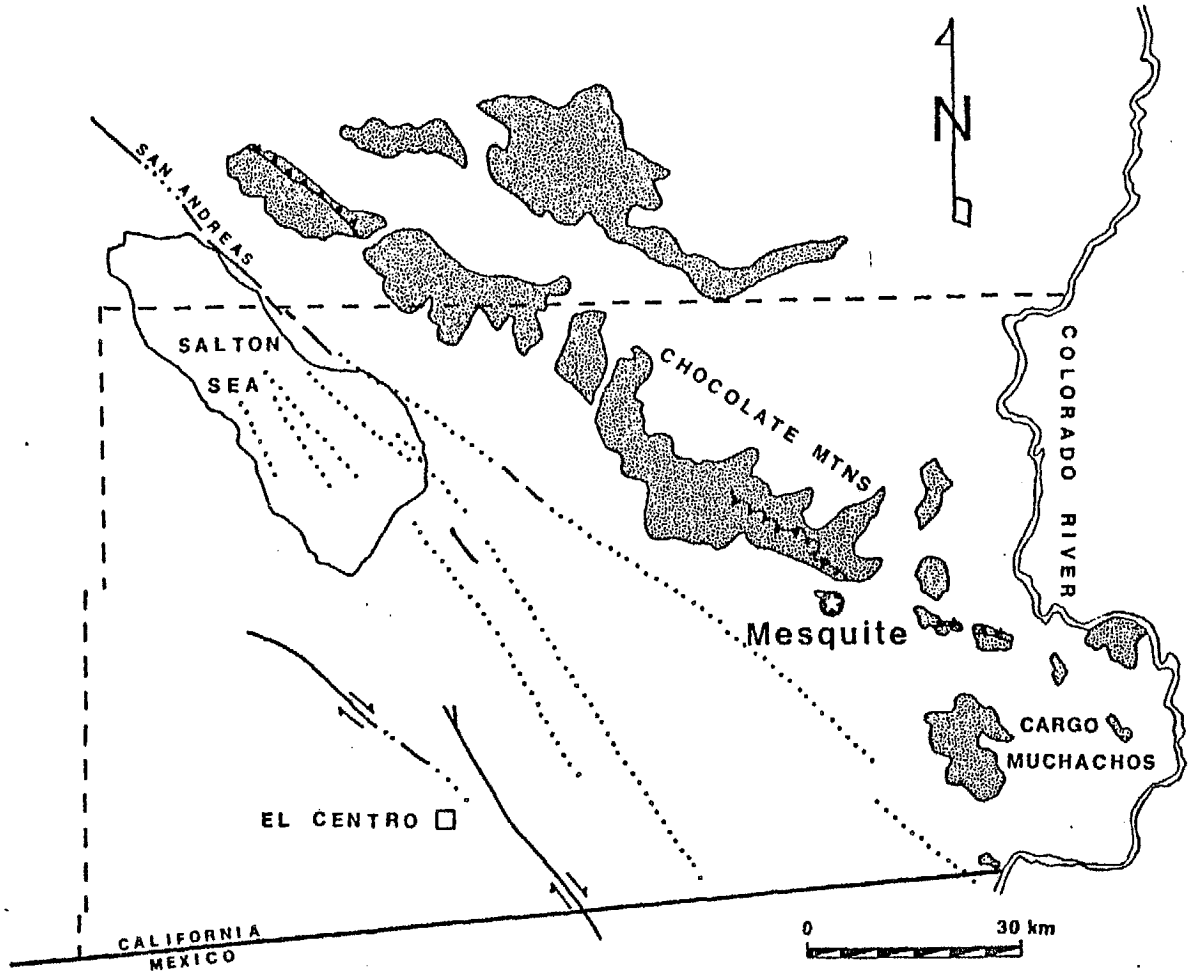


Figure 1. Location Map of the Mesquite Deposit and the Distribution of Exposed Crystalline Rocks in Southeastern California. (After Jennings, 1977.)

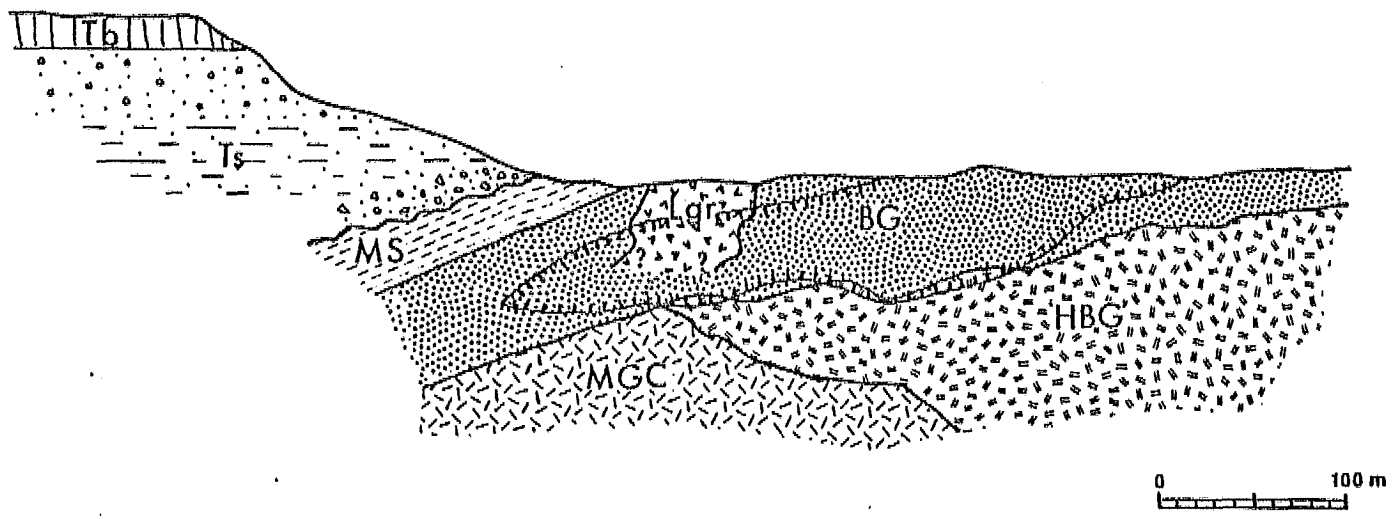


Figure 2. Generalized Geologic Section of the Mesquite Deposit.

MGC, HBG, BG, MS, and Lgr as in text; Ts = Tertiary sediments, Tb = Tertiary basalt. Hachured outline indicates limits of ore. View is to the NNW, parallel to the long axis of the orebody.

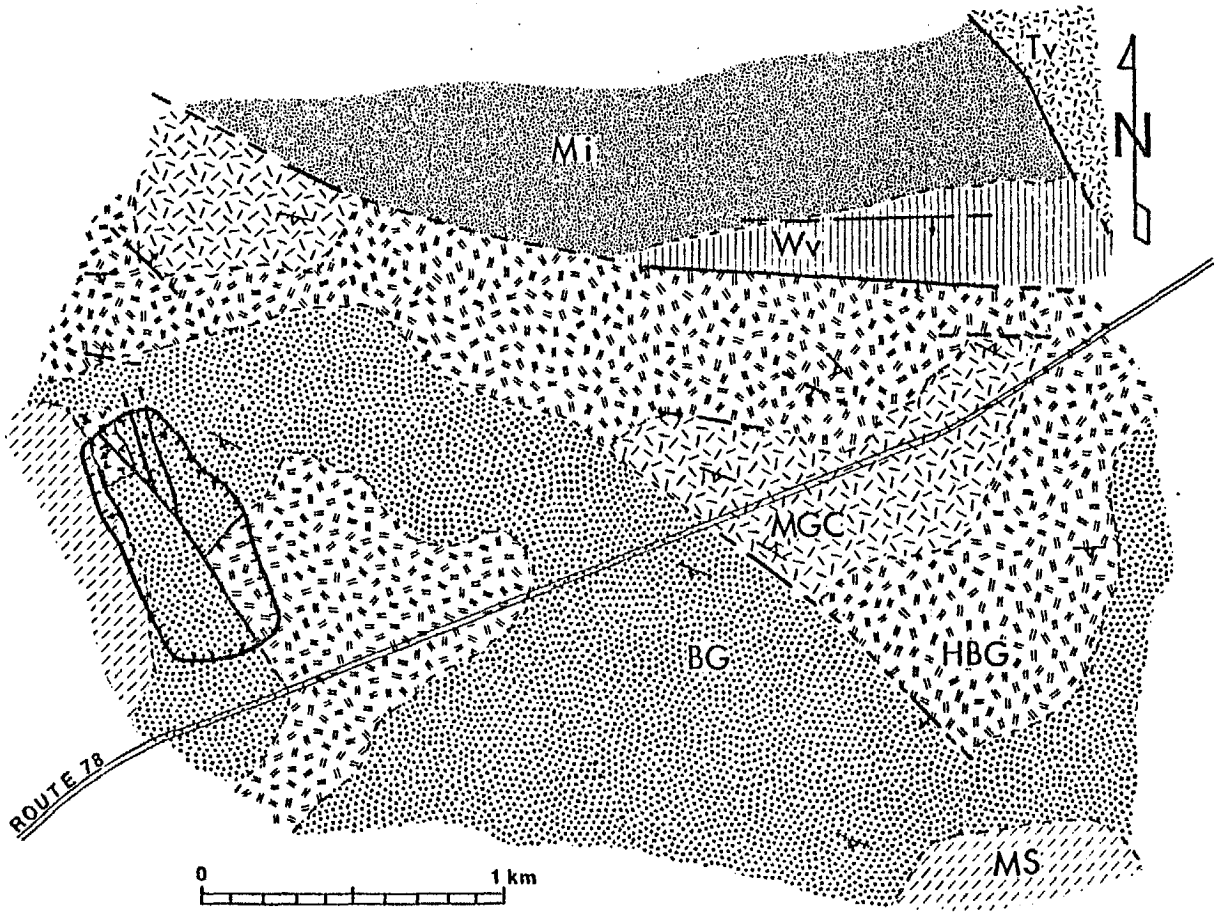


Figure 3. Outcrop and Subcrop Distribution of Mesquite Gneisses.

Bold lines are exposed faults and inferred extensions; covered contacts are light dashed lines. MGC, HBG, BG, and MS as in text; Mi = undifferentiated (meta)igneous rocks, Wv = Winterhaven Fm., Tv = Tertiary volcanics. Hachured outline is the Mesquite pit. (Pit geology after G. F. Willis, 1986; area mapping by S. L. Manske and GFMC staff.)

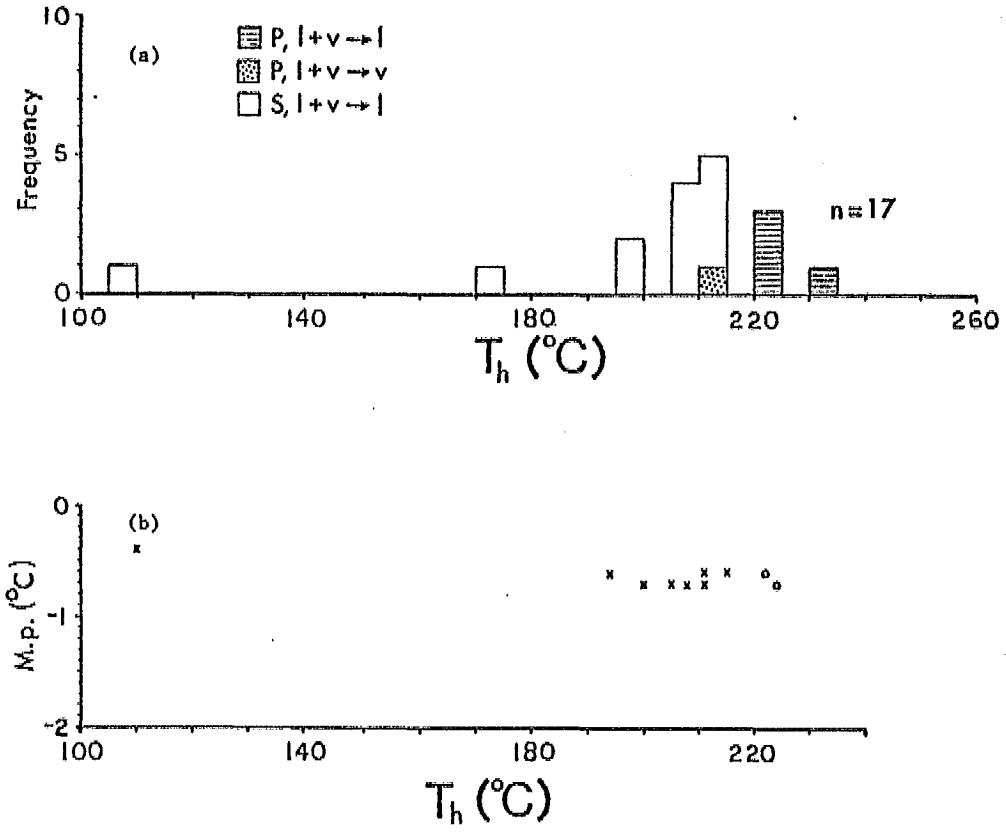


Figure 4. Fluid Inclusion Data on Vuggy Quartz Veinlets.

(a) Homogenization temperature histogram. "P" = primary, "S" = secondary or pseudosecondary, "l" = liquid, "v" = vapor.
(b) Melting point vs. homogenization temperature. "o" = primary, "x" = secondary or pseudosecondary.

WLK Gold Deposit Description

ASARCO

Southwestern Exploration Division

WLK

October 21, 1986

R.L. Brown
New York Office

Mesquite, etc., Deposit(s)
Imperial County, California

The Arizona Geological Society conducted an extremely interesting field trip on October 17-18-19. Asarco attendees included H.G. Kreis, J.H. Courtright, and J.D. Sell.

The trip included visits to the Mesquite Mine, the American Girl - Padre-Madre Property, and the Picacho Mine.

I attach a Xerox of the cover of the guidebook and also a copy of a handout by the Mesquite staff for your interest.

Of, perhaps, the biggest of surprises was that the ore at Gold Fields' Mesquite is now largely controlled by high-angled structures as they get below the low-angled structures originally thought to control the ore mineralization.

The story of Mesquite is continually being rewritten as exposures are made.

H. Kreis has collected a number of samples and his report will be forwarded upon receipt.

The guidebook proper contains 221 pages with the following titles:

Precious Metal Mineralization, Stratigraphy, and Tectonics in Southeastern California (1 p.).

First Day Road Log (25 p.).

Gneissic Host Rocks to Gold Mineralization in the Cargo Muchacho Mountains, SE Calif. (8 p.).

Second Day Road Log (10 p.).

Field Guide to the Picacho Mine and Vicinity, SE Calif. (33 p.).

(Reprint) Day Three: Picacho Basin - Picacho Mine Area; Detachment Faults and Gold Mineralization (23 p.).

(Reprint) Field Guide to the Chocolate Mountains Thrust and Orocopia Schist, Gavilan Wash Area, SE California (12 p.).

(Reprint) The Pelona-Orocopia Schist and Vincent-Chocolate Mountain Thrust System, S. California (17 p.).

(Reprint) Abstract: The Geology of the Cargo Muchacho Mountains and S. Chocolate Mountains, SE California (4 p.).

(Reprint) Tectonic Setting and Lithology of the Winterhaven Formation (22 p.).

(Reprint) Petrochemical Variations in Laramide Magmatism and their Relationship to Laramide Tectonic and Metallogenic Evolution in Arizona and Adjacent Regions (12 p.).

(Reprint) Gold Fields begins Mesquite Mine Construction.

(Reprint) The Picacho Mine: A Gold Mineralized Detachment in SE California (34 p.).

(Reprint) Geology and Mineralization of the Picacho Gold Prospect, Imperial County, California (9 p.).

(Reprint) (Several pages of Abstracts).

James D. Sell

James D. Sell

JDS:mek
attachments

cc: W. L. Kurtz

ARIZONA GEOLOGICAL SOCIETY

Fall Field Trip 1986

Field Trip to Mesquite Mine, American Girl - Padre-Madre Properties, and Picacho Mine, Imperial County, California

led by Will Wilkinson and Clancy Wendt,
NICOR Mineral Ventures, Inc.

GEOLOGY AND MINERALIZATION

OF THE MESQUITE OPEN PIT

GOLD MINE

Gearld F. Willis
Mine Geologist

Gold Fields Operating Co.-Mesquite
HCR 76 Glamis 100
Brawley, CA 92227

The Mesquite orebody is located on the southwestern flank of the Chocolate Mountains of southeasternmost California. Gold mineralization occurs in rocks of the upper plate of the Chocolate Mountains thrust. This thrust is reported to have moved gneisses and intrusive rocks at least 48 kilometers to the northeast over the greenschist facies Orocopia and Pelona schists (Dillon, 1975). Various attempts have been made to correlate the upper plate gneissic rocks to similar rocks in the Picacho area, Peter Kane Mountain area, the Cargo Muchacho Mountains and Pilot Knob (Fig. 1), based on scattered radiometric age dates and similarity in appearance (Miller, 1944; Crowell, 1975; Dillon, 1975; Haxel, 1975; Morton, 1977). More recent work (Tosdal and others 1985) has indicated the rocks in the Cargo Muchacho Mountains and the Picacho Peak area are Mesozoic in age, possibly Middle to Late Jurassic, based on U-Pb zircon dates. Similar dating done on biotite gneiss from the Mesquite pit has also shown a Jurrasic age (Tosdal pers. commun., 1986).

A pseudostratigraphic sequence of rocks within the Mesquite pit has been defined through reconnaissance mapping, diamond core drilling, reverse circulation drilling and pit mapping (Fig. 2 and Fig 3). Mafic

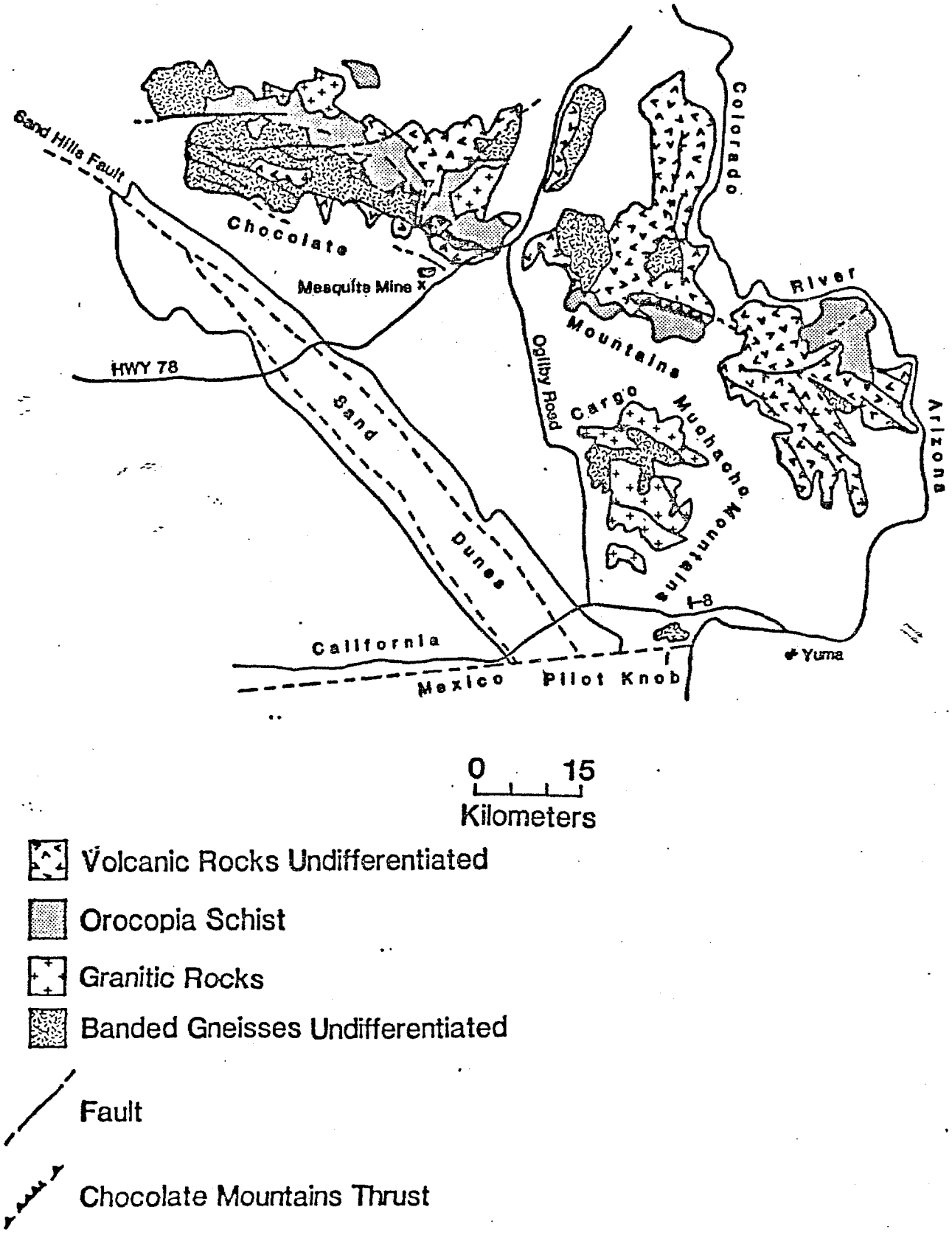


Fig. 1. Regional geologic map of southeasternmost California (adapted from Morton, 1977).

MESQUITE PIT
PSEUDO-STRATIGRAPHIC SECTION

Not to scale

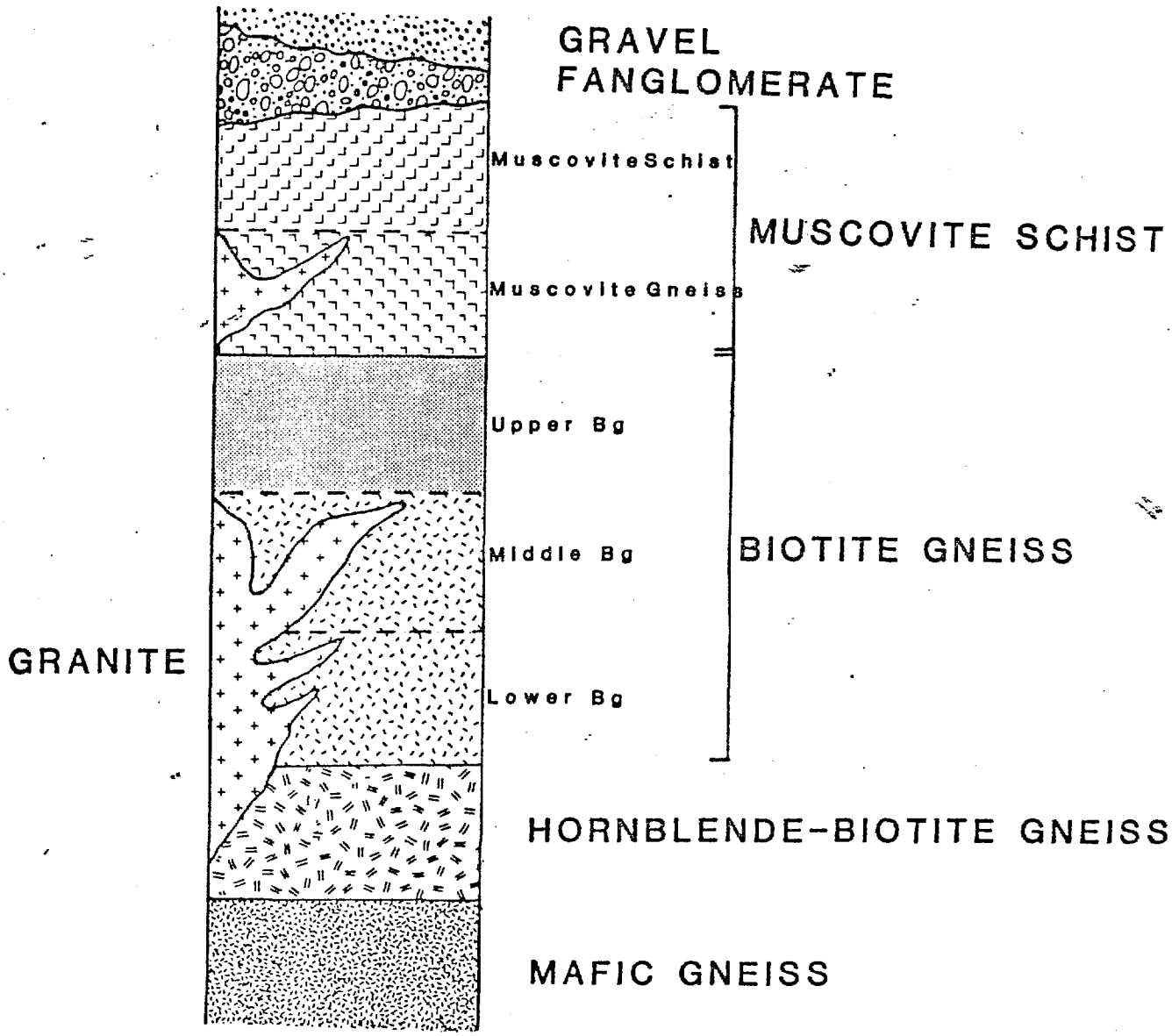


Fig. 2

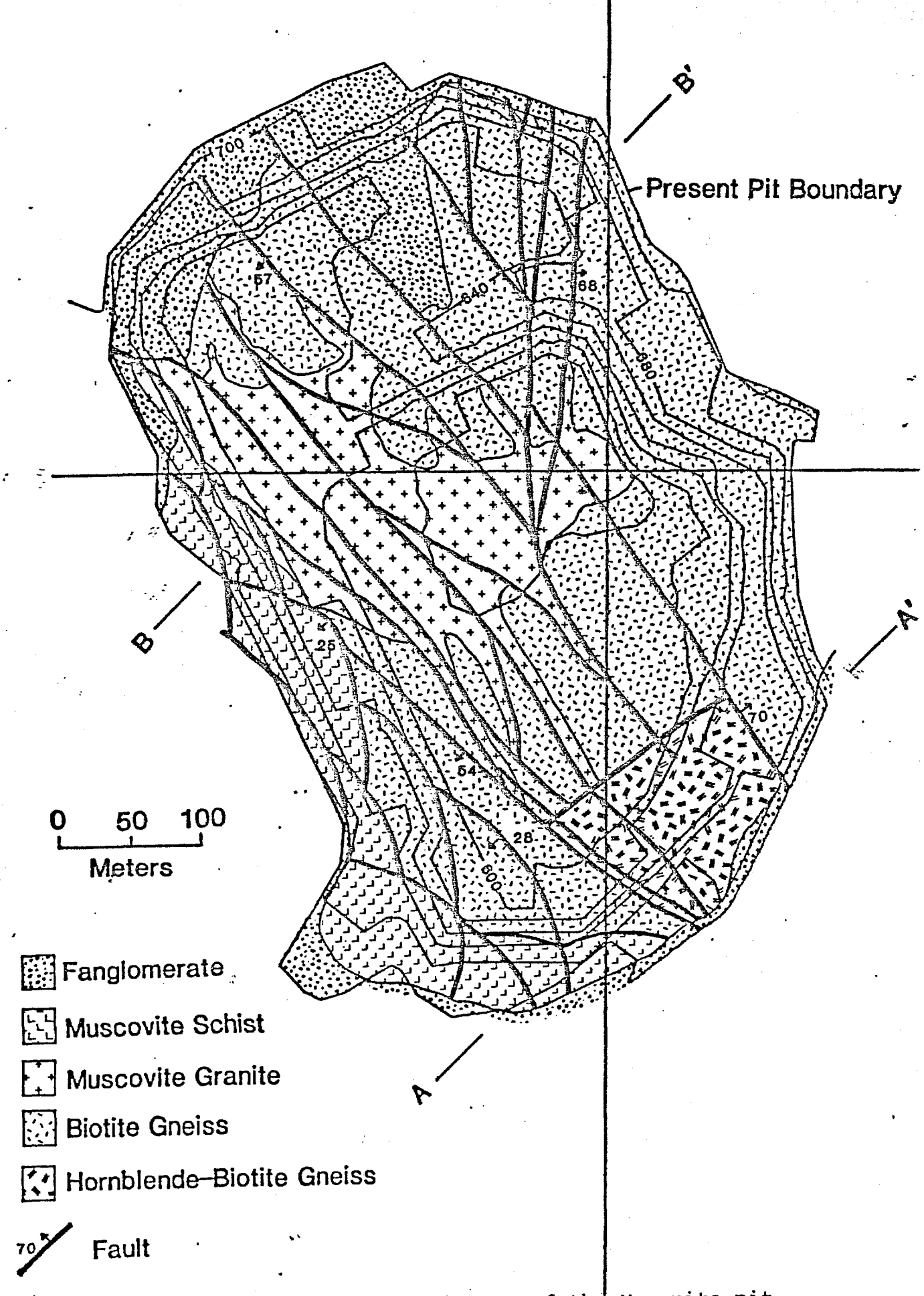


Fig. 3. Generalized geologic map of the Mesquite pit.

gneiss is the lowermost unit defined and forms the core of a northwest trending antiformal structure. The Mesquite orebody lies on the southwestern limb of this inferred structure. Moving upwards, the sequence consists of hornblende biotite gneiss, biotite gneiss, muscovite schist, Tertiary conglomeratic sediments and recent gravel cover. The biotite gneiss has been further divided into a lower salt and pepper unit, a middle unit consisting of alternating layers of salt and pepper gneiss and biotite rich layers and an upper quartzofeldspathic unit. The muscovite schist has been divided into a lower quartzofeldspathic muscovite gneiss and a very friable muscovite schist.

A coarse grained to pegmatitic muscovite bearing granite crosscuts the lower and middle units of the biotite gneiss and the muscovite gneiss. The intrusive may be sill-like, with a series of smaller dikes and sills radiating away from the main mass. Potassium-argon dating puts the age of the intrusive at around 38 m.y., but it is probable this is a reset metamorphic date.

Pit geology is dominated by two sets of major faults (Fig. 3). The first set has a strike of N. 40 to 50 W., with a split near mid-pit trending due north. This fault set has a range of dips from 55 to 80 southwest and northeast. The second major fault

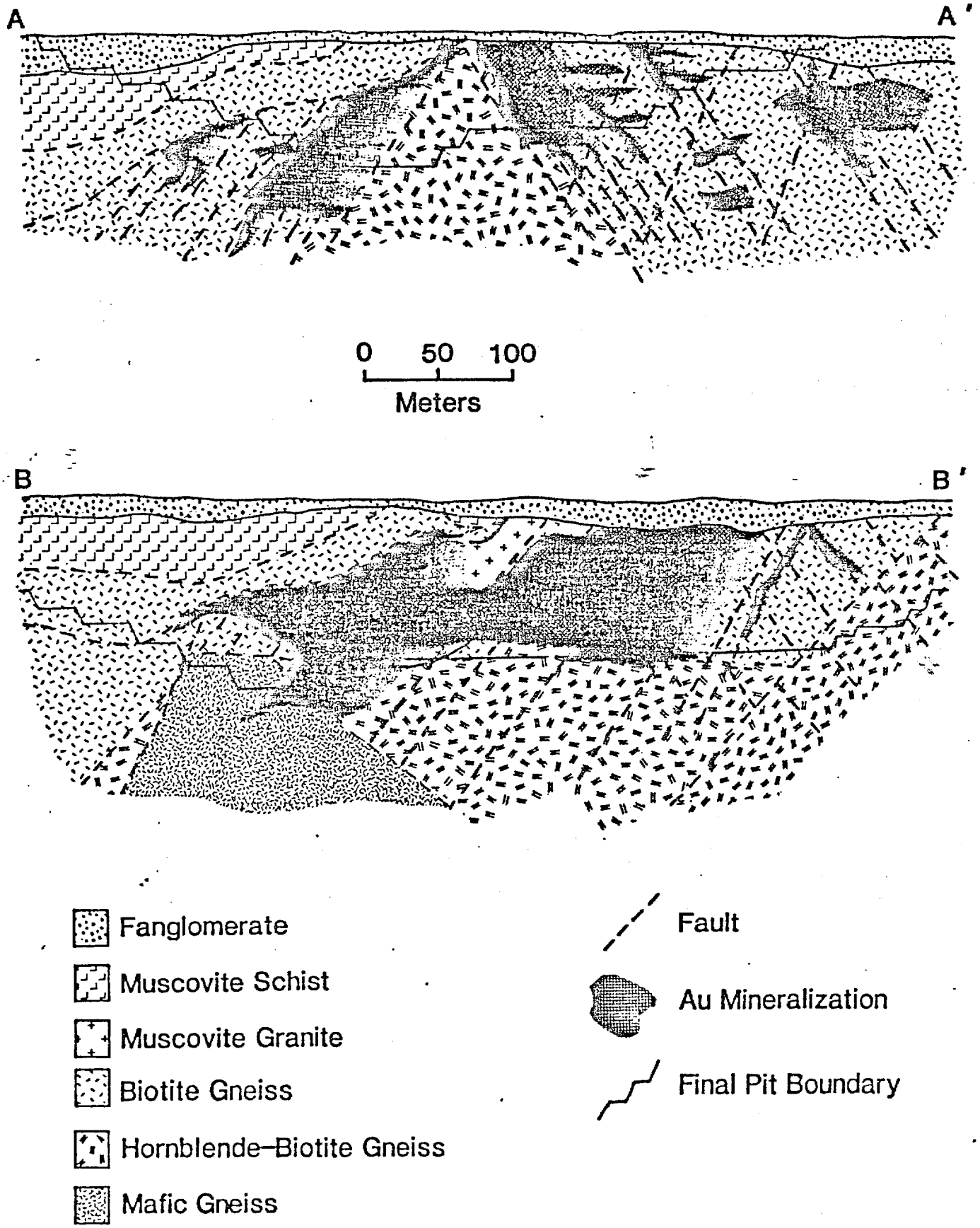


Fig. 4. Generalized geologic cross sections looking northwest through the Mesquite orebody.

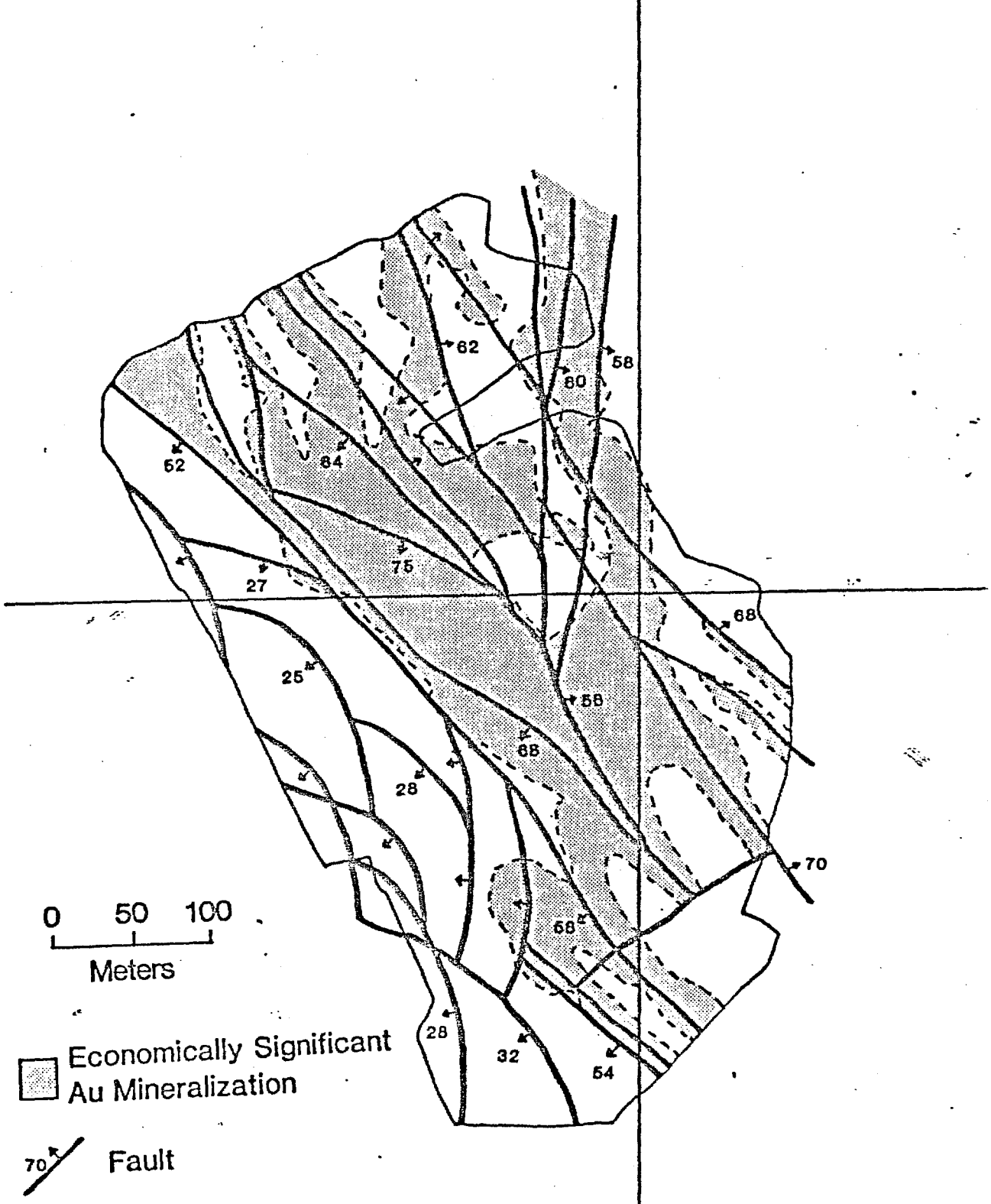


Fig. 5. Simplified fault map showing relationship of mineralization to faulting on the 640 bench.

trend dips from 20 to 40 to the southwest, with individual faults having an arcuate trace. In cross section the arcuate system has a braided appearance which may be evidence for a tensional detachment system, (Adams and others, 1983) but locally there is evidence for low angle reverse movement or thrusting.

Detailed fault mapping and blast hole sampling has shown that the majority of the gold mineralization is closely associated with, if not totally controlled by the high angle north to northwest trending fault system (Fig. 4 and 5). The low angle fault system is not mineralized and appears to have moved barren rock over the top of the high angle mineralized system often concealing it. Mineralization dies out to the northwest and southeast with higher grade zones occurring where the system is narrowest.

It is possible that the granite intrusive has played a major role in concentration of gold mineralization. The intrusive may have acted as the heat sources that brought in gold mineralization or remobilized anamalous syngenetic gold, concentrating it in the high angle structures, as well as in the receptive middle biotite gneiss.

It is also possible that the mineralization would fit into the detachment model as proposed by Drobeck and others (1986) for the Picacho Mine. In the Mesquite

instance the mineralization would be concentrated in the high angle normal faults rather than the low angle or detachment zone.

There are unanswered questions in relating gold mineralization to either of these two models. What is evident is the high angle normal faulting is very important in the Mesquite orebody. Relatively recent reactivation of many of these normal faults has complicated the picture even further and dictates the present signature of the orebody.

Adams, M.A., Hillemeyer, F.L., and Frost, E.G., 1983, Anastomosing shear zones - A geometric expansion for mid-Tertiary crustal extension in the detachment terrane of the Colorado River region, California, Arizona, and Nevada: Geological Society of America Abs w/Programs, v. 15, no. 7, p. 375.

Crowell, J.C., 1975, Geologic sketch of the Orocopia Mountains, southeastern California: California Div. Mines and Geology Spec. Rept. 118, p. 99-110.

Dillon, J.T., 1975, Geology of the Chocolate and Cargo Muchacho Mountains, southeasternmost California: Univ. Calif. Santa Barbara, Ph.D. thesis, 405 p.

Dillon, J.T., and Haxel, G.B., 1975, The Chocolate Mountain- Orocopia-Vincent thrust systems as a tectonic element of late Mesozoic California: Geol. Soc. America, Abs. with Programs, v. 7, no. 3, p. 311.

Drobeck, P.A.; Hillemeyer, F.L., Frost, E.G., Liebler, G.S., 1986, The Picacho Mine: A gold mineralized detachment in southeastern California: Arizona Geological Society Digest, v. XVI.

Haxel, G.B., 1975, The Orocopia Schist and the Chocolate Mountain thrust, Picacho-Peter Kane Mountain area, southeasternmost California: Univ. Calif. Santa Barbara, Ph.D. thesis, 277 p.

Miller, W.J., 1944, Geology of Palm Springs-Blythe strip, Riverside County, California: California Jour. Mines and Geology, v. 40, no. 1, p. 11-72.

Tosdal, R.M., Haxel, G.B., Dillon, J.T., 1985, Lithologic associations of gold deposits, southern California and southwestern Arizona: Geologic Society of America Abs. w/Programs, v. 17, no. 6, p. 414.

REPRINTED FROM
August 29, 1987 Vol. 76 No. 35

Skillings' Mining Review

RECEIVED
SEP 14 1987
EXPLORATION DEPARTMENT

PUBLISHED EVERY WEEK ESTABLISHED 1912

USMX

141 Union Blvd. / Suite 100
Denver, Colorado 80228
(303) 985-4665

Reprinted from August 29, 1987, issue of Skillings' Mining Review
First Bank Place—Suite 728, Duluth, MN 55802 U.S.A.

ASARCO

~~JDK~~ - ~~JDS~~

Exploration Department
Frederick T. Graybeal
Chief Geologist

January 14, 1991

DDHarper
HSJacobson
JEWorthington
COWindels
WLKurtz/JDSell
PGVikre
JCBalla
MAMcClave
RSGray

ASARCO Inc.
JAN 20 1992
SW Exploration

Muruntau
CIS (USSR)

The attached note from Doug Smith should be of some interest. If I recall, Spence Titley remarked to us in Denver a year or so ago (subsequently published in Geology) that gold deposits tend to occur more frequently in host rocks of specific ages. Among those specific age intervals was the Ordovician-Silurian interval. The significance of his observation is that areas where rocks of these ages are extensively heated or deformed may be unusually prospective for gold deposits.

F.T. Graybeal

FTG/mev

Attachment

ASARCO Incorporated 180 Maiden Lane New York, N.Y. 10038 (212) 510-2000
Telex:RCA 232378 Cable: MINEDEPART Fax: (212) 510-1978

F. T. G.
JAN 14 1992

ASARCO

Rocky Mountain
Exploration Division

January 9, 1992

TO: F. T. Graybeal

FROM: D. M. Smith, Jr.

Muruntau, Uzbekistan

B. Berger of the U.S.G.S. addressed DREGS on the subject gold deposit summarizing as follows: "It is that big and it is that good."

The deposit is located at the southeast end of the Tamdytau Range at longitude 62°W and latitude 42°N in the Kyzylkum Desert 400 km west of Tashkent.

Basement in the region is composed of carbonate, flysch, and mafic volcanic rocks of an upper Proterozoic island arc sequence. Most of the deposit is hosted by rocks of Unit III of the Cambrian to Ordovician-Silurian Bezapan Formation which consists of two nappe sequences.

Unit	Lithology
I.	Flysch, siltstone, sandstone, metavolcanics
II.	Coarser clastic rocks
III.	Variegated highly carbonaceous shale and sandstone with plenty of metatuff; assays >50 ppb Au regionally.
IV.	Metavolcanic greenstone schist.

These units are overlain by carbonate and clastic rocks of Devonian age.

Discovery occurred in the 1950's when high-grade outcrops that had been mined during the 13th Century were reexamined. Underground development, not drilling, is the preferred method of exploration even today. Remarkably, no exploration has yet been done under cover in the Muruntau region (scenery slides look like Nevada Basin and Range).

"Ore" for milling assays ≥1.5 g/t Au. Large volumes of the surrounding wallrock assay ≥0.5 g/t Au, but no material is heap leached for lack of technology. Berger noted that assays of samples collected by the U.S.G.S. group (n=4) tend to confirm

what they were told about grades by mine personnel. Bonanza silver ores are found at the southeast end of the district. U.S.G.S. people were denied access to the mill which Berger describes as a very large building covering a few acres located several kilometers from the mine. The deposit is shaped in transverse section like a point-down triangle, and measures 5 km x 2 km x 1 km deep. The final pit will measure 3 km x 2.5 km x 300 m deep*. At present 30 percent dilution is incurred by mining, but effort is underway to reduce this to 10 percent.

The deposit is sandwiched between two large regional-scale wrench faults related to suturing of the Karakum terrain to the Kazakh terrain during upper Carboniferous. It has been termed a stockwork, but veining is less anastomosing and more like sheeting. The ore zone consists of veins and veinlets hosted by northeast trending fractures of Caledonian age, as well as stacked north-south trending thrust faults that formed during a Hercynian folding event. Berger calls the ore "classic mesothermal," composed of milky quartz, arsenopyrite, pyrite, and microscopic native gold, plus minor chalcopyrite, molybdenite, and bismuthinite. The silver mineralization occurs as sulfosalts with sphalerite and galena. Sulfides total 1 - 2 percent of the ore. Vein ore filling high-angle fissures assays >5 g/t Au, and stockwork ore in low-angle fractures assays 2.5 - 5 g/t Au.

Hydrothermal alteration consists of pyrrhotite-muscovite-chlorite in a zone peripheral to a central zone of chlorite-K-sparimuscovite with superimposed albite. Fuchsite is present. Altered rocks contain 0.5 - 2.5 percent introduced CO_3, as well as 0.5 - 5 percent graphitic organic material.

Mineralization has been K/Ar dated at 280 million years.

Alaskitic dikes in the region have elevated REO contents.

According to Berger several "major companies" have been invited by the Uzbekistani government to visit the mine with an eye towards participating in a joint venture on the deposit. Given the regional elevated gold content of Unit III of the Bezapan Formation the exploration potential could be as awesome as the deposit itself.

D. M. Smith, Jr.

* At an arbitrary average grade of 2 g/t Au and ore density of 2.0 this pit will produce on the order of 290,000,000 ounces of gold (see attached calculation sheet).

ESTIMATE OF GOLD CONTENT OF FINAL PIT AT MURUNTAU, UZBEKISTAN

Muruntau Final Pit Size:

Length (m)	Width (m)	Depth (m)	Ore Density	Grade (kg/t)	Gold Content (kg)	Gold Content (oz)
3,000	2,500	300	2.0	0.0015	6,750,000	217,017,512
3,000	2,500	300	2.0	0.0020	9,000,000	289,356,683
3,000	2,500	300	2.0	0.0025	11,250,000	361,695,853

RECEIVED
FEB 21 1986
EXPLORATION DEPARTMENT

February 18, 1986

TO: W. L. Kurtz

FROM: D. M. Smith, Jr.

89th National Western Mining Conference

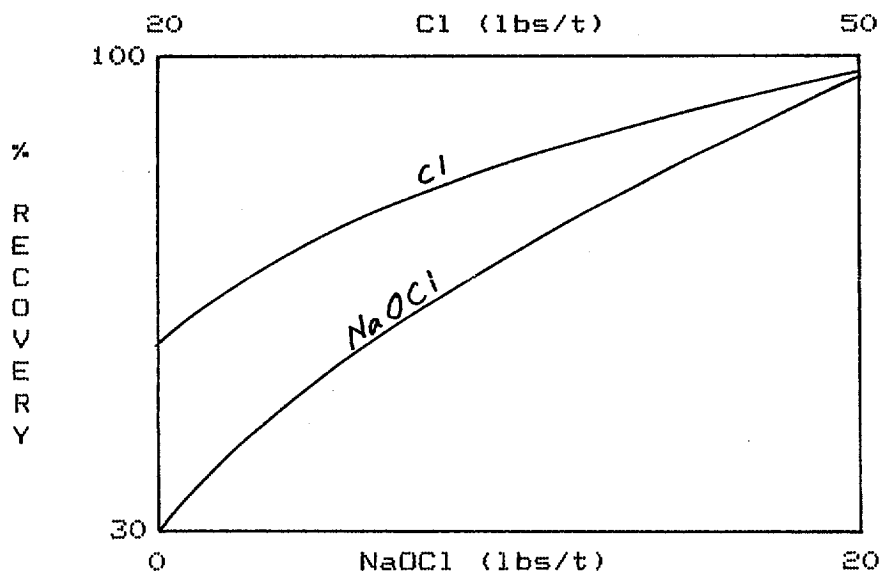
Exhibits, devoid of freebies and shotgun raffles, were sparsely attended, but talks on any facet of gold mining drew crowds. Of interest were the following presentations:

Carbonaceous Gold Ores - Update of Industry Practices; Bernie J. Scheiner, U.S.B.M., Tuscaloosa Research Center.

Carbonaceous ore is defined as any gold ore with organic materials which interfere with the cyanidation process. Four types of interference are recognized:

1) Adsorption of $Au(CN)_2^-$
2) Coating of Au
3) Complexing of Au with organic (e.g. Mercur)
4) Association of Au with sulfides

Gold recoveries typically are about 90% in organic-free ores, but drop to around 30% when the ore consists of 50% organics. Oxidation of "organic" ore dramatically increases recoveries. Both Carlin and Jerrit Canyon use Cl- (in excess supply on the West coast) as their principal oxidant. NaOCl also is excellent.



T.D.H.
MAR 14 1986

The general sequence of beneficiation at each plant is shown below:

CARLIN JERRIT CANYON

D. E. C.
FEB 21 1986

Grind		Grind
Oxidation	Cl	Oxidation
		NaHS (kills residual NaOCl)
Cyanidation		CIP
CCD		Tails
Tails		
Recovery = mid 80's		Recovery = high 80's to low 90's

Carlin has a significant reserve of deep highly carbonaceous ore having an average grade on the order of 1 oz per ton that will require considerable ingenuity to treat. Unfortunately their plant still runs in the same way that it did at start-up. Jerrit Canyon on the other hand has a state-of-the-art plant that utilizes on-line redox sensors with computer monitoring. Freeport is working on an "expert system" (experience-based computer program used for trouble shooting and control where the knowledge required exceeds human storage capacity) to control the redox phase of the process. Unlike Carlin they must add $NaCO_3$ and $CaCO_3$ for pH control which in turn controls the evolution of Cl gas.

Hog Ranch, Washoe County, Nevada; Ralph Barnard (speaker), V.P. Exploration, and Sigfried Holso, Senior Geologist, Ferret Exploration Co., Denver, Colorado.

The Hog Ranch property is located 47 mi. north of Gerlach and consists of 534 unpatented lode claims and 14 mill-site claims. The discovery resulted from the follow-up of a 1979 uranium exploration program which had defined a low-level anomaly in the area. Ground check found iron-stained altered rhyolite anomalous in gold located on a hillside above the basinal area that produced the anomalous radioactivity. No uranium mineralization was ever located in the vicinity. Initial soil sampling was done on a 100 x 300 ft grid with detailed coverage of anomalies at 100 x 100 ft. Anomalous values were determined to be equal to or greater than 100 ppb Au. Coincident with the Au anomaly are silver ("strong"), As (=200 ppm), and Sb (=100 ppm ?). Hg (500 to 5,000 ppb) forms a halo around the anomalous gold area. Asked if much fluorite was found associated with the deposit the speaker replied "not much."

Drilling thus far has consisted of 431 reverse-circulation holes sampled at 5 ft intervals and 13 core holes. Four ore zones have been defined to date and about 25 (my estimate) holes containing at least 5 ft of 0.025 oz Au are scattered around the property awaiting future exploration. Drilling in ore zones has been done on 100 ft. centers. All samples of cuttings are assayed by atomic absorbtion and those assaying greater than 0.01 oz are fire assayed as well.

The four ore zones, each containing one or more pods of ore, are

1) South Hog Ranch - flow dome of spherulitic rhyolite capped by pyroclastic breccia.

2) North Hog Ranch - explosive vents with ore "nearby."

3) Section 24 - silicified pyroclastics (slides look a lot like

Henley's hydrothermal eruption breccias) will be mined this year.

4) East Hog Ranch - more drilling needed.

Most of the ore reserves are reputed to be found in sedimentary tuffaceous units of the Canyon Rhyolite of Miocene age. A seemingly endless series of slides showing boxes of core demonstrated that the ore consists of steel gray colored zones of silicification interspersed with zones of bleached unsilicified (?) rock, both of which may be fresh or stained by iron oxides. Limonitic clay is abundant near the center of the deposit. Siliceous ore is of higher grade than the clay-rich material. Electrum is the source of the gold. It occurs as flakes measuring 1 to 450 microns across and contains "very little" silver. The ore pods in the Section 24 deposit mirror the present topographic surface. They have the form of stacked lenses 5 to 80 ft thick and actually crop out at one end of the area to be mined.

Metallurgical testing has been carried out by Kappes, Cassiday and Associates (Sparks). A total of 25 t was collected from two pits, one at each end of the Section 24 deposit. Ore from each pit was kept separate. Thirteen bench column-leach tests were run on various sizes (-3", -1 1/2", -5/8", and -1/4") of crushed ore, both agglomerated and unagglomerated. The -1 1/2 in size proved to be the optimum. Two 10 t column tests were made on agglomerated and unagglomerated ore crushed to -1 1/2 in:

North pit, unagglomerated = 80% recovery after 80 days

South pit, agglomerated = 90% recovery after 63 days

Mining will be done on 15 ft benches with a waste to ore ratio of 2.5:1. Some waste will be used to backfill the open pit as mining progresses. The remainder will be trucked a half mile to the waste dump which could itself be leached if the future price of gold warrants such action.

Should there be prepared a price for leach recovery? JBS

The in-house geologic ore reserve for the Section 24 zone is 3.5 million tons having an average grade of 0.065 oz Au per ton. The recoverable mine reserve is 2 million tons of the same grade. Total reserves are currently indicated at about 8 million tons containing 450,000 oz (about 0.06 oz/t). Three areas of widely spaced ("isolated") drill holes have the potential to double the existing "total" reserve if they drill out successfully.

Magma Series Chemistry in Metal Content of Mineral Deposits: A Powerful New Exploration Tool; Stanley B. Keith, President, MagmaChem, Inc., Phoenix, Arizona.

The MagmaChem MegaChart measures approximately 3 x 12 ft, is done in glorious colors reminiscent of the Michel-Levy chart, and tells you everything (well almost) you need to know in order to explore successfully for practically anything. The chart has a data base of 20,000 whole-rock analyses tied in time and space to mineral deposits which, it turns out, group according to their associated and hence related

magmatism. In computer parlance this constitutes (loosely) an "expert system." Keith advocates exploration that begins with a few whole-rock analyses of igneous rocks known to be on a time line with the target mineralization at any given prospect. The results are plugged into the chart in order to determine whether to walk or to stay and, if the decision is to stay, to determine if the future mine will be underground or an open pit. Of course all of this relates back to very specific types of plate tectonic events. For example, alkali-calcic magmatism resulting from a continent - continent collision and characterized by reduced, hydrous, Fe-poor magmas will produce deposits of Sn and W, while the same type of magmatism produced by a continent - ocean plate collision where Franciscan-type melange rocks are being subducted will result in the formation of Au deposits such as Mesquite. With specific emphasis on gold it was noted that the yellow metal is not associated with metaluminous anhydrous-mineral magmatism such as that found at Yellowstone, but that it favors metaluminous hydrous-mineral magmatism (e.g. Broadlands and McLaughlin) and, more particularly, hydrous calc-alkaline rocks such as hornblende andesite.

The cost of the MegaChart was rumored in the audience to be in the neighborhood of $500. The same source put the price of the chart plus dog-and-pony show at about $5,000.

D. M. Smith, Jr.

Douglas M. Smith, Jr.

cc: FTG
PGV

Lek Gold Deposit Research

JDS → WLK

ASARCO

Rocky Mountain
Exploration Division

RECEIVED

FEB 27 1987

EXPLORATION DEPARTMENT

February 24, 1987

TO: W. L. Kurtz

FROM: D. M. Smith, Jr.

Notes on Papers
90th National Western
Mining Conference

Following are notes on selected talks pertaining to gold and its deposits.

McCoy, Nevada; J. Michael Corcorcan (chem. eng.), resident manager, CanAm Gold Corp. (Echo Bay). Property is located in the Fish Creek Range 30 mi. south of Battle Mountain. It was first staked in about 1914. By 1920 two small mills were in operation and the "town" boasted 70 residents. In more recent years the deposit was acquired by Summa which sold out to Houston Oil and Minerals, thence to Tenneco which recently sold its precious-metal properties to Echo Bay. Gold Fields leased the property for 3 years and conducted extensive exploration. Early in 1985 Tenneco committed to make a mine based on an ore reserve of 6 million tons having an average grade of 0.055 oz. Au per ton and a waste to ore ratio of 3.2:1. This involved a capital investment of 7.8 million dollars and was accomplished within a short time frame:

August 1985 - engineering studies completed

November 1985 - all permitting completed

December 2, 1985 - groundbreaking

January 15, 1986 - plant construction started

April 15, 1986 - first precipitate obtained

April 29, 1986 - pouring of first dore

Grade control is accomplished by two surveyors and one junior engineer who use laser surveying equipment (storing in an HP hand-held computer) to locate 170 to 200 blast holes daily. All holes are assayed (hot CN leach, AA), and location and grade data are stored in an AT for rapid digital plotting onto a single grade-control map. This overall system is highly touted.

The mine produces 55,000 to 56,000 tpd of ore and waste, on two 10-hour shifts per day, 5 days per week. Ore is placed by conveyor on a 16-cell leach pad measuring 900 x 2300 ft., which will hold all 6 million tons of ore when finally heaped to a height of 75 ft. Crushing of ore to -1 in. incurs a cost of between $1 and $1.50 per ton. Gold is recovered by the Merrill-Crowe process with overall recoveries of about 65%.

Low-grade (0.02 oz/t Au) ore is "clastic" with free gold. High-grade ore is skarn. Five rigs are currently drilling exploration holes on the property.

Round Mountain; Otto Walls (metallurgist), Echo Bay. Reviewed beneficiation of ore at the mine. Treatment of "lean" ore (0.008 to 0.02 oz/t Au) is of interest since it might pertain to deposits such as the one at Carbonate Hill in Cripple Creek.

Most of the gold in the lean ore is contained in the -10 mesh fraction. Lean ore is sent to a special dump, the uppermost 1/3 of which is harvested and placed on the leach pads. This procedure doubles the grade since the large-sized material tends to roll down the flanks of the dump leaving the fines concentrated near the top. Because of its small size the scalped product has a lower than normal permeability.

Paradise Peak; David J. Collins (manager), FMC. A descriptive handout is attached. Ore reserves are:

12 million tons averaging 0.097 oz/t Au and 3.52 oz/t Ag

W:O = 1.5:1 mining rate = 1,000,000/yr

The largest grain of gold seen to date was 9 microns in diameter. The ore contains 0.5 to 0.8% total sulfur and as much as 200 ppm Hg with an average of 50 ppm Hg. (36,000 lbs. of mercury were produced in 1986 by retorting precipitate. It is still for sale!)

Recoveries are 94% for Au and 75 to 80% for Ag.

The plant experiences about 50 power outages per year.

The 110 acre tailings pond proved to be a magnet for migratory birds which tended to settle in and OD on CN. H_2O_2 is now added to the tails in order to kill the CN and save the ducks.

Building a scale model of the plant saved mega-bucks in avoided field changes during construction.

Design capacity was reached and maintained 18 days after startup.

All 191 employees are salaried.

Total cash costs are $17/t.

The bottom of the old mercury mine located at the base of the hill that contains the FMC deposit stopped only 40 ft. horizontally and 20 ft. vertically from the outer limit of the gold-silver orebody.

Ore Shoots Within Gold Vein Systems; L. P. James (consultant).
The Golden Rule: He who has the gold makes the rule.

Ore Control at Cannon Gold Mine; Diane Groody (mine geologist), Asamera.
Past production = 1,000,000 t at 0.4 oz/t Au

Current production = 2,000 tpd at 0.3 oz/t Au and 0.6 oz/t Ag

Geologic reserve = 5,500,000 t at 0.233 oz/t Au using 0.1 oz/t cutoff

Proved reserve = 1,740,000 t at 0.22 oz/t Au

Open pit (D reef) reserve = 1,340,000 t at unspecified grade

Gold occurs in quartz-adularia veins, quartz stockworks, hydrothermal breccias, and silicified zones. Host rocks are silicified arkose and siltstone. Broken ore is "pretty fine grained."

Sampling for grade control consists of round by round sampling of development headings with one hand scoop of rock removed from every LHD bucket load (about 10 lbs. of sample per ton of ore). Stope blocks are fan drilled with BW or AW core on 25 ft. centers (1 hole per 200 t of ore) at the rate of about 8,000 ft. per month. Core recovery is excellent (90 to 100%). The entire core is crushed for assay (1 assay ton split) after logging. In general development muck sampling shows slightly higher grades than actual mill heads for ore subsequently mined from the same area. Core assays usually are much lower than muck and production grades. An average of the three sets of numbers is used for grade control. High-grade values are cut only when obtained from core.

Total costs are $46/t. Profit per ounce = $160.

Mill recovery is now up to 88%. Problems have been caused by encapsulation of gold in pyrite and silica.

Since the mine is located beneath the town of Wenatchee (pop. 42,000; The Apple Capital of America), blasting and hoisting are prohibited between the hours of 11:00 P.M. and 7:00 A.M.

Illipah Project, Nevada; Gregory A. Lang (manager), CanAm (Echo Bay). Located 6 mi. northwest of Ely. Plant and equipment eventually will be moved to the Easy Junior property located about 30 mi. south of Illipah.

The first claims were located in 1979 by Earth Resources on a north-south-trending ridge of jasperoid. Tenneco bought the property in 1980 and sold it in 1986 to Echo Bay. Only BLM land is involved, so there is no royalty due except for a small residual to Tenneco.

Jasperoid is hosted by a north-south anticline having flank dips of 15°. Gold mineralization occurs at the contact between Chainman Shale and Joana Limestone where it is cut by high-angle faults (feeders). The ore has 25% void space which makes it the best leaching of all Echo Bay's ores.

The orebody was drilled out with 600 holes on 100 ft. (locally less) centers. Reserves are 1.25 million tons averaging 0.031 recoverable ounces per ton with W:O = 3.5:1. An unspecified amount of additional mineralization is available with W:O = 8:1. Ore grade at the steep feeder faults is 0.11 oz/t.

A trailer-based modular Merrill-Crowe plant housed in a steel pre-fab building will recover gold from leach solutions collected from a 600,000 sq. ft. leach pad heaped to a final height of 60 ft. Recovery is expected to be 90% and the mine will produce 40,000 oz. of gold over its 18-month life. Only 19 CanAm employees (11 salaried) will be required to run the operation since ore will be handled from mine to heap by a contractor.

Operational statistics:

Capital costs - $2,370,000
Mining costs - $4.21/t
Processing costs - $3.09/t
Administrative costs - $0.50/t
DD&A costs - $1.40/t

9.20

Open Cut Mine at Homestake; Jeffy Pfarr (planning engineer), Homestake. Mining done prior to the current operation removed about 4 million tons of ore. Overall grade of the ore now being mined is 0.112 oz/t, but the deeper parts will average 0.13 oz/t. During its expected 10-year life the mine will produce about 35,000 oz/yr.

Conveyor transport of ore has proved to be 60% cheaper than trucks. It is also quieter and makes no dust; important considerations since the haul route from mine to mill passes through the town of Lead.

Douglas M. Smith, Jr.

DMS:lb
Att.

cc: FTGraybeal - w/att.
PJBartos - w/att.
DIFletcher - w/att.

FMC

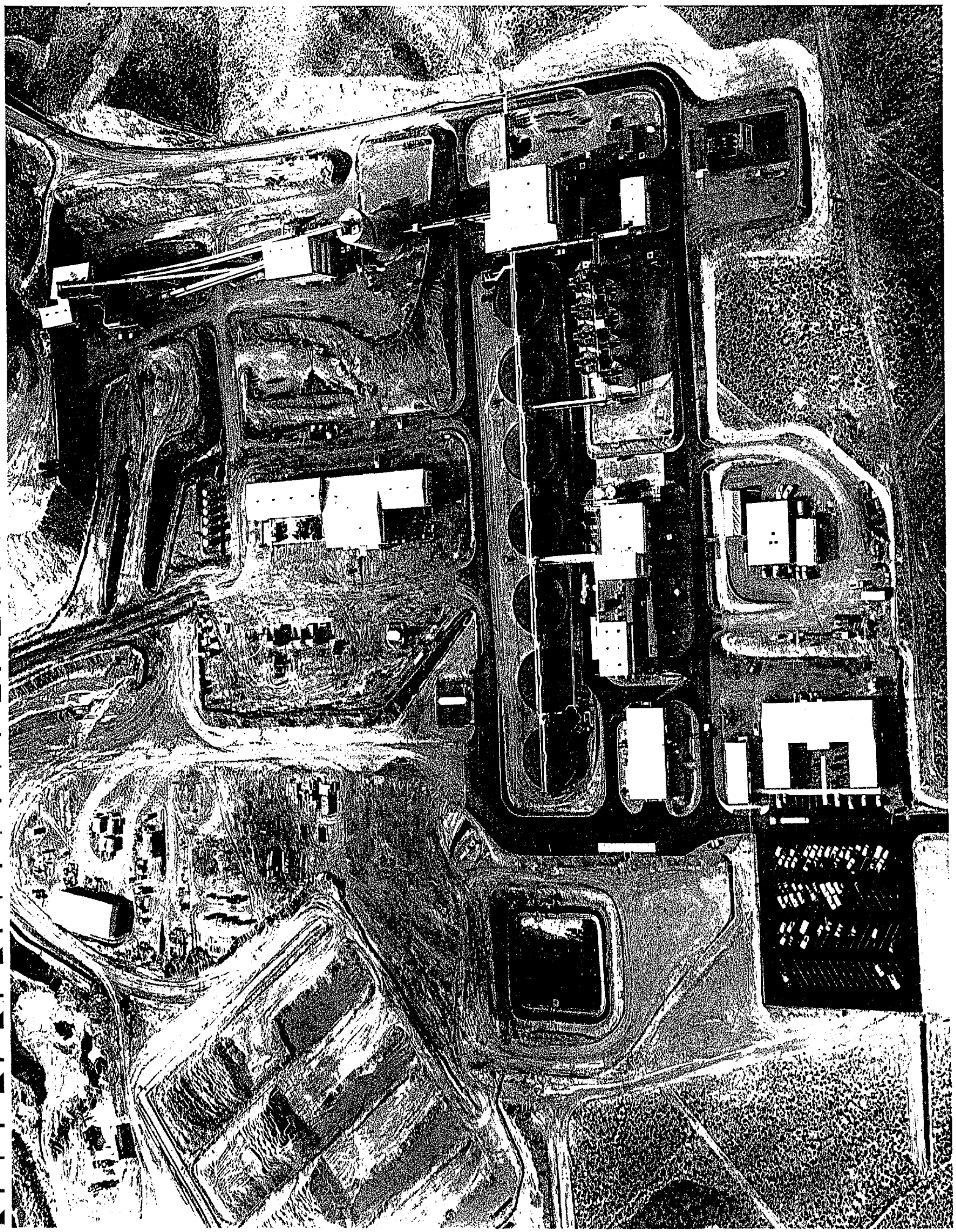
PARADISE PEAK

PROJECT

BY

DAVID J. COLLINS

FMC PARADISE PEAK CORPORATION



INTRODUCTION

FMC's Paradise Peak Mine was discovered in July 1983. The deposit contains 12,000,000 tons of ore grading 0.105 oz/ton Au and 3.75 oz/ton Ag. A feasibility study was completed by Davy McKee in May 1984 and detailed engineering was started in June 1984. Construction of the facility started on January 2, 1985 with plant start-up taking place on April 14, 1986, two and a half months ahead of schedule and more than 10% under budget. This paper describes the 4000 tpd gold and silver cyanidation plant and start up activities.

CRUSHING

Run of mine ore is delivered from the mine in 50 ton haul trucks to a 300,000 ton capacity open air stockpile. Ore is reclaimed using 7 cubic yard front end loaders which feeds a 100 ton hopper equipped with a 24" x 24" grizzly. A 54" x 35' apron feeder delivers ore from the hopper via a vibrating grizzly screen with 5" openings to a 43" x 51" Rexnord Jaw Crusher. Crushed material is conveyed to a 6' x 14' Link Belt vibrating screen equipped with a 2" manganese grizzly bar deck. Screen oversize is fed to a 5 1/2' Rexnord standard core crusher; product from this crusher joins the minus 2" screen undersize and is conveyed to a 150 ton surge bin. Three hydraulically driven belt feeders deliver ore from the ore bin to three 7' x 20' Link Belt single deck tertiary screens fitted with 1/4" x 1" slotted polyethylene screens. Screen undersize - minus 1/4" rock is conveyed to a 4000 ton ore storage bin. Screen oversize is delivered via conveyor belt to a 100 ton surge bin. From this bin two belt feeders feed ore to two - 66" gyradisc crushers which are in closed circuit with the tertiary screens.

Design Features:

* Magnetic protection for tramp iron removal
* Sloping floors and pump sumps for ease of clean up
* Dust scrubbers to keep working environment clean and comply with State dust emission regulations

GRINDING

Two 42" x 15′ belt feeders deliver ore from the fine ore bin to a conveyor belt which feeds ore to the 16′ x 22′ Allis Chalmers ball mill. The conveyor belt is equipped with a Merrick Weightometer which controls feed rate to the ball mill by speed control on the hydraulic motors driving the feeders. The 3500 HP powered mill grinds 4000 tpd to an average grind of 85% minus 200 mesh. The mill is in closed circuit with four - 26" Krebs Cyclones, three of which are normally in operation with one as a standby. Warman Pumps feed the cyclones through a cyclone distribution manifold. The cyclone underflow returns to the ball mill which has a 300% average circulating load. Mill discharge pH is 10.5.

Cyclone overflow is sampled using a Heath & Sherwood two-stage sampler and then flows to a 90′ diameter thickener. Thickener overflow is returned to the grinding circuit, while underflow is pumped to the leaching circuit.

Design Features:

* Steeply sloping floors for ease of clean up
* Open area over pumps for maintenance accessibility
* Ball hopper with self-discharge bottom to speed ball addition
* Air actuated knife gate valves on pump and cyclones
* Mill liner handler
* Air clutch connects mill motor to the mill

LEACHING & CCD

Thickened slurry at 50% solids is fed from the grinding thickener to the leaching circuit which consists of eight - 33′ x 36′ agitated tanks. Agitator gear boxes are 30 HP Philadelphia Gear which drive axial flow propellers. The first agitated tank can be used as a preoxidation stage. Cyanide is presently added to both the No. 1 & No. 2 tanks and leaching is carried out for a period of 24 hours at a pH of 10 - 10.5 and sodium cyanide concentration of 2 lbs/ton of solution.

Following leaching at .08 - 0.1% NaCN, the slurry is sampled and then fed to a six stage counter-current decantation (CCD) circuit using 90 ft. diameter Eimco thickeners. Pregnant solution overflows the first stage into a 65,000 gallon tank while barren solution is added to the sixth stage and flows counter-currently to the solids which are pumped from the first stage to the sixth. Slurry leaving the sixth stage is sampled and then pumped to the HDPE lined tailings impoundment. A tunnel under the in-line thickeners provides good operation and maintenance access. Washing efficiencies are in the order of 99%.

Design Features:

* All thickeners have standby pumps
* Steeply sloping floors for clean up ease
* Open air leach tanks interconnected for bypassing
* Multiple flocculant addition points in wide thickener feed launders fitted with mixing baffler
* Mixing boxes to feed each thickener
* Bypass piping to remove thickener from circuit

PRECIPITATION

Pregnant solution is pumped through four - 750 sq. ft. Stella Meta Candle filters, which are precoated with diatomaceous earth, to clarify (remove suspended solids) the pregnant solution. Following clarification the solution is deoxygenated in a vacuum tower, zinc dust is added and then the solution is pumped using a vertical centrifucal pump to our 750 sq. ft. Stella Meta Filters where the precipitate is filtered. Barren solution is pumped to the CCD circuit while the precious metal precipitate is discharged into a storage tank. Operation of both banks of Stella Meta Filters are controlled by a Texas Instruments computer.

Capability to add lead nitrate to the circuit is provided. Flow rates through the clarification and precipitation circuits are 2400 gpm which yields a wash ratio of about 3.5 to 1 in CCD.

Design Features:

* Equipment selection to minimize/eliminate physical labor

* Overhead crane to service Stella Meta Filters for ease of maintenance

* Variable zinc additions based on barren solution assays

BULLION

The precipitate is pumped into a stainless steel agitated tank which is used to acid digest excess zinc out of the precipitate using sulfuric acid. The acid digestion tank is kept under a nitrogen gas atmosphere to safeguard against the possibility of hydrogen explosions. The acid digested precipitate is then fed to three Funda filters - which are horizontal driven pressure filters and discharge a moist filter cake. The precipitate is discharged into retort trays which are then placed into four retorts. Retorting, used to remove mercury from the precipitate, is carried out over a 20-hour period during which the precipitate is heated to 1350° F under vacuum. Mercury vapors are collected in condensers and stored. Final cleaning of the vacuum stream is carried out in a charcoal filter to remove trace mercury vapors. Mercury is stored in one ton capacity flasks. The retorts and condensers are housed in a concrete block building which is supplied with large amounts of ventilation - one room volume charge per minute. All interior walls are coated with special epoxy coatings to prevent mercury adsorption by the structure.

The dry retorted precipitate is conveyed using a vacuum system into a 75 cubic foot capacity double cone mixer. The mixer is mounted on load cells which measure the weight of precipitate loaded into the mixer. The vacuum system pulls vacuum through a baghouse filter which removes precipitate dust from the air stream. The filtered precipitate is returned to the mixer. A small computer utilizes the precipitate weight to automatically feed, via load cells and conveyor belt, the correct weight of the various fluxes to the mixer. A small amount of water for dust suppression is also added to the mixer. Following mixing the precipitate is transferred to one of two 10 cu. ft., 500 kw induction furnaces for melting. Following melting the slag is first decanted off into slag pots and the bullion is then poured into 1000 oz. cascade molds. Bullion assay samples are taken during the pour using glass vacuum tubes. The bars are cleaned using a ball peening machine and shipped to

refineries. Slag is crushed to minus 20 mesh using a jaw and roll cursher. Coarse metal is recovered by screening finer metallic prills and are recovered using a Carpco Electrostatic Separator. Metal recoveries from the slag are in the plus 95% range.

Design Features:

* High volume ventilation for personnel protection

* Mechanized and automated material handling to reduce manpower requirements

* Novel application of equipment - e.g., Funda Filters, vacuum transfer of precipitate and electrostatic separator slag treatment

REAGENT PREPARATION

Lime - Received in bulk and air conveyed into a 100 ton silo. 75 - 80% of lime requirements are fed by screw conveyor into the ball mill feed conveyor. A Portec Kahaban slaker prepares lime slurry which is used to trim pH in the leaching circuit.

Sodium Cyanide - Received in 3000 lb. tote bins. The outdoor mixing facility is surrounded by a concrete pad onto which delivery trucks can drive for easy and safe unloading. A forklift is used to place a tote bin on top of the mixing tank. This arrangement allows the bin to discharge directly into the mixing tank. Caustic soda solution is added to maintain a pH of 12 or higher. The mixed 20% solution is transferred to a storage tank from which it is pumped to the leaching tanks using a glandless pump and stainless steel pipe. Small magflowmeters are used to measure addition rates.

Flocculant - Two packaged dry flocculant mixing units prepare concentrated flocculant solutions which are then diluted and held in two 8900 gallon storage tanks. Moyno pumps are used to distribute the solution to the seven thickeners.

Sulfuric Acid - Is received in bulk at 93% concentration into a 6100 gallon stainless steel tank. The acid is pumped directly to the acid digestion tank.

Diatomaceous Earth - Dicalite, delivered in 50 lb. bags is mixed with water in a 1750 gallon capacity tank. The filter and slurry is pumped into both clarification and precipitation filters for use as a precoat.

Zinc Dust - Merrilite Zinc Dust received in 5 gallon pails is fed into a mixing cone using a Vibra Screw Feeder. Barren solution is used to make up a slurry which is then pumped into the suction side of the precipitation filter feed pump.

Design Features:

* Centrally located so that one operator can mix all reagents
* Sloping floors and sump pumps for ease of clean up
* Unloading docks and concrete pads for ease of reagent delivery

SERVICES

Two 1200 gpm water wells, some three and a half miles to the south east of the plant, supply water through a 10" pipeline to the facility. A 737,000 gallon water tank is used for storage with the bottom one third reserved for fire fighting purposes.

A 20 mile, 120 kilovolt power line from Luning supplies electrical energy to the 8 mega watt load plant.

A fire water pumphouse which houses two 1000 gpm pumps, one electrically driven the other diesel power, supply water to a plantwide fire main. A jockey pump maintains line pressure at 120 psi until water demand initiates start-up of a main pump.

Two Atlas Copco 125 psi 656 cfm compresors provide plant air. A Gardner Denver 50 psi 760 cfm compressor supplies process air while a Worthington 125 psi 88 cfm supplies instrument air which is dried before use. Two 500 kw diesel powered generators provide emergency electrical power during power outages.

A chlorinator injects chlorine into the potable water circuit.

OPERATING STATISTICS

Design Throughput	4000 tpd
Feed Grade	0.105 oz/t Au 3.75 oz/t Ag
Average Production Per Year	100,000 oz Au 3,500,000 oz Ag
Metal Recovery	Au - 92-95 % Ag - 62-75 %

REAGENTS CONSUMPTIONS

Grinding Balls	2.5 - 4.0 lbs/ton
Sodium Cyanide	2.0 - 3.5 lbs/ton
Lime	2.5 - 4.0 lbs/ton
Caustic Soda	0.2 - 0.5 lbs/ton
Zinc Dust	0.15 - 0.3 lbs/ton
Flocculant	0.001 - 0.005 lbs/ton
Diatomaceous Earth	0.20 - 0.40 lbs/ton
Sulfuric Acid	0.05 - 0.10 lbs/ton

START-UP

On April 14, 1986, the mill was started up with ore. The first dore' was poured on April 24 and just eighteen days after start-up the mill achieved 100% of design throughput. During May several minor modifications were conducted, and plant throughput averaged 93%. Tonnage processed during June was 103% of design, and the plant operated at or above design rates for the rest of 1986, averaging 101.5% of design for its first eight and a half months of operation.

Several key acts were instrumental in the accomplishment of this achievement.

Senior operating staff with extensive experience in processing were hired during the early stages of detailed design, which was conducted by Davy McKee. They formed part of the design team. A model of the plant was built which allowed the team to readily evaluate the design of the plant and ensure access for ease of maintenance. The model also saved considerably on field design changes. The model was transferred from the engineering offices to the project site and construction contractors used the model extensively as a reference. It later served as a valuable training tool for mill operators.

Detailed and comprehensive training manuals were prepared by Performance Associates. The manuals explain in non-technical terms the principles of milling operations and were also prepared for mine equipment. They include written tests to evaluate the learning. The tests also provide a support for the justification of the progression of an operator or mechanic to a higher pay grade. Operations supervisors were trained in the use of the manuals. Recruitment of crew members was carried out by the individual supervisors and were hired and brought on between 1 and 2 months for mine personnel and 3 and 4 months for mill operators, prior to start-up.

The mine started operations in December 1985 and by April had achieved their goal of having 200,000 tons of ore on the mill stockpile.

An all-salaried pay system incorporating a progression system was implemented. Team members can obtain higher pay grades by learning more skills. Annual pay raises are determined by performance which is consistent with our philosophy to pay for performance.

Mill operator training started with classroom training using the manuals and the model and progressed to field training. The crews took part in all pre-operational testing conducted by Davy McKee, and included final water testing of the entire plant. Throughout the entire program teamwork was emphasized. In fact, all personnel are called and proud to be called Team Members.

By April 14th each operator had received training in at least two operating sections and were ready to start-up the plant. The start-up schedule allowed six months to achieve design rates and, as mentioned, this was achieved just eighteen days after start-up. Only very minor modifications were required to the plant, which were conducted in May 1985. It is felt that the actions that are described above contributed in great part to the highly successful and rapid start-up of the Paradise Peak project.

Gold Deposit Description

ASARCO

Southwestern Exploration Division

September 9, 1981

TO: FILE FOR RECORD

FROM: Peter G. Vikre

New Savage Mine
Virginia City, Nevada

On August 25, 1981, I visited the New Savage Mine, Virginia City, Nevada, at the invitation of Bob Carrington, mine geologist. The New Savage Mine is developing unmined mineralization and stope fill on the Comstock Lode. Mine workings explore parts of the Savage, Hale and Norcross, and Chollar-Potosi claims on about the 465 foot level (datum point is the Hale and Norcross lode outcrop). Underground work began in May, 1979. Development consists of about 3000 feet of crosscuts, drifts, and access incline (Fig. 1). All mining is by trackless equipment. Despite closely spaced timbering and welded I-beam supports that are required nearly throughout the mine, mining costs are reportedly $27.00 per ton. About 55 people are employed at the mine.

Proven reserves are 250,000 tons containing 0.18 oz Au/ton and 7.1 oz Ag/ton. Possible reserves exceed 3 m.t. at grades unknown. Much of the proven reserve was developed in the 1920s by Comstock Merger Mines. Comstock Merger exploration to ∿ -800 feet at that time is also the basis for possible reserves.

The New Savage Mine is a limited partnership between United Mining Company of Nevada, the principal owner, and numerous others. United Mining currently controls the Comstock Lode from the Union workings at the north end to Gold Hill. Houston International Minerals Company has leased the lode from Gold Hill south. United is stockpiling development ore and the company is presently undecided about milling. They appear to be waiting for HIMCO's plant to be sold.

The Comstock Lode on the New Savage Mine 465 level is an 80-150 foot thick stockwork composed of 70% quartz + sulfide veins, and 30% silicified, pyritic Alta "andesite." More than 90% of the lode is oxidized. Ore corresponds closely to the stockwork and is enclosed on both sides by up to 100 feet of crushed wall rock (East and West faults). Wall rock composition is largely quartz + clay-mica (montmorillonite) + pyrite adjacent to stockwork. Quartz + chlorite + pyrite ± epidote increases in abundance in the hanging wall with distance from the lode. Numerous faults and thick zones of crushed andesite occur throughout the hanging wall. Silicate-sulfide assemblages in these faults appear to be the same as those of the lode-bounding crushed zones. Footwall lithology consists of Davidson granodiorite, intrusive basalt, and Mesozoic meta-andesite.

P. Vikre

Peter G. Vikre

cc: Messrs. Kurtz, Payne, Graybeal

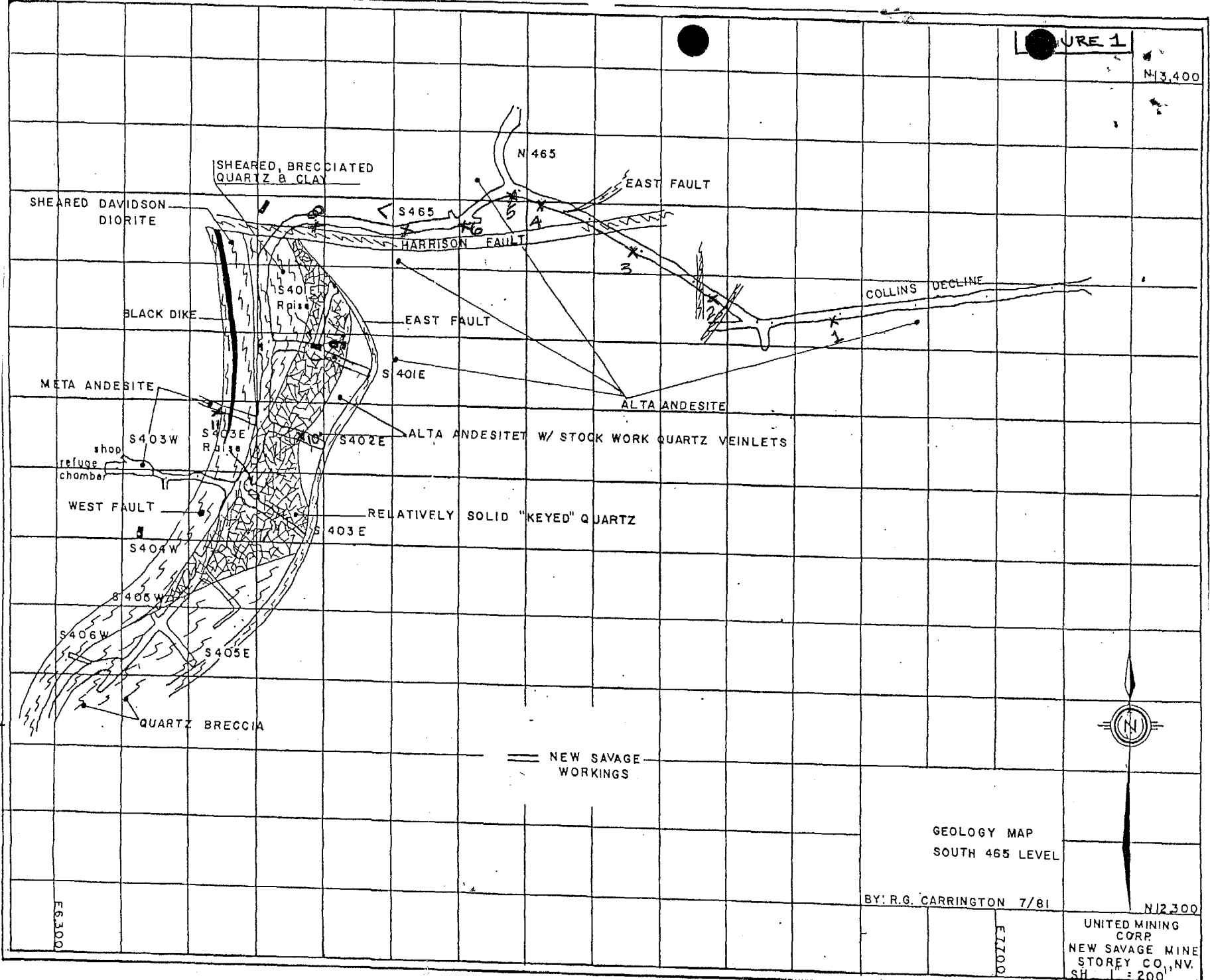


FIGURE 1
N13,400
N465
SHEARED, BRECCIATED QUARTZ & CLAY
EAST FAULT
SHEARED DAVIDSON DIORITE
S465
HARRISON FAULT
S401E Raise
COLLINS DECLINE
BLACK DIKE
EAST FAULT
S401E
META ANDESITE
ALTA ANDESITE
S403W
S403E Raise
S402E
ALTA ANDESITE W/ STOCK WORK QUARTZ VEINLETS
shop
refuge chamber
WEST FAULT
RELATIVELY SOLID "KEYED" QUARTZ
S403E
S404W
S406W
S406W
S405E
QUARTZ BRECCIA
NEW SAVAGE WORKINGS
GEOLOGY MAP
SOUTH 465 LEVEL
BY: R.G. CARRINGTON 7/81
N12,300
E6,300
E7,700
UNITED MINING CORP.
NEW SAVAGE MINE
STOREY CO., NV.
SH 1" = 200'

LOLK copy

File Gold Deposit Description

Fischer-Watt Mining Co. Inc.

ADMINISTRATIVE OFFICE: 114 TUCKER, SUITE 2
KINGMAN, ARIZONA 86401
PHONE: (602) 753-1622

GEOLOGY, ALTERATION AND MINERALIZATION

IN THE OATMAN MINING DISTRICT, MOHAVE COUNTY, ARIZONA

Text of Talk Presented by Perry Durning

to the Arizona Geological Society Meeting

August 5, 1980

xc: Library 8/31/82

xc: FRK
GOLD ROAD FILE
1/24/84

CONTENTS

I.	Introduction and Acknowledgements	1
II.	Location	1
III.	History of Fischer-Watt Mining Involvement	1
IV.	History and Production	3
V.	Regional Geology and Structure	3
VI.	Local Geology	9
VII.	Mineralization and Alteration	9
VIII.	Exploration Techniques	15
	A) Alteration Mapping and Vein Contouring	15
	B) Fluid Inclusion Studies	21
	C) Geochemistry	22
IX.	Conclusions	22

ILLUSTRATIONS

Figures		Page
Figure 1	Location Map	2
Figure 2	Regional Geology	6
Figure 3a	Geology and Structure of the	7
3b	Oatman District	8
Figure 4	Geology of the Central District	10
Figure 5	Effect of Rock Type on Fracture Pattern	11
Figure 6	Alteration in the Central District	13
Figure 7	Cross Section, United Eastern Orebody	14
Figure 8a,b	Vein Contours, Tom Reed Vein	17, 18
Figure 9	Vein Contours, Kokomo Vein	20
Tables		
Table 1	Individual Mine Production	4
Table 2	Summary of Orebody Characteristics	5

Fischer-Watt Mining Co. Inc.

ADMINISTRATIVE OFFICE: 114 TUCKER, SUITE 2
KINGMAN, ARIZONA 86401
PHONE: (602) 753-1622

I. INTRODUCTION AND ACKNOWLEDGEMENTS

I'd like to thank you for the opportunity to present some of the results of our work at Oatman and share with you some of our successes and disappointments.

I'd also like to thank Fischer-Watt Mining and Canadian Natural Resources for their continuing support of our exploration efforts, and acknowledge the contributions of Larry Buchanan, Gary Clifton, Fred Haynes, Don Muchow and Masters thesis students Bob Smith and Al Morris, all of whom have contributed to our geological understanding of Oatman.

III. LOCATION

The Oatman district is located about 30 miles southwest of Kingman and approximately 100 miles SSE of Las Vegas on old Highway 66. (Figure 1)

III. HISTORY OF FISCHER-WATT MINING INVOLVEMENT

Carl Fischer and Tim Watt as individuals became interested in the Oatman district in 1977. Initial work involved deepening the Ida Shaft on the Tom Reed Jr. Vein. In 1979, Fischer-Watt Mining was organized to evaluate the exploration potential for the entire Oatman district as well as identify other exploration and mine development opportunities throughout the western United States.

During April, 1979, critical land positions were negotiated and geological, geochemical and fluid inclusion studies were initiated.

Drilling was begun in September, 1979, and to date 35 drill holes varying 200 to 1,900 feet have been completed.

FW - 32,000' drilling (by Fischer-Watt and Canadian Natural Resources)
Hecla - pulled out Feb '83 after 11 holes. (see Prog Rept Feb '83)

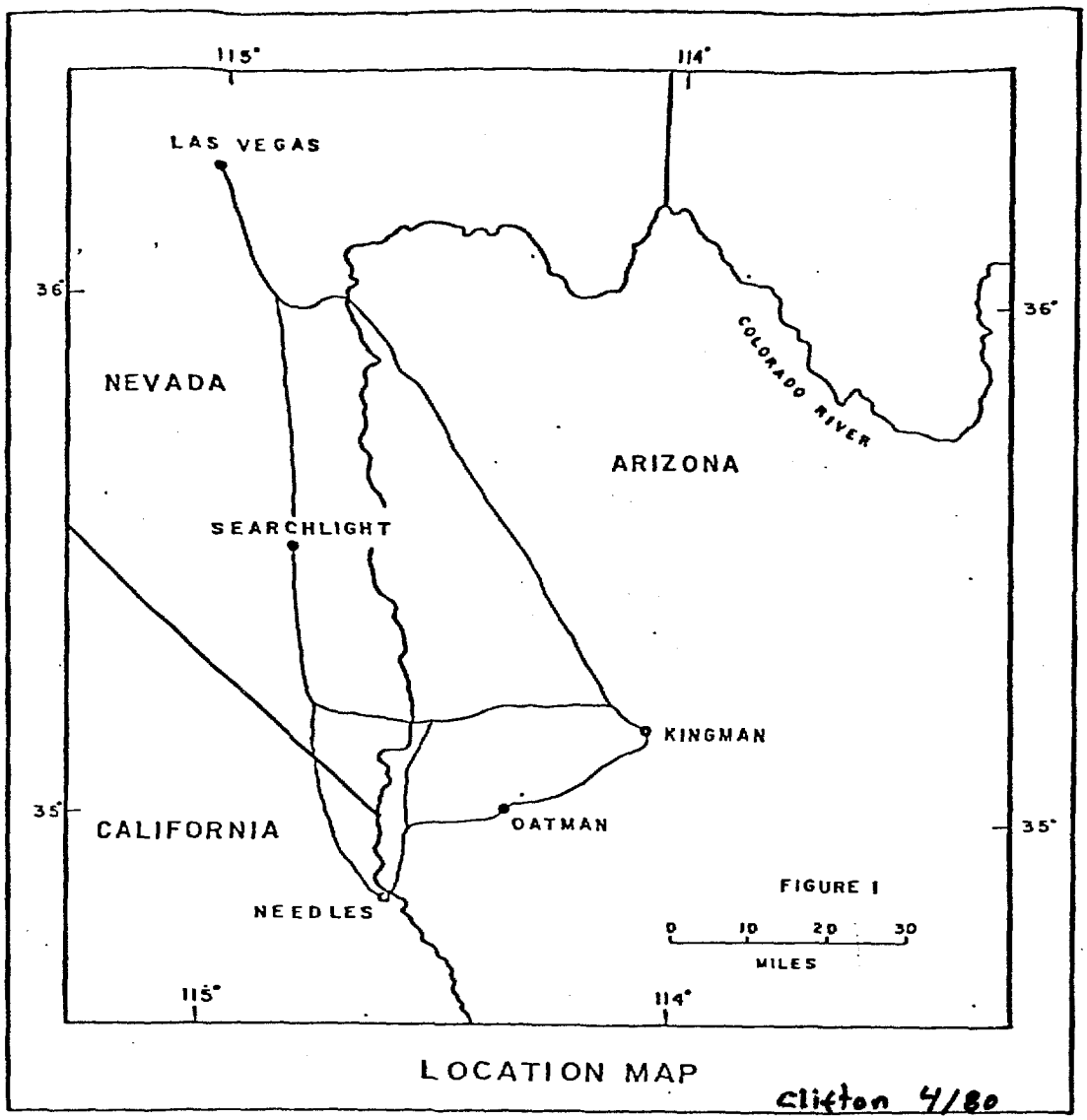

115°
114°
LAS VEGAS
36°
36°
NEVADA
COLORADO RIVER
ARIZONA
SEARCHLIGHT
KINGMAN
35°
35°
CALIFORNIA
OATMAN
FIGURE I
NEEDLES
0 10 20 30
MILES
115°
114°
LOCATION MAP
Clifton 4/80

figure I

IV. HISTORY AND PRODUCTION

The original discovery at Oatman was made on the Moss vein in the western part of the district in 1863. However, mine development was discouraged by unfriendly Indians. Mining activities resumed in the 1880's but it was not until the discovery of the Gold Road Vein in 1900 that prospecting activities centered in the central part of the district. In 1901 gold was found on the Tom Reed vein but it was not until 1906 that rich ore in the Tip Top and Ben Harrison ore shoots was discovered. In 1915 and 1916 the Big Jim, Aztec and United Eastern ore bodies were discovered on the Tom Reed vein and the resultant boom swelled the population of Oatman and Gold Road to over 10,000 people. By the mid 1920's Oatman's population had dwindled and most of the mines had turned to leasor operations. Elevation of the gold price from $20. to $35./oz. in 1933 resulted in a revival of the Tom Reed and Gold Road Mining Company properties until they were closed by war board order L-208 in 1942.

The town of Oatman was named after Olive Oatman who was held captive by Indians for several years then found wandering in the desert by a rancher near the present town site.

Total production for the Oatman district between 1897 and 1942 was about 2.2×10^6 ounces Au and $.8 \times 10^6$ ounces Ag. The metal was derived from 3.8×10^6 T of ore with an average grade of 0.59 o/T Au, 0.20 o/T Ag. (Table 1) The majority of this production came from 8 major ore shoots on the Tom Reed and Gold Road vein. (Table 2) All other mines contributed about 10% of total district production.

V. REGIONAL GEOLOGY AND STRUCTURE

Geologic maps covering the Oatman District compiled by Ransome 1923, Lausen 1931, and Thorson 1971, provide excellent regional geologic coverage. Since the meat of my discussion will involve detailed description of the local vein geology I will deal only briefly with the regional geological environment.

The Oatman district lies within a thick sequence of 30 to 10 million year old Trachyatic, latitic and rhyolitic volacanic rocks on the southwestern flank of the Black Mountains. (Figure 2) The Oatman district may lie within a large circular caldron-like structure characterized by exceptionally thick sequences of Trachytes and latites and intruded along its margins by late stage epizonal quartz monzonite to rhyolitic stocks and plugs. (Figures 3a, 3b) The circular feature is also the margin for a

Table 1

INDIVIDUAL MINE PRODUCTION

OATMAN MINING DISTRICT, MOHAVE COUNTY, ARIZONA

Mine	Gold $20.67/oz 1897-1933 Tons of Ore	Mined Grade oz/T	Gold $35/oz 1934-1942 Tons of Ore	Mined Grade oz/T	Total Tons of Ore	Average Mined Grade oz/T
Tom Reed	981,090	0.70	205,125	0.32	1,186,215	0.64
United Eastern	687,038	1.12	0	0	687,038	1.12
Gold Road	737,926	0.47	775,895	0.22	1,513,823	0.32
Total Prod.	2,406,054	0.74	981,020	0.24	3,387,076	0.59
Other Mines				(est.)	400,000	0.60

Clifton 4/80

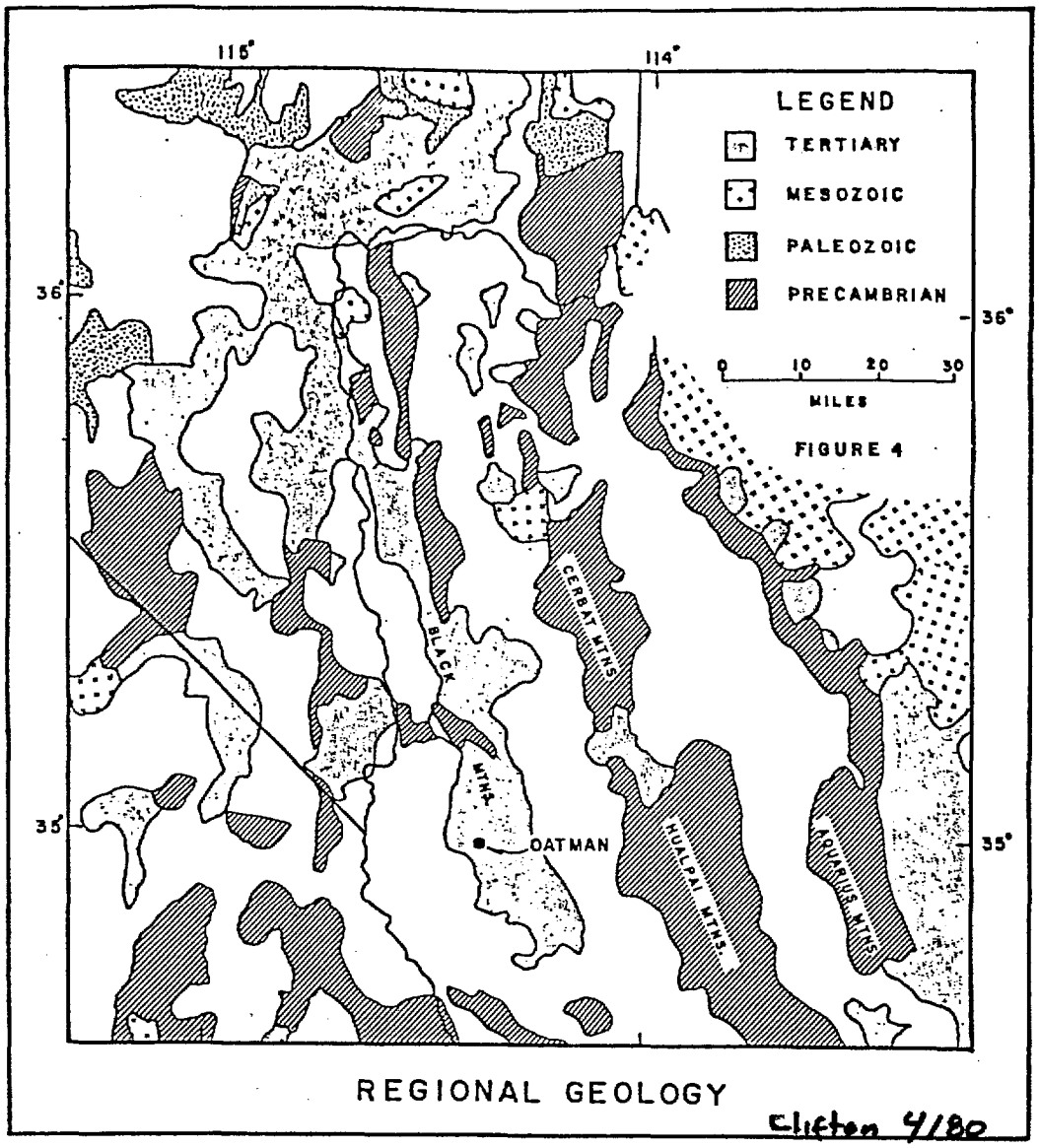
Table 2

SUMMARY OF OREBODY CHARACTERISTICS MINED FROM THE
TOM REED-UNITED EASTERN AND GOLD ROAD VEINS, OATMAN, ARIZONA

Orebody	Symbol Fig. 3 & 14	Tonnage	Grade O/T Au	Maximum Dimensions Length	Width	Height
United Eastern	(UE)	550,000	1.10	450	45	700
Tip Top	(TT)	250,000	±0.70	500	20	1300
Ben Harrison	(BH)	250,000	±0.70	650	20	750
Big Jim Aztec	(BJ) (A)	±500,000	±0.75	1950	35	800
Black Eagle	(B)	±200,000	±0.50	350	10	1000
United American	(UA)	±140,000	±0.50	300	10	1000
United Western	(UW)	40,000	0.30	990	6	300
Gold Road	(GR)	1,500,000	0.32	6,200	22	1300
Telluride	(T) *	20,000	1.0	200	2-3	200
Argo	(AR)	none				
Olla Oatman	(OO)	none				
Red Cloud	(RC)	none				
United Eastern #3	(UE3)	none				
Pasadena	(P)	none				

* Figures are estimates

Clifton 4/80



REGIONAL GEOLOGY

Clifton 4/80

Figure 2

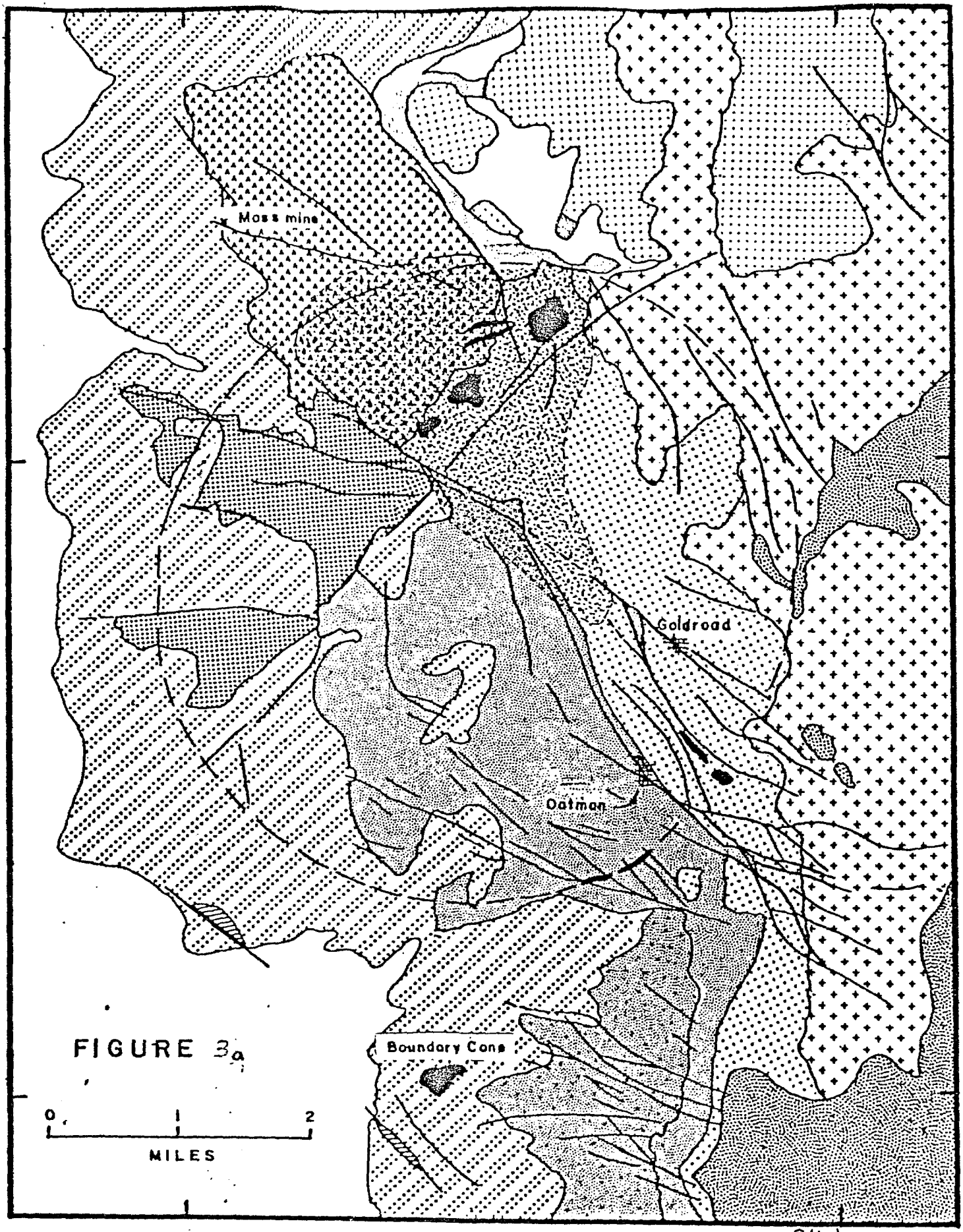


FIGURE 3a

Clifton 4/80

GEOLOGY AND STRUCTURE OF THE OATMAN DISTRICT

FIGURE 3b

LEGEND

VEIN

JOINTS OR LINEARS

PHYLLIC/ARGILLIC ALTERATION

QUAT.		ALLUVIUM	
MIDDLE AND UPPER MIOCENE		OLIVINE BASALT	
		RHYOLITE DIKES, PLUGS, FLOWS	
		MOSS PORPHYRY 10.4 ±.5 my	
		LATITE, RHYOLITE (undifferentiated) 19.7 ±.9 my	UPPER VOLCANICS
		GOLD ROAD LATITE 18.2 ±.9 my	MIDDLE VOLCANICS
		OATMAN LATITE	
		ESPERANZA TRACHYTE	
LOWER MIOCENE		TIMES PORPHYRY 22.6 my	LOWER VOLCANICS
EOCENE		ALCYONE FM.	
PRECAM.		GRANITE, GNEISS, SCHIST	

COMPILED FROM:

RANSOME (1923)

LAUSEN (1931)

THORSON (1971)

THIS REPORT

Clifton 4/80

thick sequence of tuffacous volcanic rocks which thin away from the Oatman district.

The structural pattern is dominated by a set of concentric fractures which define a near perfect 5 mile diameter circular feature identified from landstat imagery and high altitude aerial photography. Cutting the concentric feature is a separate set of fractures which radiate from a common point near the center of the circular feature. The major ore deposits of the central district are located within a wedge of radial fractures which cut the concentric fracture set 3 miles southeast of the center-point.

VI. LOCAL - GEOLOGY

The predominant features of this geology in the vecinity of the Tom Reed and Gold Road veins is a thick sequence of biotite free latite (Oatman latite), biotite rich latite (Gold Road latite) and intrusive biotite rhyolite plugs and dikes (Elephant tooth rhyolite). (Figure 4) Underlying the volcanics near the town of Oatman at a depth of about 2,000 feet is preCambrian Granite as identified in drill holes from the bottom of the United Eastern Mine.

The volcanic units are cut by a series of NW trending fault veins which dip primarily to the north and are the host for the majority of the gold mineralization at Oatman. Oblique slip movement on each of the major faults was probably a few hundred feet and is both pre and post-mineral. The emplacement of the rhyolite dikes was also controlled by pre-mineral NW fault trends and the rhyolites are probably closely related in age to the mineralization. Post-ore faults such as the Mallery and Oatman faults have had a significant impact, in that locally they displace major ore shoots.

Rock types exert a profound influence on the nature of mineralization in the veins. In the Gold Road latite, the mineralization is frequently in long, narrow fissure veins. (Figure 5) In the Oatman latite however, stockwork vein development occurs with quartz and calcite replacing the host Oatman latite over widths of up to 45'. Ore bodies in the Gold Road therefore, have a long strike length and limited vertical range while those in the Oatman exhibit a short strike length and a vertical range 1 to 4 times the strike.

VII. MINERALIZATION AND ALTERATION

The epithermal precious metal veins at Oatman are typical of those found throughout the world in the tertiary volcanic

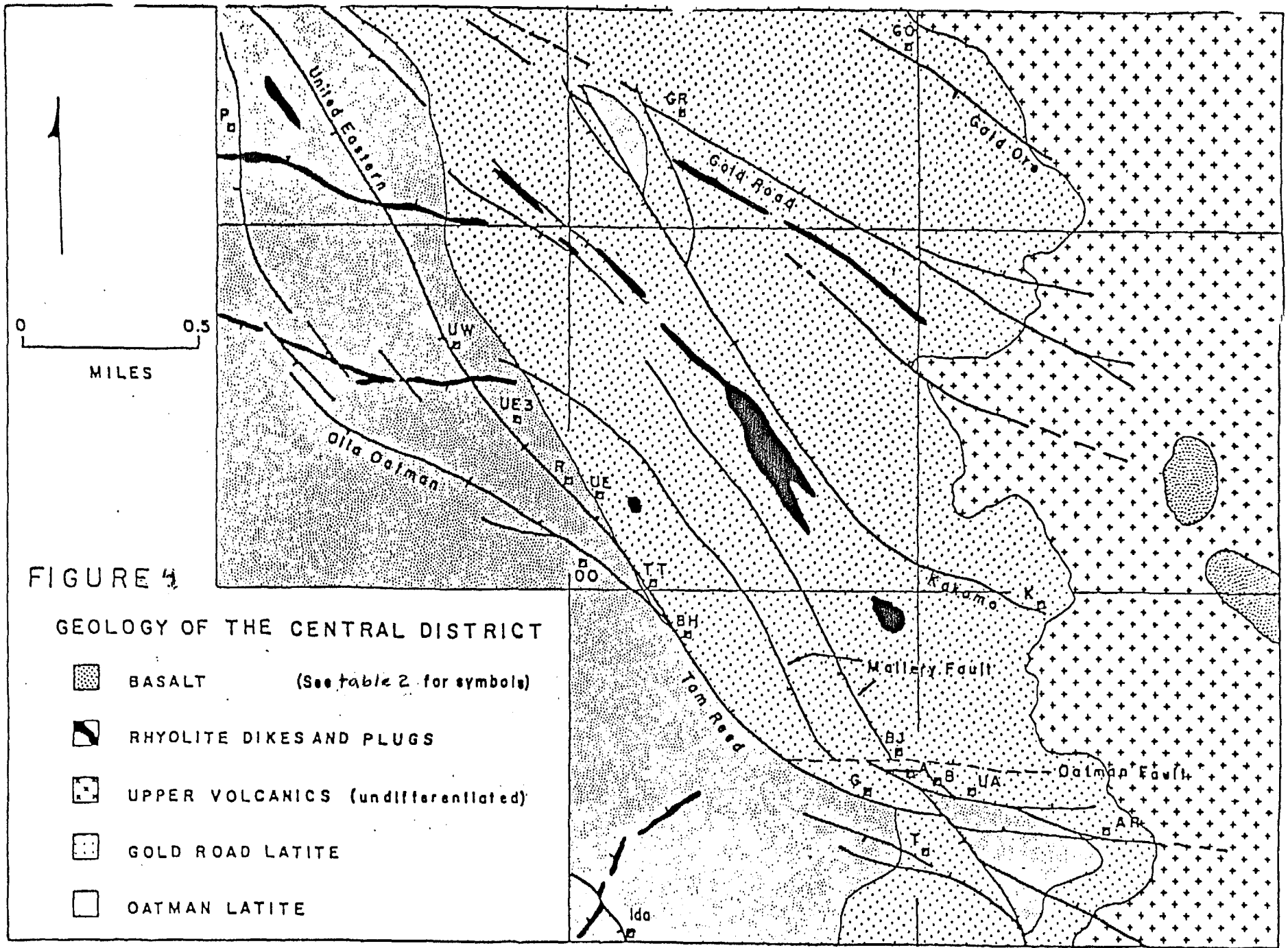


FIGURE 4

GEOLOGY OF THE CENTRAL DISTRICT

BASALT (See table 2 for symbols)

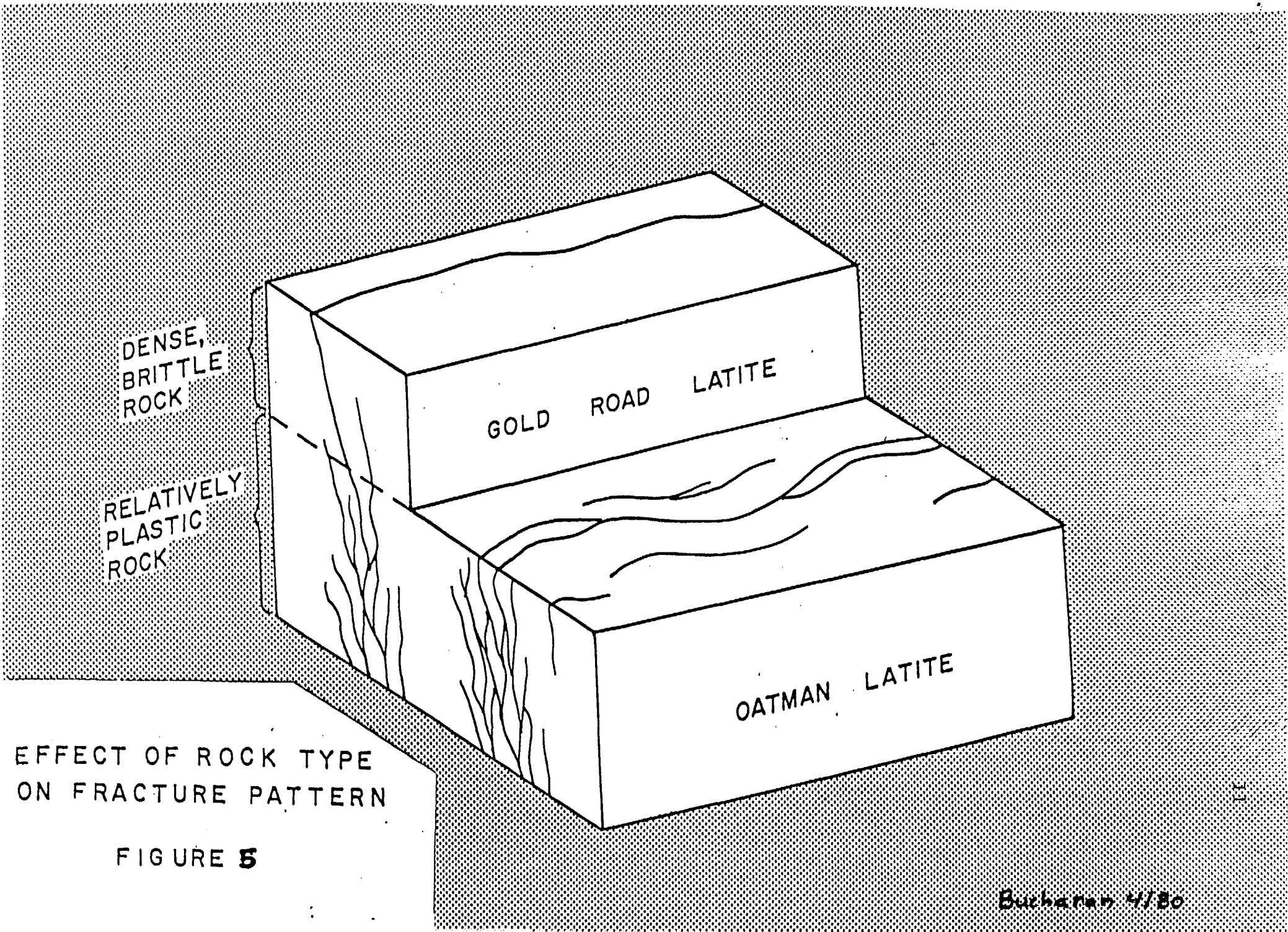
RHYOLITE DIKES AND PLUGS

UPPER VOLCANICS (undifferentiated)

GOLD ROAD LATITE

OATMAN LATITE

clifton 4/80



EFFECT OF ROCK TYPE ON FRACTURE PATTERN

FIGURE 5

environment. They are quartz-calcite adularia fissure fillings and/or replacement lodes which for the majority of their strike length are barren but which locally form shoots of ore grade mineralization. Mineralization at Oatman consists of free gold and electrum with <¼% sulfides. As with most epithermal districts neither vein material nor mineralization extended to the surface at the time of formation and it was only through the kindness of Nature that erosion exposed the tops of the Gold Road and Tip Top ore shoots. (Figure 6) The ore shoots at Oatman pinch vertically and laterally and decrease in grade and depth. Lausen identified 5 stages of quartz-calcite adularia vein formation and it is only in areas of multiple stage mineralization that significant high grade mineralized ore shoots were formed.

The Gold Road vein to the north is a fissure filling in Gold Road latite more or less continuously mineralized over its explored length of 6,200 feet. Ore shoots are centered at local irregularities along the strike of the vein. Ore grade mineralization cropped out at the surface and led to its early discovery. Enveloping the vein are local zones of phyllic alteration with minor silicification. High in the volcanic pile in exposures believed to be near the paleosurface at the time of formation the vein is expressed as a 2-5' wide zone of phyllic alteration with a 1" thick seam of calcedonic quartz. The Gold Road vein had a total production of about 1.5 x 10^6 T of ore grading 0.32 o/T Au.

The Tom Reed vein which lies about 1 mile south of the Gold Road vein has a much more subtle expression. Only above the Tip Top and Ben Harrison ore shoots was there significant quartz or silicification. Ore on the Tom Reed vein is entirely in Oatman latite and rather than forming a discrete fissure filling produced stockwork quartz-calcite adularia loads which locally exceeded 45' in width. Ore shoots were localized at flexures along the vein. Unlike the Gold Road vein most of the Tom Reed vein ore shoots had an extremely subtle surface expression and it was only through sinking shafts that buried ore shoots were discovered.

I'll use the surface expression over the great United Eastern ore shoot to illustrate how subtle the surface expression of these ore shoots can be.

The surface expression of the United Eastern ore shoot is a 200' wide zone of phyllic alteration of the Oatman latite which shows moderate chemical destruction of the andesite but no discoloration and no significant quartz or calcite veining. (Figure 7)

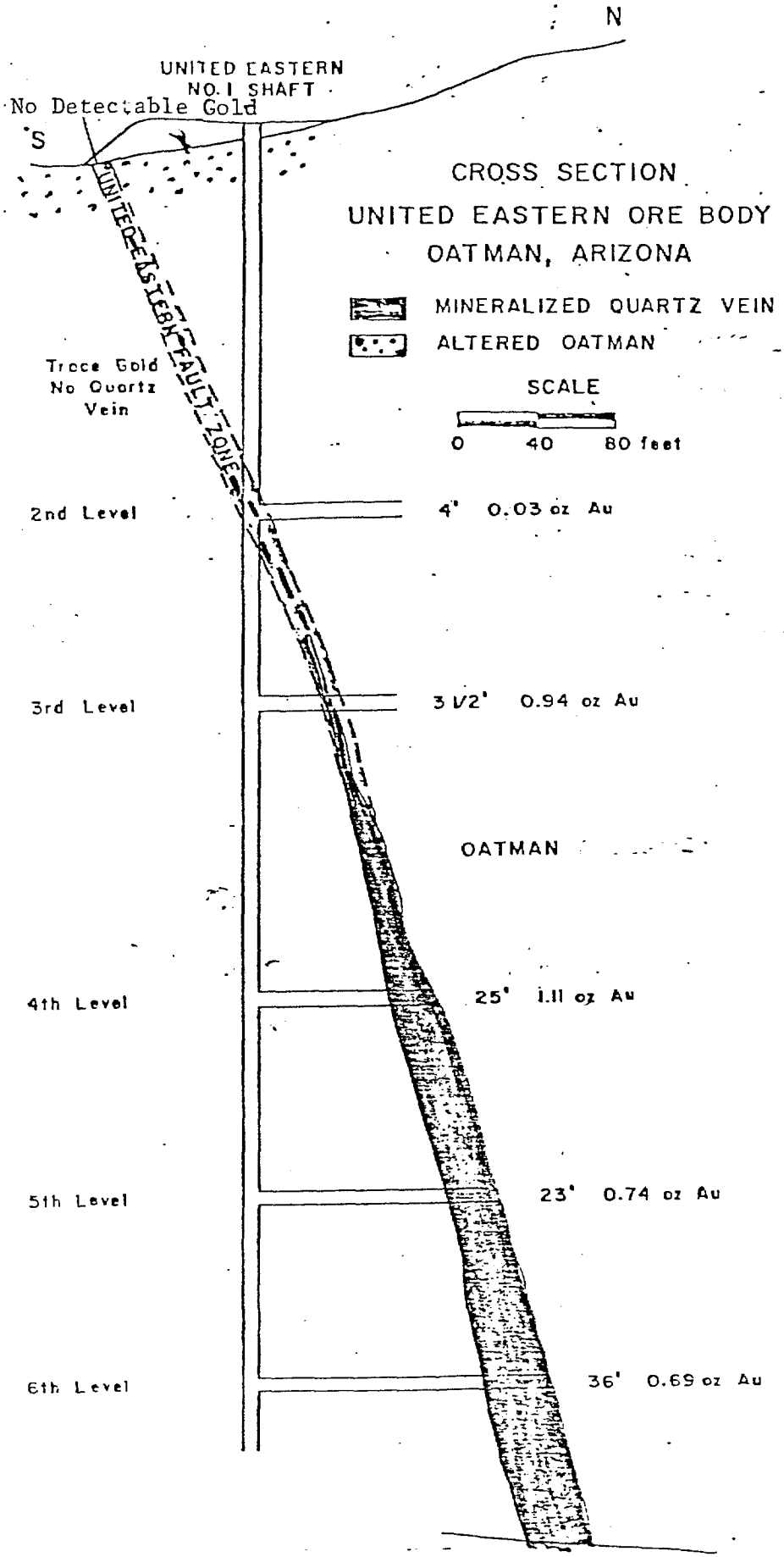

N
UNITED EASTERN
NO. I SHAFT
No Detectable Gold
S
UNITED EASTERN FAULT ZONE
CROSS SECTION
UNITED EASTERN ORE BODY
OATMAN, ARIZONA
MINERALIZED QUARTZ VEIN
ALTERED OATMAN
SCALE
0 40 80 feet
Trace Gold
No Quartz
Vein
2nd Level
4' 0.03 oz Au
3rd Level
3 1/2' 0.94 oz Au
OATMAN
4th Level
25' 1.11 oz Au
5th Level
23' 0.74 oz Au
6th Level
36' 0.69 oz Au

Figure 7

The Oatman latite has lost its original textural characteristics and appears to the casual observer to be nothing more than strongly weathered volcanics. A cross section through the United Eastern #1 or discovery shaft shows there is no vein material and no detectable gold at the surface. At 200 feet the shaft cut a 4' wide fault gouge zone containing 4' of 0.03 o/T Au; at 300 feet, 3½' of quartz and calcite returned 0.94 o/T Au and at 450' the vein showed 25' of vein material which graded 1.11 o/T Au. Total production from the United Eastern ore shoot was 550,000 T of 1.11 o/T Au!

It should be noted that in the work by Ransome and Lausen no specific structural control or alteration features were associated with the localization of the ore shoots at Oatman.

VIII. EXPLORATION TECHNIQUES

Fischer-Watt Mining entered the Oatman district believing that with detailed geology, specific structural controls and the high level expression of buried ore shoots could be identified. This information would then be utilized to evaluate the inadequately prospected areas along the major vein structures and areas covered by pre-ore cover, that is, areas where the only expression of a buried ore shoot might be a small area of alteration.

Four principal techniques were utilized at Oatman: detailed alteration mapping; vein contouring; rock chip vein geochemistry; and fluid inclusion analysis. The vein contouring and alteration mapping have largely been completed, however, the geochem and fluid inclusion studies are continuing.

A) Alteration Mapping and Vein Contouring

As mentioned earlier, alteration features at Oatman probably extended to the paleosurface at the time of ore formation and even though no gold mineralization overlies most of the ore shoots characteristic and identifiable alteration halos were found.

Mapping was initiated in the central part of the district to identify specific alteration features over the past productive ore shoots and then extend the mapping into lesser prospected areas. (Figure 5)

At Oatman, mapping of phyllic and/or argillic alteration proved most significant. However, on a broad scale propylitic alteration also enveloped the veins although often not directly ore associated. Mapping was done at 1"=100' which was necessary in order to map subtle alteration changes.

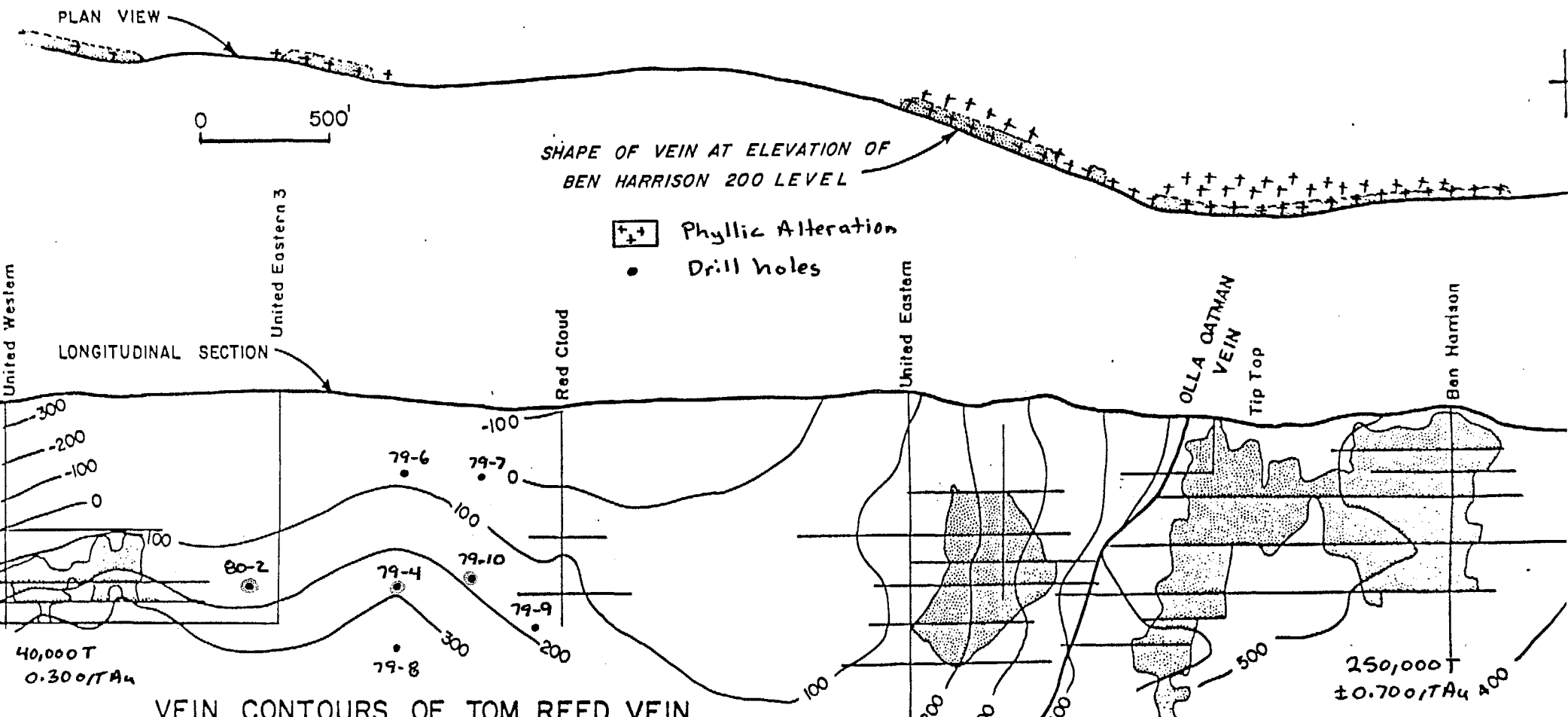
With field mapping it was nearly impossible to distinguish between phyllic and argillic alteration except for their differing distribution patterns. The phyllic alteration (illite and sericite as identified by X-Ray) tends to blossom beyond the specific cracks over the tops of ore shoots and may pervasively alter the wall rocks for up to 100' away from the vein. The argillic alteration is most frequently associated with post-mineral faulting and barren portions of pre-mineral faults, and has a definite footwall and hanging wall. Silicification or quartz or calcite veining is most frequently found within a few tens of feet from the top of ore.

Phyllic alteration is frequently expressed as small valleys less resistant to erosion than the surrounding rock. The rock is often light gray to locally white. Original textures may be totally to locally destroyed and in extreme cases some yellowing from oxidation of pyrite may be present.

For the most part the phyllic alteration over the tops of the oreshoots was so subtle that detailed mapping was absolutely necessary. As will be discussed later the distribution of phyllic alteration frequently corresponds with bends representing dialatant zones along the veins.

This detailed alteration mapping showed that every past productive ore shoot had a distinctive phyllic alteration envelope over it. (Figure 8a, 8b)

In addition to the alteration mapping, very careful attention was given to mapping slight changes in attitude of the vein. This involved not only plotting the information on the field sheets but also marking the position of each exposure on the ground then actually surveying its precise position and orientation so bends due to topographic effects could be removed. This survey data was then plotted on a map and the position of the surface and underground expression of the vein related to the distance from a hypothetical perfect plane. These distances were then contoured and showed irregularities in the vein in both a vertical and horizontal plan which might be related to ore. (Figure 8a, 8b) A horizontal slice through the long section of the Tom Reed vein showed pronounced to subtle concave north bends associated with every known ore shoot. Convex north bends related to pinch zones along the vein. The contouring also identified one inadequately explored area between the United Western and United Eastern ore shoots with a subtle concave north bend and weak phyllic alteration at the surface. This then became one of our principal targets. These subtle bends along an otherwise straight vein structure permitted development, during oblique slip fault



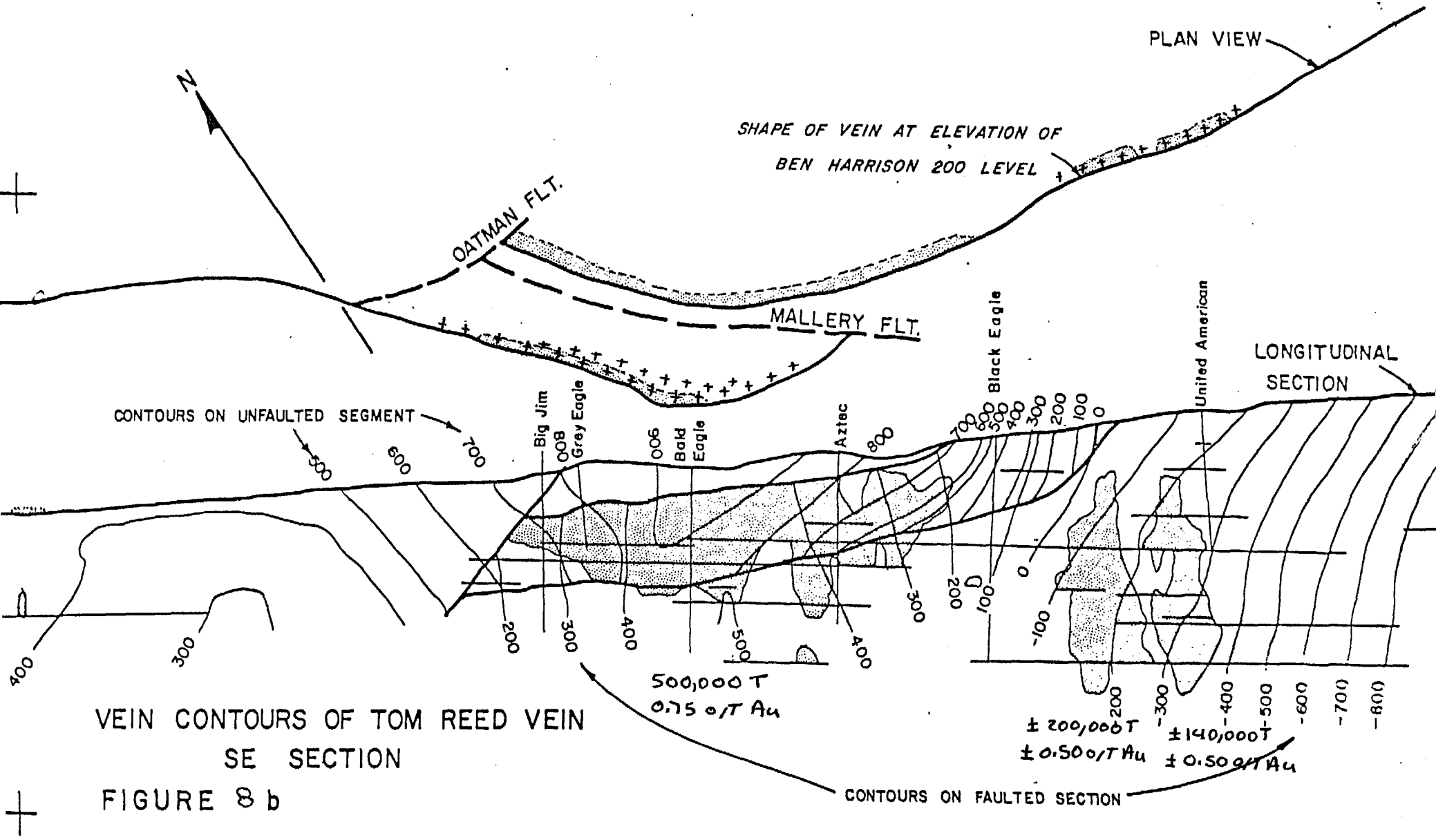
VEIN CONTOURS OF TOM REED VEIN
NW SECTION

FIGURE 8a

DH	Thickness	o/T Au
~~79-4~~	~~30 & 8~~	~~0.20 & 0.22~~
79-6	2	0.05
79-7	3	0.04
79-8	20	0.02
79-9	10	0.04
~~79-10~~	~~3.4~~	~~0.16~~
~~80-2~~	~~3 & 5~~	~~0.16 & 0.17~~

Fred Haynes calculates this as 200,000 T @ .2 Au

Modified after Clifton 4/80



VEIN CONTOURS OF TOM REED VEIN
SE SECTION

FIGURE 8 b

Modified after Clifton 4/80

movement, of dialatent zones or open areas which permitted ingress of ore forming fluids. Recurrent movement along these faults permitted up to 5 episodes of ore forming solutions.

Vein contouring on the Tom Reed vein was essential in establishing structural control for ore at Oatman and provided us with critical data needed to evaluate the structural favorability of less prospected veins.

The Kokomo vein which lies between the Tom Reed and Gold Road vein is a prime example. (Figure 9) Alteration mapping identified several alteration blossoms along the strike and vein contouring identified a major concave north bend in the area of best alteration which was comparable in magnitude to the beds associated with the Ben Harrison - Tip Top - United Eastern or Big Jim-Aztec ore shoots. The vein contouring was done strictly from surface measurements and then projected to a specified data plane. The magnitude of the bend and the intensity of the alteration identified the Kokomo as a major exploration opportunity not unlike the situation which resulted in the discovery of the Bulldog Mountain vein at Creede, Colorado.

I would like to now digress a bit and show some photos of the surface expression of the past-productive ore shoots as related to our observations regarding alteration and structure.

1) The unexplored area between the United Western and United Eastern shaft was drill tested by FWM and showed in our best intercept 30' T.T., 0.20 o/T Au, 500' below the surface. The surface outcrop showed a small area of very weak phyllic alteration, and gave no geochem anomaly.

2) The United Eastern ore shoot, 550,000 T, 1.11 o/T Au as discussed before shows gray phyllically altered Oatman latite 300' above ore.

3) The Tip Top ore shoot, 250,000 T, 0.70 o/T Au shows a massive quartz-calcite ridge with minor gold values at the surface ore is 70' below the outcrop.

4) Ben Harrison ore shoot, 300,000 T, 0.70 o/T Au shows a 10' wide silicified ledge with very minor gold values, 70' above ore.

5) The Gray Eagle-Bald Eagle area is the upper portion of the Big Jim-Aztec ore shoot which yielded 500,000 T, 0.75 o/T Au and shows a 50-100' wide zone of phyllic alteration with very minor quartz-calcite vein material and very minor gold values.

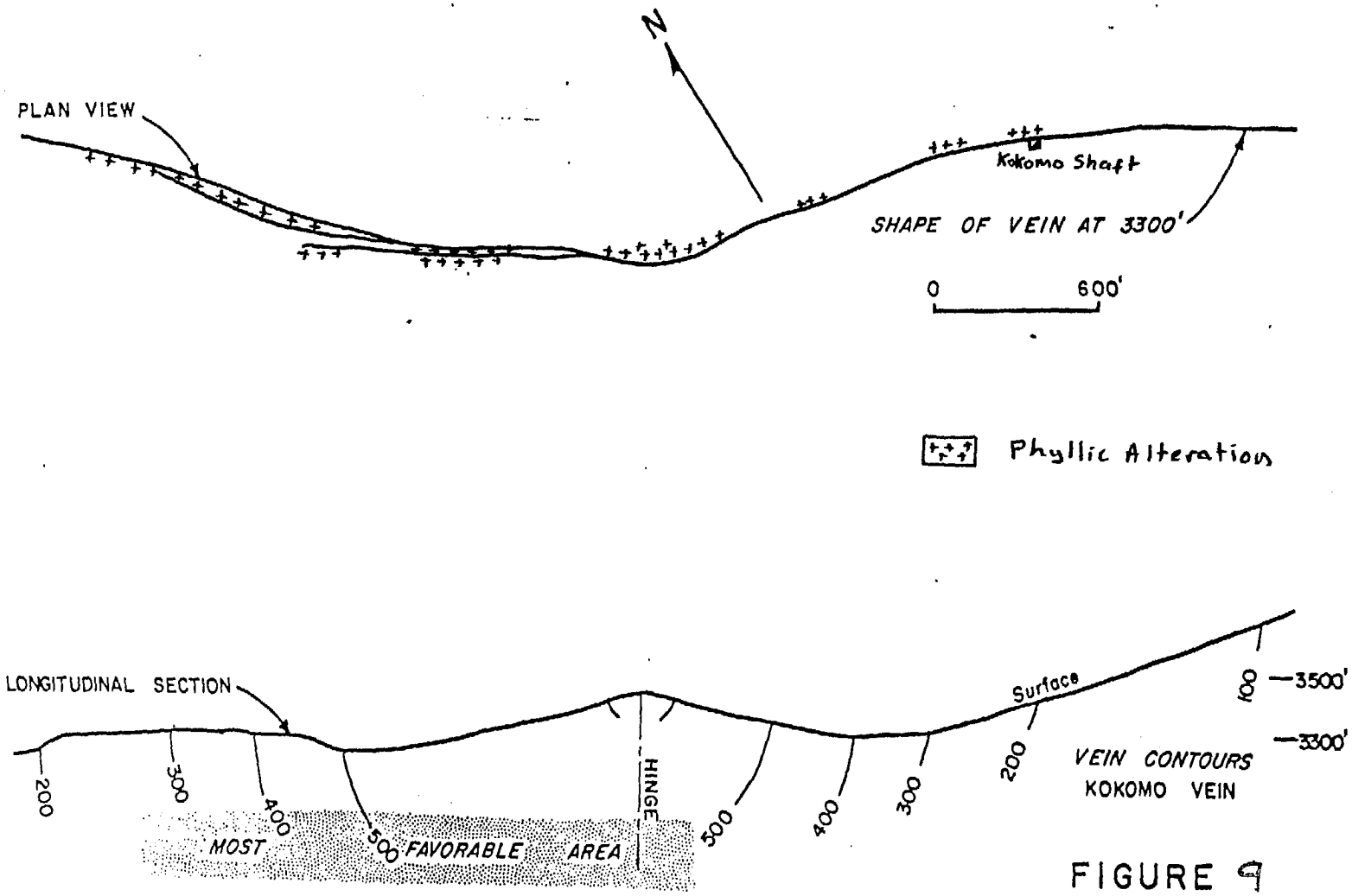


FIGURE 9

Modified after Clifton 4/80

6) The Black Eagle ore shoot, 200,000 T, 0.50 o/T Au shows a 10' wide zone of moderate to strong phyllic alteration and no quartz 300 feet above ore.

7) The United American ore shoot, 140,000 T, 0.50 o/T Au shows a 20' wide zone of phyllic alteration with minor quartz stringers 300' above ore.

8) The Kokomo vein one of our primary exploration targets, shows up to 100' of moderate to strong phyllic alteration.

The purpose of this suite of photos is to illustrate the subtle high level expression of buried epithermal ore shoots and to emphasize that without careful geological mapping and structural interpretation major buried ore shoots could easily be missed.

B) Fluid Inclusion Studies

A fluid inclusion study was initiated at Oatman in hopes of identifying specific hot spots where quartz or calcite vein material is exposed high above the ore shoots. We had also hoped to develop this tool as a reconnaissance techniqe to be used on virgin prospects by systematically sampling along the vein strike length in hopes of pinpointing local areas of boiling and with the temperature determinations and salinities, then predict the depth to the tops of potential buried ore shoots.

We have at Oatman a petrographic microscope and heating stage purchased from the University of Arizona. Our fluid inclusion results to date have shown that ore deposition occurred in the general temperature range of 220 to 240° and were of low salinities which is typical of epithermal vein systems. Boiling is locally present as identified by explosion textures from the top of the Tip Top ore shoot. To date the concept of utilizing fluid inclusions as a reconnaissance tool has not proven as useful as once anticipated. At Oatman, as in other less prospected areas, definitive fluid inclusion work is hindered for the following reasons:

1) High above the tops of ore shoots vein material is generally lacking.

2) If vein material is present it is often too fine grained for easy temperature and morphology determination and probably does not represent ore stage quartz.

3) Fluid inclusion determinations maybe extremely tedious and time consuming. From the fine grained quartz characteristic of the Oatman ores 3-5 fluid inclusion determinations are a good days production.

4) The thermal gradient which we had hoped to establish for quartz overlying ore shoots at Oatman has not materialized. So using fluid inclusion temperatures and salinities to predict the depth to tops of ore shoots at Oatman has not yet been perfected.

We still feel fluid inclusion determination will prove useful in reconnaissance and in target exploration, and we are continuing our research along these lines in hopes of a significant breakthrough.

C) Geochemistry

At Oatman we have found that gold and silver geochemistry have limited application for the following reasons:

1) Vein material is frequently absent over the tops of ore shoots and altered wall rocks give no anomalous gold or silver values.

2) Gold and silver anomalies are most frequently found at Oatman associated with quartz and calcite not accompanied by phyllic alteration. Drill tests of these anomalies have indicated we are probably looking at the low grade roots of eroded vein systems.

3) Trace element determinations for Cu, Mo, Pb, Zn, As, and Hg have given local anomalies which generally show no relationship to buried ore shoots. However, other elements may be useful.

4) If vein material associated with phyllic alteration is present gold and silver determinations are the best guide to ore. If no vein material is present assessment of ore potential is best based on structure and alteration.

IX. CONCLUSIONS

From our work at Oatman which to date has consisted of detailed mapping, structural interpretation, vein geochemistry, fluid inclusion studies, more than 25,000 feet of drilling and expenditures well in excess of $1. x 10^6, the following conclusions can be drawn.

A) With detailed geological and structural studies specific ore controls were established for gold mineralization at Oatman. It was necessary to utilize all available geological tools at our disposal in order to do this.

B) The surface expression of the buried ore shoots at Oatman is frequently no more than a zone of phyllic alteration with very poorly defined structure.

C) Fluid inclusion studies show much promise for aiding the explorationist in identifying the lateral and vertical position of buried ore shoots but much refining needs to be done with this tool.

D) Geochemistry may have limited application in the exploration of epithermal systems. Unless vein material comes through to the surface the veins are best evaluated by detailed geological mapping supported by geochemistry. The lack of geochemical anomalies should not in itself be discouraging.

E) Drilling vein targets is costly and in the case of gold, drilling results even after large expenditures may be inconclusive. At Oatman, we have drilled numerous holes which grade 0.10 o/T Au or better; a few of our holes have shown better than 0.5 o/T Au. We have not even with the extensive drilling completed to date been able to establish grade continuity between closely spaced holes.

F) Before one enters into an exploration program such as Oatman, they must realize that the ultimate proof of grade and tonnage will probably have to come through underground exploration. The decision to go underground will probably be based on little or no proven ore reserves. At Toyotita, Durango, Mexico, for example, drilling is done primarily to prove structure and not to establish grade. At Bulldog Mountain, Creede, Colorado, Bill Cox drilled 2 core holes but because of very bad drilling conditions and poor core recovery could confirm nothing more than the presence of a mineralized structure. Based on this data, a decision was made to explore the vein underground and resulted in the discovery of the Bulldog Mountain mine. At Oatman, our fate may be the same and if so, I hope our luck will be as good.

G) Luck accompanied by geological insight and utilizing of every tool at one's disposal plays a vital role in the exploration of high grade veins. It is much easier to drill a pinch, above or below an ore shoot than it is to hit the ore shoot. For example, Coastal Mining, at Seven Troughs, Nevada cut a couple of feet of 4. o/T Au in their first hole; their next 49 holes were disappointing and the project has been abandoned.

On the other hand, Lacana in their first drill hole at Guanajuato, Mexico, hit 35 feet of 17 oz. Ag and 0.20 o/T Au. Subsequent drilling outlined 3.6×10^6 T $\pm$ 9. o/T Ag and now provides the feed for the Las Torres mine and mill complex.

H) There are no sure bets in vein exploration. If the potential for significant targets exists, management must be willing to persist until all reasonable targets are tested.

I) If one is hoping for quick, definitive exploration results you will likely be disappointed.

J) And last but not least, we all dream of finding our pot of gold at the end of the rainbow. (Photo with end of rainbow on Tom Reed vein)

File Gold Deposit Description
1/84 ROAD

Fischer-Watt Mining Co. Inc.

ADMINISTRATIVE OFFICE: 114 TUCKER, SUITE 2
KINGMAN, ARIZONA 86401
PHONE: (602) 753-1622

GEOLOGY, ALTERATION AND MINERALIZATION

IN THE OATMAN MINING DISTRICT, MOHAVE COUNTY, ARIZONA

Text of Talk Presented by Perry Durning

to the Arizona Geological Society Meeting

August 5, 1980

xc: Library 8/31/82

CONTENTS

I.	Introduction and Acknowledgements	1
II.	Location	1
III.	History of Fischer-Watt Mining Involvement	1
IV.	History and Production	3
V.	Regional Geology and Structure	3
VI.	Local Geology	9
VII.	Mineralization and Alteration	9
VIII.	Exploration Techniques	15
	A) Alteration Mapping and Vein Contouring	15
	B) Fluid Inclusion Studies	21
	C) Geochemistry	22
IX.	Conclusions	22

ILLUSTRATIONS

Figures		Page
Figure 1	Location Map	2
Figure 2	Regional Geology	6
Figure 3a.	Geology and Structure of the	7
3b	Oatman District	8
Figure 4	Geology of the Central District	10
Figure 5	Effect of Rock Type on Fracture Pattern	11
Figure 6	Alteration in the Central District	13
Figure 7	Cross Section, United Eastern Orebody	14
Figure 8a,b	Vein Contours, Tom Reed Vein	17, 18
Figure 9	Vein Contours, Kokomo Vein	20
Tables		
Table 1	Individual Mine Production	4
Table 2	Summary of Orebody Characteristics	5

Fischer-Watt Mining Co. Inc.

ADMINISTRATIVE OFFICE: 114 TUCKER, SUITE 2
KINGMAN, ARIZONA 86401
PHONE: (602) 753-1622

I. INTRODUCTION AND ACKNOWLEDGEMENTS

I'd like to thank you for the opportunity to present some of the results of our work at Oatman and share with you some of our successes and disappointments.

I'd also like to thank Fischer-Watt Mining and Canadian Natural Resources for their continuing support of our exploration efforts, and acknowledge the contributions of Larry Buchanan, Gary Clifton, Fred Haynes, Don Muchow and Masters thesis students Bob Smith and Al Morris, all of whom have contributed to our geological understanding of Oatman.

III. LOCATION

The Oatman district is located about 30 miles southwest of Kingman and approximately 100 miles SSE of Las Vegas on old Highway 66. (Figure 1)

III. HISTORY OF FISCHER-WATT MINING INVOLVEMENT

Carl Fischer and Tim Watt as individuals became interested in the Oatman district in 1977. Initial work involved deepening the Ida Shaft on the Tom Reed Jr. Vein. In 1979, Fischer-Watt Mining was organized to evaluate the exploration potential for the entire Oatman district as well as identify other exploration and mine development opportunities throughout the western United States.

During April, 1979, critical land positions were negotiated and geological, geochemical and fluid inclusion studies were initiated.

Drilling was begun in September, 1979, and to date 35 drill holes varying 200 to 1,900 feet have been completed.

FW - 32,000' drilling (by Fischer-Watt and Canadian Natural Resources)
Hecla - pulled out Feb '83 after 11 holes. (see Pay Dirt Feb '83)

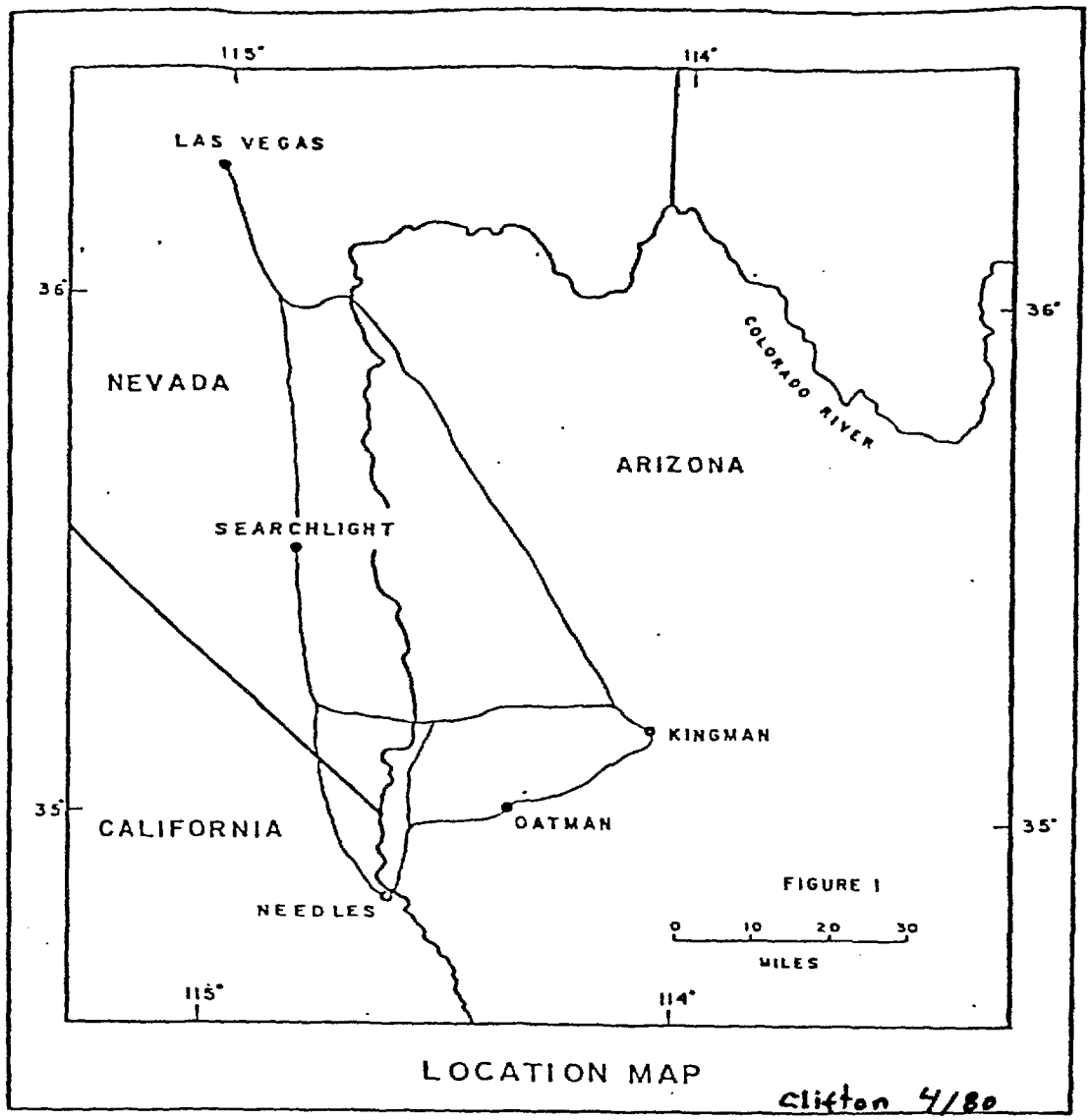

115°
114°
LAS VEGAS
36°
NEVADA
COLORADO RIVER
ARIZONA
SEARCHLIGHT
KINGMAN
35°
CALIFORNIA
OATMAN
FIGURE 1
NEEDLES
0 10 20 30
MILES
115°
114°
LOCATION MAP
Clifton 4/80

figure I

IV. HISTORY AND PRODUCTION

The original discovery at Oatman was made on the Moss vein in the western part of the district in 1863. However, mine development was discouraged by unfriendly Indians. Mining activities resumed in the 1880's but it was not until the discovery of the Gold Road Vein in 1900 that prospecting activities centered in the central part of the district. In 1901 gold was found on the Tom Reed vein but it was not until 1906 that rich ore in the Tip Top and Ben Harrison ore shoots was discovered. In 1915 and 1916 the Big Jim, Aztec and United Eastern ore bodies were discovered on the Tom Reed vein and the resultant boom swelled the population of Oatman and Gold Road to over 10,000 people. By the mid 1920's Oatman's population had dwindled and most of the mines had turned to leasor operations. Elevation of the gold price from $20. to $35./oz. in 1933 resulted in a revival of the Tom Reed and Gold Road Mining Company properties until they were closed by war board order L-208 in 1942.

The town of Oatman was named after Olive Oatman who was held captive by Indians for several years then found wandering in the desert by a rancher near the present town site.

Total production for the Oatman district between 1897 and 1942 was about 2.2×10^6 ounces Au and $.8 \times 10^6$ ounces Ag. The metal was derived from 3.8×10^6 T of ore with an average grade of 0.59 o/T Au, 0.20 o/T Ag. (Table 1) The majority of this production came from 8 major ore shoots on the Tom Reed and Gold Road vein. (Table 2) All other mines contributed about 10% of total district production.

V. REGIONAL GEOLOGY AND STRUCTURE

Geologic maps covering the Oatman District compiled by Ransome 1923, Lausen 1931, and Thorson 1971, provide excellent regional geologic coverage. Since the meat of my discussion will involve detailed description of the local vein geology I will deal only briefly with the regional geological environment.

The Oatman district lies within a thick sequence of 30 to 10 million year old Trachyatic, latitic and rhyolitic volacanic rocks on the southwestern flank of the Black Mountains. (Figure 2) The Oatman district may lie within a large circular caldron-like structure characterized by exceptionally thick sequences of Trachytes and latites and intruded along its margins by late stage epizonal quartz monzonite to rhyolitic stocks and plugs. (Figures 3a, 3b) The circular feature is also the margin for a

Table 1

INDIVIDUAL MINE PRODUCTION

OATMAN MINING DISTRICT, MOHAVE COUNTY, ARIZONA

Mine	Gold $20.67/oz 1897-1933 Tons of Ore	Mined Grade oz/T	Gold $35/oz 1934-1942 Tons of Ore	Mined Grade oz/T	Total Tons of Ore	Average Mined Grade oz/T
Tom Reed	981,090	0.70	205,125	0.32	1,186,215	0.64
United Eastern	687,038	1.12	0	0	687,038	1.12
Gold Road	737,926	0.47	775,895	0.22	1,513,823	0.32
Total Prod.	2,406,054	0.74	981,020	0.24	3,387,076	0.59
Other Mines				(est.)	400,000	0.60

Clifton Wilson

Table 2

SUMMARY OF OREBODY CHARACTERISTICS MINED FROM THE
TOM REED-UNITED EASTERN AND GOLD ROAD VEINS, OATMAN, ARIZONA

Orebody	Symbol Fig. 3 & 14	Tonnage	Grade O/T Au	Maximum Dimensions Length	Width	Height
United Eastern	(UE)	550,000	1.10	450	45	700
Tip Top	(TT)	250,000	±0.70	500	20	1300
Ben Harrison	(BH)	250,000	±0.70	650	20	750
Big Jim	(BJ)					
Aztec	(A)	±500,000	±0.75	1950	35	800
Black Eagle	(B)	±200,000	±0.50	350	10	1000
United American	(UA)	±140,000	±0.50	300	10	1000
United Western	(UW)	40,000	0.30	990	6	300
Gold Road	(GR)	1,500,000	0.32	6,200	22	1300
Telluride	(T) *	20,000	1.0	200	2-3	200
Argo	(AR)	none				
Olla Oatman	(OO)	none				
Red Cloud	(RC)	none				
United Eastern #3	(UE3)	none				
Pasadena	(P)	none				

* Figures are estimates

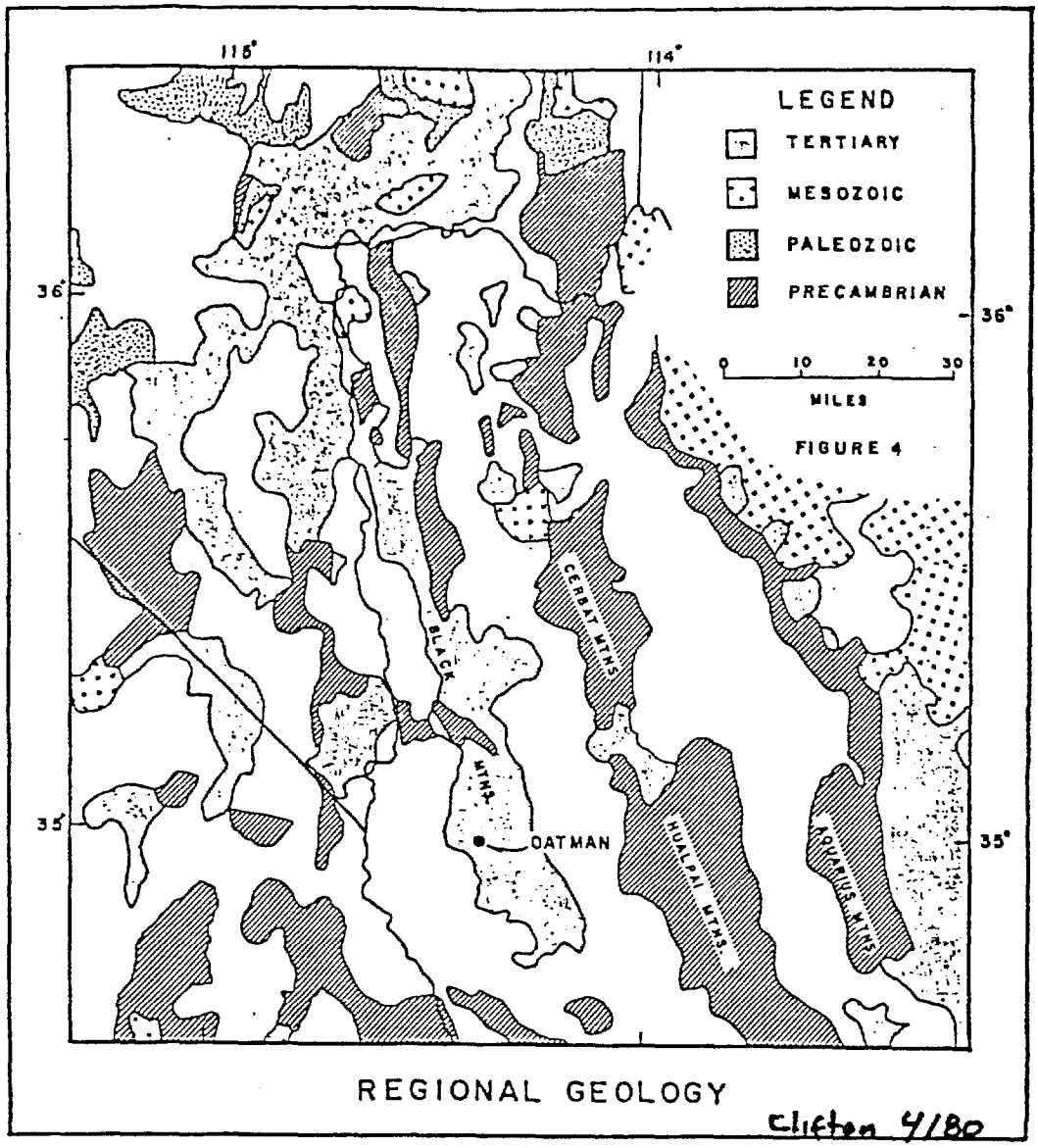
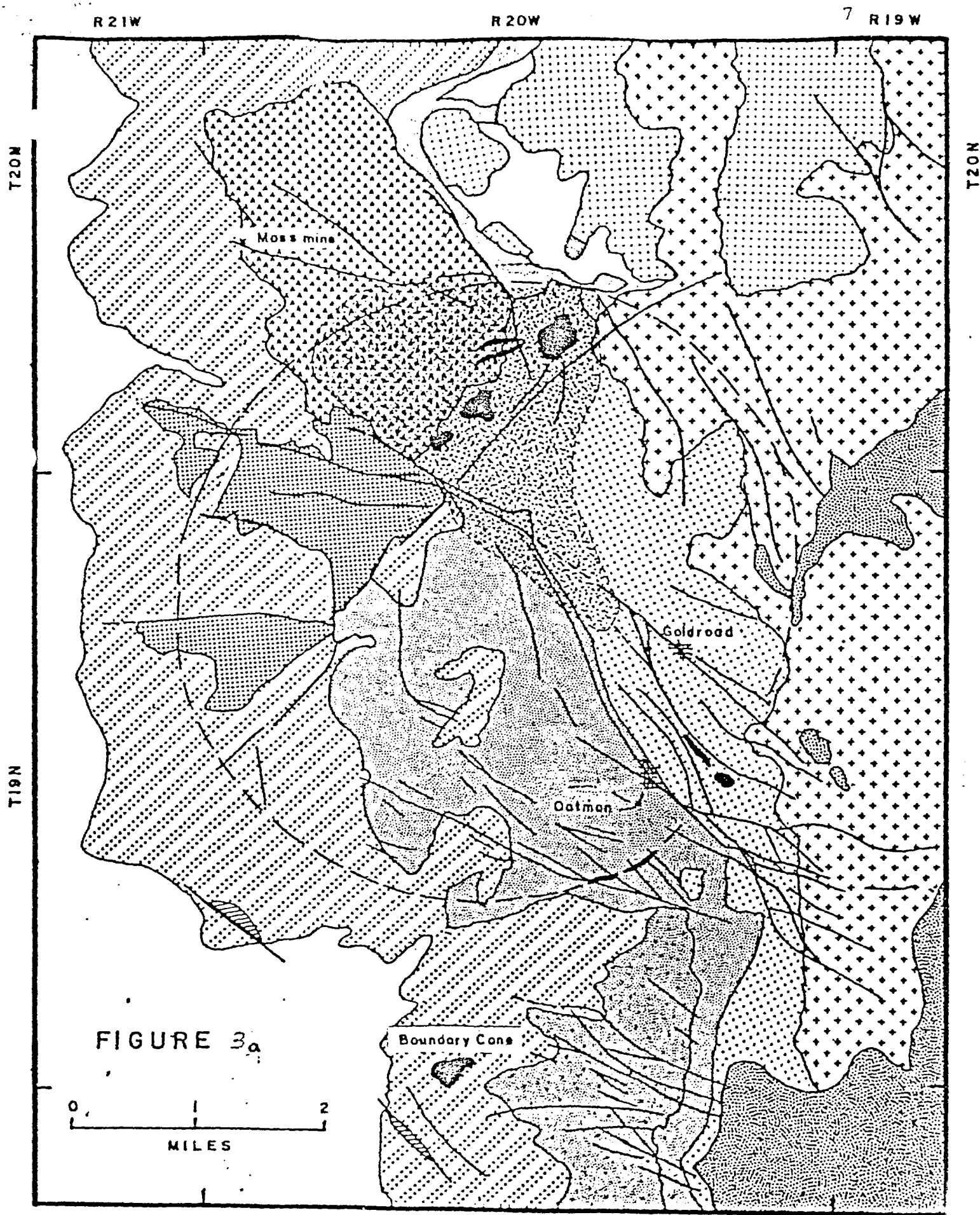

115°
114°
36°
35°
LEGEND
TERTIARY
MESOZOIC
PALEOZOIC
PRECAMBRIAN
0 10 20 30
MILES
FIGURE 4
BLACK MTNS.
CERBAT MTNS.
HUALPAI MTNS.
AQUARIUS MTNS.
OATMAN
REGIONAL GEOLOGY
Clifton 4/80

Figure 2



Clifton 4/80

GEOLOGY AND STRUCTURE OF THE OATMAN DISTRICT

FIGURE 3b

LEGEND

VEIN

JOINTS OR LINEARS

PHYLLIC/ARGILLIC ALTERATION

QUAT.		ALLUVIUM	
MIDDLE AND UPPER MIOCENE		OLIVINE BASALT	
		RHYOLITE DIKES, PLUGS, FLOWS	
		MOSS PORPHYRY 10.4 ±.5 my	
		LATITE, RHYOLITE (undifferentiated) 19.7 ±.9 my	UPPER VOLCANICS
		GOLD ROAD LATITE 18.2 ±.9 my	MIDDLE VOLCANICS
		OATMAN LATITE	
		ESPERANZA TRACHYTE	
LOWER MIOCENE		TIMES PORPHYRY 22.6 my	LOWER VOLCANICS
EOCENE		ALCYONE FM.	
PRECAM.		GRANITE, GNEISS, SCHIST	

COMPILED FROM:

RANSOME (1923)

LAUSEN (1931)

THORSON (1971)

THIS REPORT

Clifton 4/80

thick sequence of tuffacous volcanic rocks which thin away from the Oatman district.

The structural pattern is dominated by a set of concentric fractures which define a near perfect 5 mile diameter circular feature identified from landstat imagery and high altitude aerial photography. Cutting the concentric feature is a separate set of fractures which radiate from a common point near the center of the circular feature. The major ore deposits of the central district are located within a wedge of radial fractures which cut the concentric fracture set 3 miles southeast of the center-point.

VI. LOCAL - GEOLOGY

The predominant features of this geology in the vecinity of the Tom Reed and Gold Road veins is a thick sequence of biotite free latite (Oatman latite), biotite rich latite (Gold Road latite) and intrusive biotite rhyolite plugs and dikes (Elephant tooth rhyolite). (Figure 4) Underlying the volcanics near the town of Oatman at a depth of about 2,000 feet is preCambrian Granite as identified in drill holes from the bottom of the United Eastern Mine.

The volcanic units are cut by a series of NW trending fault veins which dip primarily to the north and are the host for the majority of the gold mineralization at Oatman. Oblique slip movement on each of the major faults was probably a few hundred feet and is both pre and post-mineral. The emplacement of the rhyolite dikes was also controlled by pre-mineral NW fault trends and the rhyolites are probably closely related in age to the mineralization. Post-ore faults such as the Mallery and Oatman faults have had a significant impact, in that locally they displace major ore shoots.

Rock types exert a profound influence on the nature of mineralization in the veins. In the Gold Road latite, the mineralization is frequently in long, narrow fissure veins. (Figure 5) In the Oatman latite however, stockwork vein development occurs with quartz and calcite replacing the host Oatman latite over widths of up to 45'. Ore bodies in the Gold Road therefore, have a long strike length and limited vertical range while those in the Oatman exhibit a short strike length and a vertical range 1 to 4 times the strike.

VII. MINERALIZATION AND ALTERATION

The epithermal precious metal veins at Oatman are typical of those found throughout the world in the tertiary volcanic

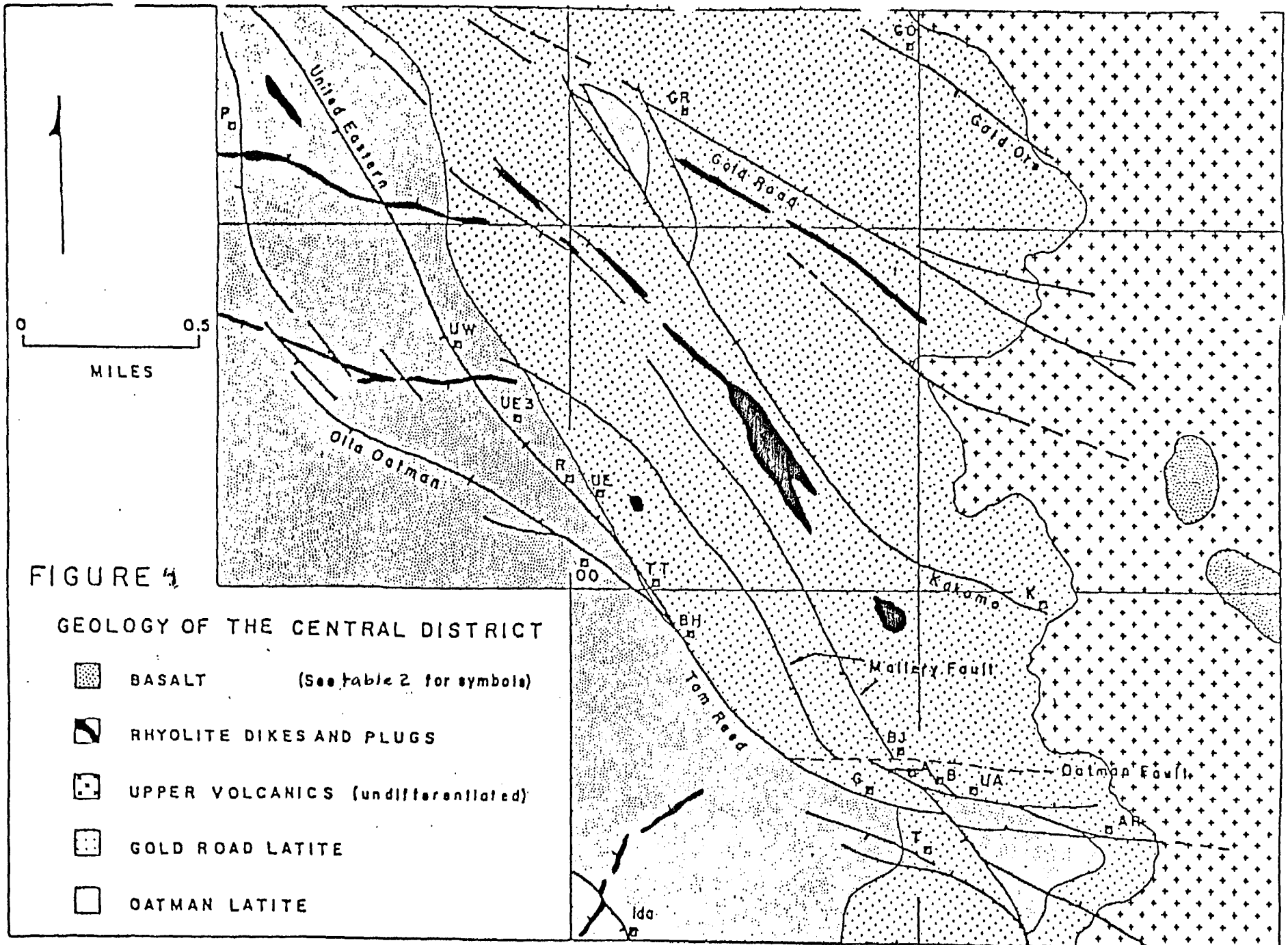
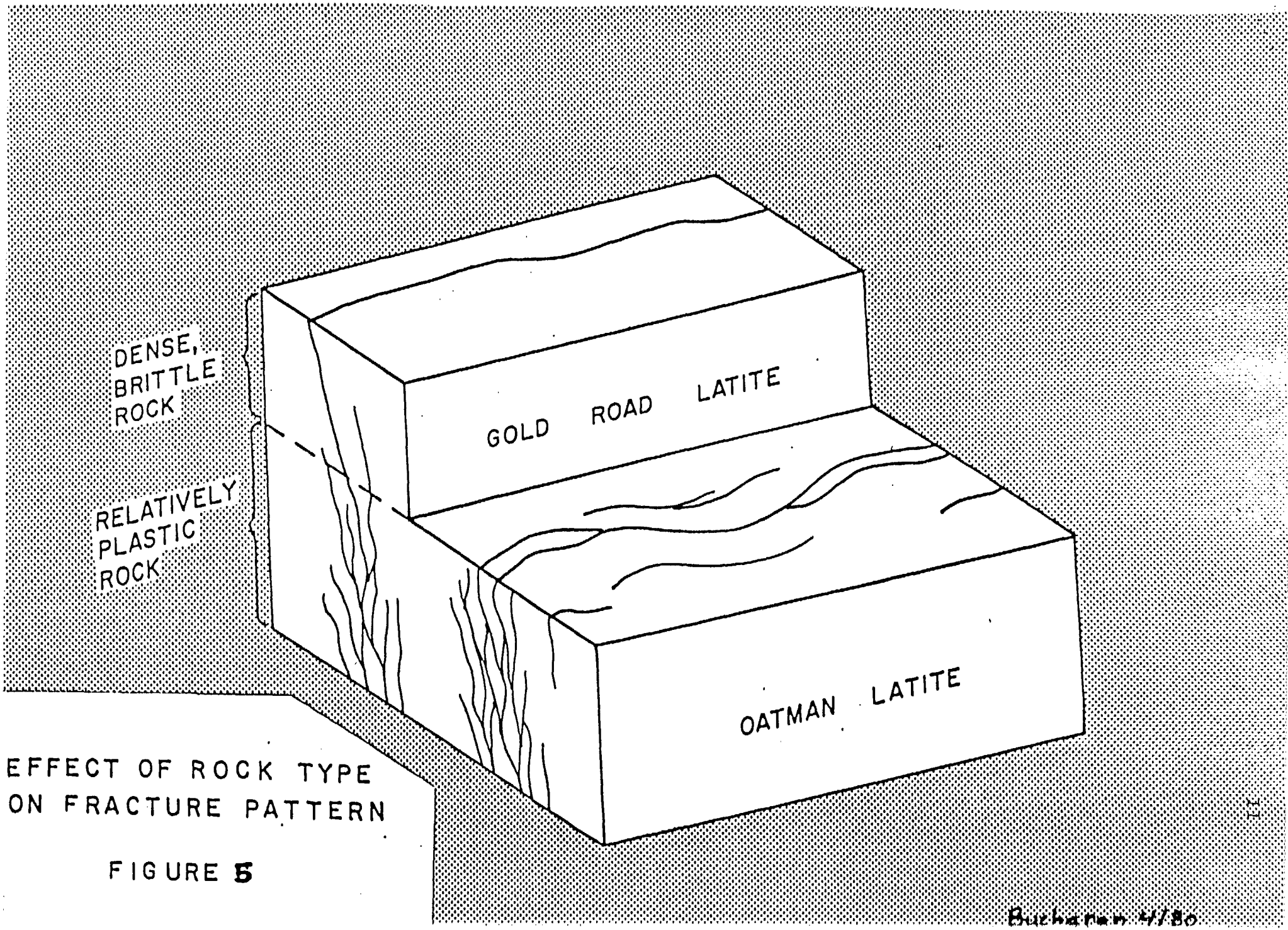


FIGURE 4

GEOLOGY OF THE CENTRAL DISTRICT

- BASALT (See table 2 for symbols)
- RHYOLITE DIKES AND PLUGS
- UPPER VOLCANICS (undifferentiated)
- GOLD ROAD LATITE
- OATMAN LATITE

Clifton 4/80



EFFECT OF ROCK TYPE ON FRACTURE PATTERN

FIGURE 5

environment. They are quartz-calcite adularia fissure fillings and/or replacement lodes which for the majority of their strike length are barren but which locally form shoots of ore grade mineralization. Mineralization at Oatman consists of free gold and electrum with <¼% sulfides. As with most epithermal districts neither vein material nor mineralization extended to the surface at the time of formation and it was only through the kindness of Nature that erosion exposed the tops of the Gold Road and Tip Top ore shoots. (Figure 6) The ore shoots at Oatman pinch vertically and laterally and decrease in grade and depth. Lausen identified 5 stages of quartz-calcite adularia vein formation and it is only in areas of multiple stage mineralization that significant high grade mineralized ore shoots were formed.

The Gold Road vein to the north is a fissure filling in Gold Road latite more or less continuously mineralized over its explored length of 6,200 feet. Ore shoots are centered at local irregularities along the strike of the vein. Ore grade mineralization cropped out at the surface and led to its early discovery. Enveloping the vein are local zones of phyllic alteration with minor silicification. High in the volcanic pile in exposures believed to be near the paleosurface at the time of formation the vein is expressed as a 2-5' wide zone of phyllic alteration with a 1" thick seam of calcedonic quartz. The Gold Road vein had a total production of about 1.5 x 10^6 T of ore grading 0.32 o/T Au.

The Tom Reed vein which lies about 1 mile south of the Gold Road vein has a much more subtle expression. Only above the Tip Top and Ben Harrison ore shoots was there significant quartz or silicification. Ore on the Tom Reed vein is entirely in Oatman latite and rather than forming a discrete fissure filling produced stockwork quartz-calcite adularia loads which locally exceeded 45' in width. Ore shoots were localized at flexures along the vein. Unlike the Gold Road vein most of the Tom Reed vein ore shoots had an extremely subtle surface expression and it was only through sinking shafts that buried ore shoots were discovered.

I'll use the surface expression over the great United Eastern ore shoot to illustrate how subtle the surface expression of these ore shoots can be.

The surface expression of the United Eastern ore shoot is a 200' wide zone of phyllic alteration of the Oatman latite which shows moderate chemical destruction of the andesite but no discoloration and no significant quartz or calcite veining. (Figure 7)

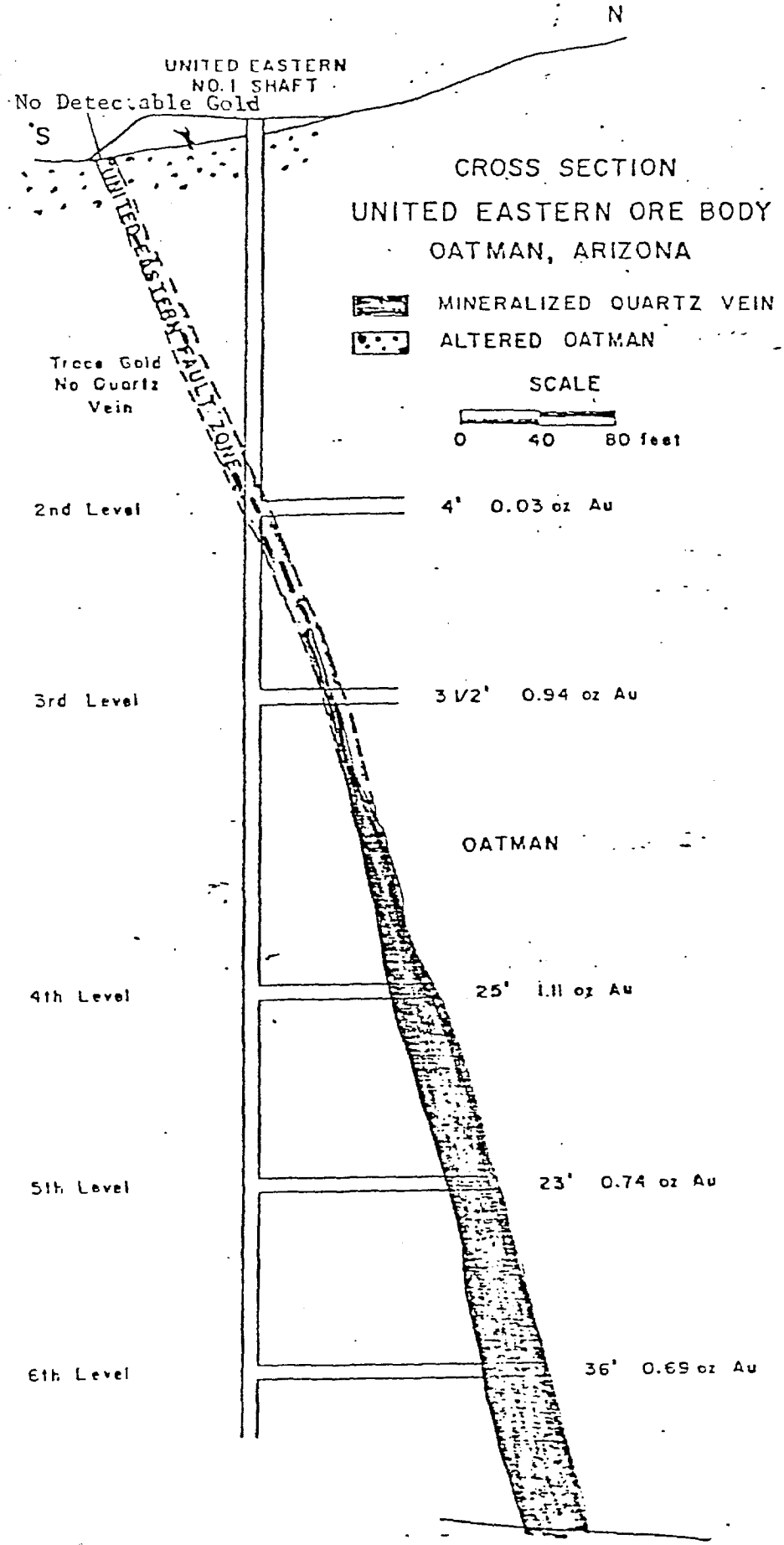

N
UNITED EASTERN
NO.1 SHAFT
No Detectable Gold
S
CROSS SECTION
UNITED EASTERN ORE BODY
OATMAN, ARIZONA
MINERALIZED QUARTZ VEIN
ALTERED OATMAN
SCALE
0 40 80 feet
UNITED EASTERN FAULT ZONE
Trace Gold
No Quartz
Vein
2nd Level
4' 0.03 oz Au
3rd Level
3 1/2' 0.94 oz Au
OATMAN
4th Level
25' 1.11 oz Au
5th Level
23' 0.74 oz Au
6th Level
36' 0.69 oz Au

Figure 7

The Oatman latite has lost its original textural characteristics and appears to the casual observer to be nothing more than strongly weathered volcanics. A cross section through the United Eastern #1 or discovery shaft shows there is no vein material and no detectable gold at the surface. At 200 feet the shaft cut a 4' wide fault gouge zone containing 4' of 0.03 o/T Au; at 300 feet, 3½' of quartz and calcite returned 0.94 o/T Au and at 450' the vein showed 25' of vein material which graded 1.11 o/T Au. Total production from the United Eastern ore shoot was 550,000 T of 1.11 o/T Au!

It should be noted that in the work by Ransome and Lausen no specific structural control or alteration features were associated with the localization of the ore shoots at Oatman.

VIII. EXPLORATION TECHNIQUES

Fischer-Watt Mining entered the Oatman district believing that with detailed geology, specific structural controls and the high level expression of buried ore shoots could be identified. This information would then be utilized to evaluate the inadequately prospected areas along the major vein structures and areas covered by pre-ore cover, that is, areas where the only expression of a buried ore shoot might be a small area of alteration.

Four principal techniques were utilized at Oatman: detailed alteration mapping; vein contouring; rock chip vein geochemistry; and fluid inclusion analysis. The vein contouring and alteration mapping have largely been completed, however, the geochem and fluid inclusion studies are continuing.

A) Alteration Mapping and Vein Contouring

As mentioned earlier, alteration features at Oatman probably extended to the paleosurface at the time of ore formation and even though no gold mineralization overlies most of the ore shoots characteristic and identifiable alteration halos were found.

Mapping was initiated in the central part of the district to identify specific alteration features over the past productive ore shoots and then extend the mapping into lesser prospected areas. (Figure 5)

At Oatman, mapping of phyllic and/or argillic alteration proved most significant. However, on a broad scale propylitic alteration also enveloped the veins although often not directly ore associated. Mapping was done at 1"=100' which was necessary in order to map subtle alteration changes.

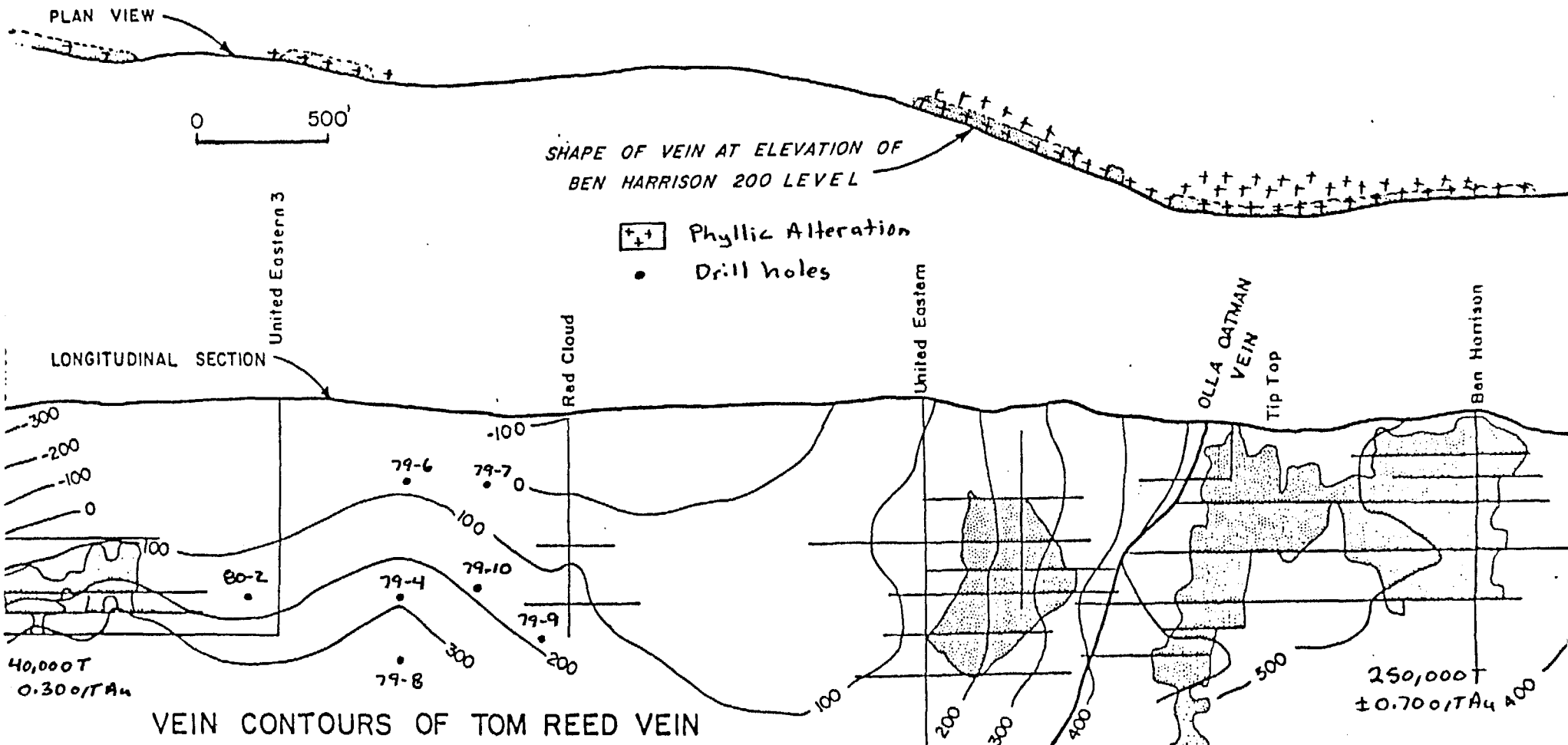
With field mapping it was nearly impossible to distinguish between phyllic and argillic alteration except for their differing distribution patterns. The phyllic alteration (illite and sericite as identified by X-Ray) tends to blossom beyond the specific cracks over the tops of ore shoots and may pervasively alter the wall rocks for up to 100' away from the vein. The argillic alteration is most frequently associated with post-mineral faulting and barren portions of pre-mineral faults, and has a definite footwall and hanging wall. Silicification or quartz or calcite veining is most frequently found within a few tens of feet from the top of ore.

Phyllic alteration is frequently expressed as small valleys less resistant to erosion than the surrounding rock. The rock is often light gray to locally white. Original textures may be totally to locally destroyed and in extreme cases some yellowing from oxidation of pyrite may be present.

For the most part the phyllic alteration over the tops of the oreshoots was so subtle that detailed mapping was absolutely necessary. As will be discussed later the distribution of phyllic alteration frequently corresponds with bends representing dialatant zones along the veins.

This detailed alteration mapping showed that every past productive ore shoot had a distinctive phyllic alteration envelope over it. (Figure 8a, 8b)

In addition to the alteration mapping, very careful attention was given to mapping slight changes in altitude of the vein. This involved not only plotting the information on the field sheets but also marking the position of each exposure on the ground then actually surveying its precise position and orientation so bends due to topographic effects could be removed. This survey data was then plotted on a map and the position of the surface and underground expression of the vein related to the distance from a hypothetical perfect plane. These distances were then contoured and showed irregularities in the vein in both a vertical and horizontal plan which might be related to ore. (Figure 8a, 8b) A horizontal slice through the long section of the Tom Reed vein showed pronounced to subtle concave north bends associated with every known ore shoot. Convex north bends related to pinch zones along the vein. The contouring also identified one inadequately explored area between the United Western and United Eastern ore shoots with a subtle concave north bend and weak phyllic alteration at the surface. This then became one of our principal targets. These subtle bends along an otherwise straight vein structure permitted development, during oblique slip fault

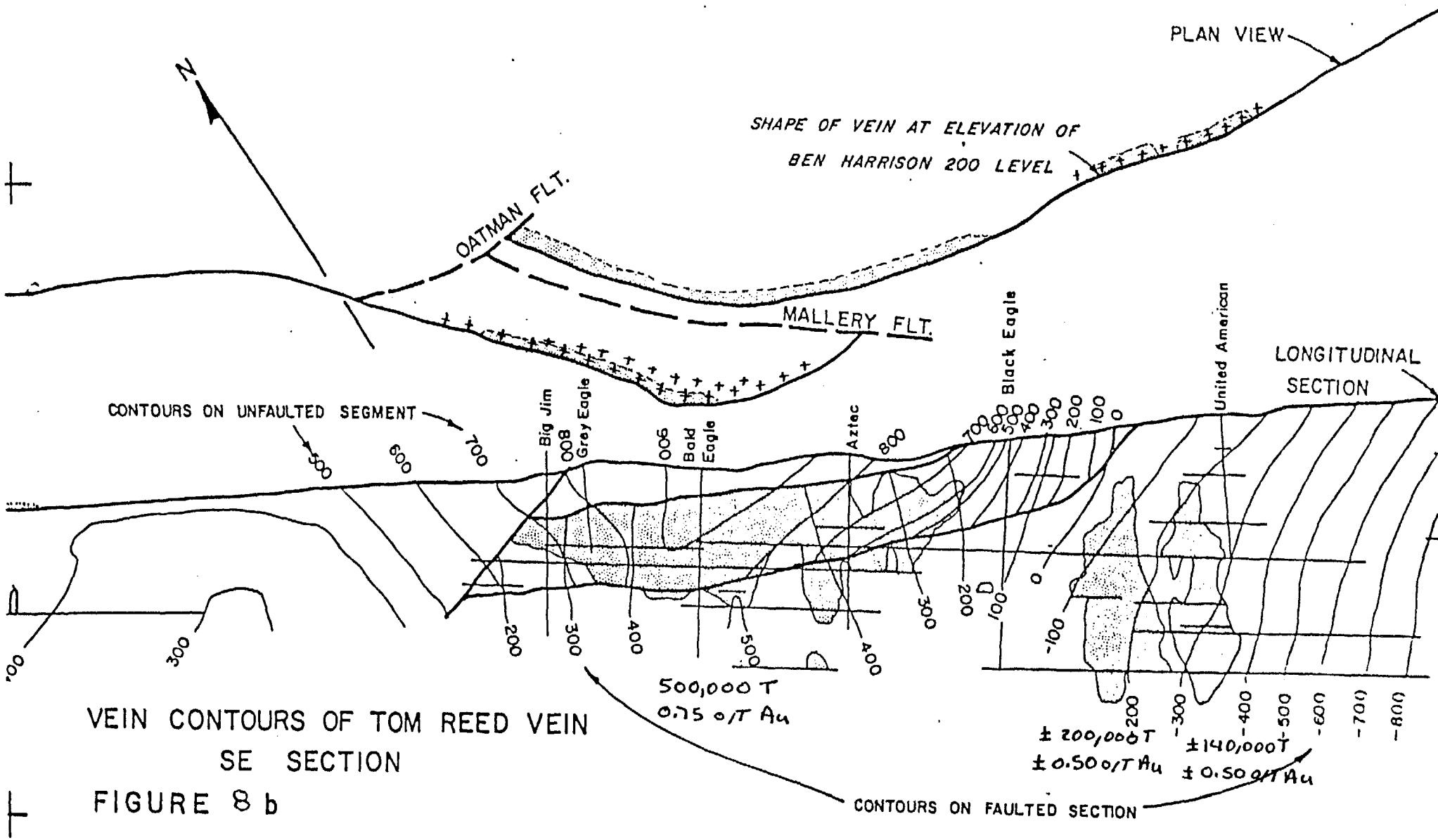


VEIN CONTOURS OF TOM REED VEIN
NW SECTION

FIGURE 8a

DH	Thickness	o/T Au
79-4	30 & 8	0.20 & 0.22
79-6	2	0.05
79-7	3	0.04
79-8	20	0.02
79-9	10	0.04
79-10	3.4	0.16

Fred Hayes calculates THIS AS 200,000 T



VEIN CONTOURS OF TOM REED VEIN
SE SECTION

FIGURE 8 b

modified after Clifton 4/80

movement, of dialatent zones or open areas which permitted ingress of ore forming fluids. Recurrent movement along these faults permitted up to 5 episodes of ore forming solutions.

Vein contouring on the Tom Reed vein was essential in establishing structural control for ore at Oatman and provided us with critical data needed to evaluate the structural favorability of less prospected veins.

The Kokomo vein which lies between the Tom Reed and Gold Road vein is a prime example. (Figure 9) Alteration mapping identified several alteration blossoms along the strike and vein contouring identified a major concave north bend in the area of best alteration which was comparable in magnitude to the beds associated with the Ben Harrison - Tip Top - United Eastern or Big Jim-Aztec ore shoots. The vein contouring was done strictly from surface measurements and then projected to a specified data plane. The magnitude of the bend and the intensity of the alteration identified the Kokomo as a major exploration opportunity not unlike the situation which resulted in the discovery of the Bulldog Mountain vein at Creede, Colorado.

I would like to now digress a bit and show some photos of the surface expression of the past-productive ore shoots as related to our observations regarding alteration and structure.

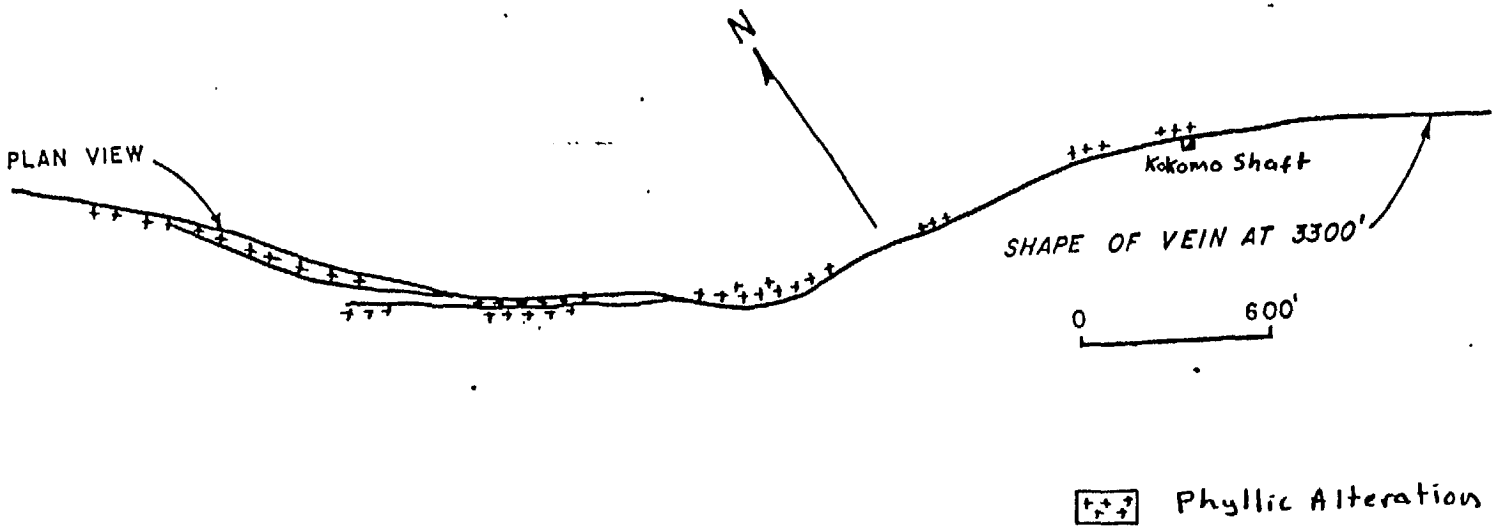
1) The unexplored area between the United Western and United Eastern shaft was drill tested by FWM and showed in our best intercept 30' T.T., 0.20 o/T Au, 500' below the surface. The surface outcrop showed a small area of very weak phyllic alteration, and gave no geochem anomaly.

2) The United Eastern ore shoot, 550,000 T, 1.11 o/T Au as discussed before shows gray phyllically altered Oatman latite 300' above ore.

3) The Tip Top ore shoot, 250,000 T, 0.70 o/T Au shows a massive quartz-calcite ridge with minor gold values at the surface ore is 70' below the outcrop.

4) Ben Harrison ore shoot, 300,000 T, 0.70 o/T Au shows a 10' wide silicified ledge with very minor gold values, 70' above ore.

5) The Gray Eagle-Bald Eagle area is the upper portion of the Big Jim-Aztec ore shoot which yielded 500,000 T, 0.75 o/T Au and shows a 50-100' wide zone of phyllic alteration with very minor quartz-calcite vein material and very minor gold values.



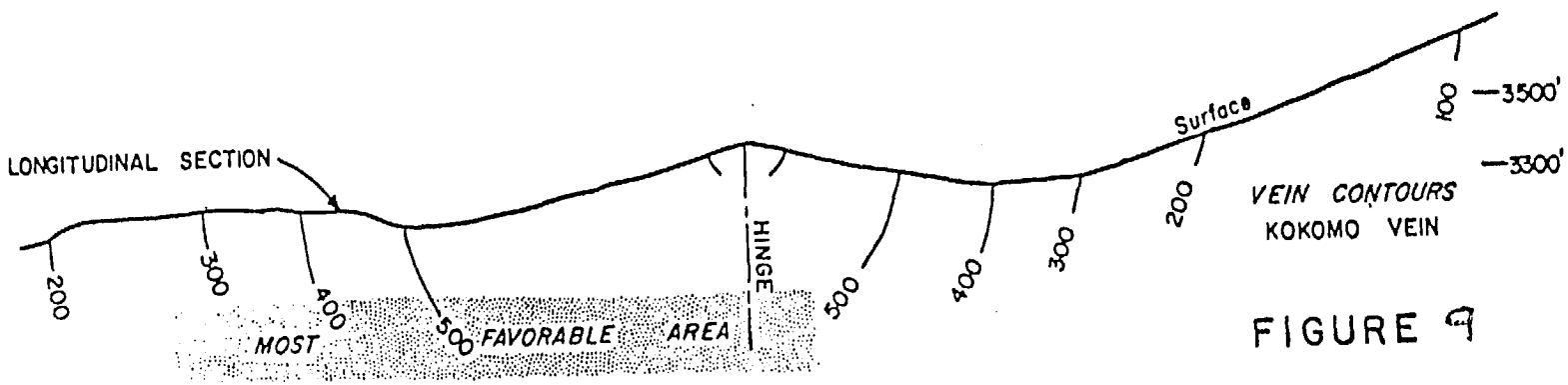


FIGURE 9

Modified after Clifton 4/80

6) The Black Eagle ore shoot, 200,000 T, 0.50 o/T Au shows a 10' wide zone of moderate to strong phyllic alteration and no quartz 300 feet above ore.

7) The United American ore shoot, 140,000 T, 0.50 o/T Au shows a 20' wide zone of phyllic alteration with minor quartz stringers 300' above ore.

8) The Kokomo vein one of our primary exploration targets, shows up to 100' of moderate to strong phyllic alteration.

The purpose of this suite of photos is to illustrate the subtle high level expression of buried epithermal ore shoots and to emphasize that without careful geological mapping and structural interpretation major buried ore shoots could easily be missed.

B) Fluid Inclusion Studies

A fluid inclusion study was initiated at Oatman in hopes of identifying specific hot spots where quartz or calcite vein material is exposed high above the ore shoots. We had also hoped to develop this tool as a reconnaissance techniqe to be used on virgin prospects by systematically sampling along the vein strike length in hopes of pinpointing local areas of boiling and with the temperature determinations and salinities, then predict the depth to the tops of potential buried ore shoots.

We have at Oatman a petrographic microscope and heating stage purchased from the University of Arizona. Our fluid inclusion results to date have shown that ore deposition occurred in the general temperature range of 220 to 240° and were of low salinities which is typical of epithermal vein systems. Boiling is locally present as identified by explosion textures from the top of the Tip Top ore shoot. To date the concept of utilizing fluid inclusions as a reconnaissance tool has not proven as useful as once anticipated. At Oatman, as in other less prospected areas, definitive fluid inclusion work is hindered for the following reasons:

1) High above the tops of ore shoots vein material is generally lacking.

2) If vein material is present it is often too fine grained for easy temperature and morphology determination and probably does not represent ore stage quartz.

3) Fluid inclusion determinations maybe extremely tedious and time consuming. From the fine grained quartz characteristic of the Oatman ores 3-5 fluid inclusion determinations are a good days production.

C) Fluid inclusion studies show much promise for aiding the explorationist in identifying the lateral and vertical position of buried ore shoots but much refining needs to be done with this tool.

D) Geochemistry may have limited application in the exploration of epithermal systems. Unless vein material comes through to the surface the veins are best evaluated by detailed geological mapping supported by geochemistry. The lack of geochemical anomalies should not in itself be discouraging.

E) Drilling vein targets is costly and in the case of gold, drilling results even after large expenditures may be inconclusive. At Oatman, we have drilled numerous holes which grade 0.10 o/T Au or better; a few of our holes have shown better than 0.5 o/T Au. We have not even with the extensive drilling completed to date been able to establish grade continuity between closely spaced holes.

F) Before one enters into an exploration program such as Oatman, they must realize that the ultimate proof of grade and tonnage will probably have to come through underground exploration. The decision to go underground will probably be based on little or no proven ore reserves. At Toyotita, Durango, Mexico, for example, drilling is done primarily to prove structure and not to establish grade. At Bulldog Mountain, Creede, Colorado, Bill Cox drilled 2 core holes but because of very bad drilling conditions and poor core recovery could confirm nothing more than the presence of a mineralized structure. Based on this data, a decision was made to explore the vein underground and resulted in the discovery of the Bulldog Mountain mine. At Oatman, our fate may be the same and if so, I hope our luck will be as good.

G) Luck accompanied by geological insight and utilizing of every tool at one's disposal plays a vital role in the exploration of high grade veins. It is much easier to drill a pinch, above or below an ore shoot than it is to hit the ore shoot. For example, Coastal Mining, at Seven Troughs, Nevada cut a couple of feet of 4. o/T Au in their first hole; their next 49 holes were disappointing and the project has been abandoned.

On the other hand, Lacana in their first drill hole at Guanajuato, Mexico, hit 35 feet of 17 oz. Ag and 0.20 o/T Au. Subsequent drilling outlined 3.6×10^6 T $\pm$ 9. o/T Ag and now provides the feed for the Las Torres mine and mill complex.

H) There are no sure bets in vein exploration. If the potential for significant targets exists, management must be willing to persist until all reasonable targets are tested.

I) If one is hoping for quick, definitive exploration results you will likely be disappointed.

J) And last but not least, we all dream of finding our pot of gold at the end of the rainbow. (Photo with end of rainbow on Tom Reed vein)

SOCIETY OF MINING ENGINEERS OF AIME

CALLER NO. D, LITTLETON, COLORADO 80123

PREPRINT NUMBER

80-143

UNK copy

UNK file Gold Deposit Description

EXPLORATION PROCEDURE AND CONTROLS OF MINERALIZATION IN THE OATMAN MINING DISTRICT, OATMAN, ARIZONA

J. D. Gill

C. G. Clifton

L. J. Buchanan

W. P. Durning

Fischer-Watt Mining Co., Inc.
Oatman, Arizona

For presentation at the AIME Annual Meeting
Las Vegas, Nevada - February 24-28, 1980

Permission is hereby given to publish with appropriate acknowledgments, excerpts or summaries not to exceed one-fourth of the entire text of the paper. Permission to print in more extended form subsequent to publication by the Institute must be obtained from the Executive Secretary of the Society of Mining Engineers of AIME.

If and when this paper is published by the Society of Mining Engineers of AIME, it may embody certain changes made by agreement between the Technical Publications Committee and the author, so that the form in which it appears here is not necessarily that in which it may be published later. SZ

These preprints are available for sale. Mail orders to PREPRINTS, Society of Mining Engineers, Caller No. D, Littleton, Colorado 80123.

PREPRINT AVAILABILITY LIST IS PUBLISHED PERIODICALLY IN MINING ENGINEERING

Abstract

The Oatman District produced approximately 2.2×10^6 ounces of gold and 0.8×10^6 ounces of silver between 1897 and 1942. A total of 3.8×10^6 tons of ore averaging 0.58 O/T gold and 0.17 O/T silver was extracted from eight major orebodies and a number of lesser deposits.

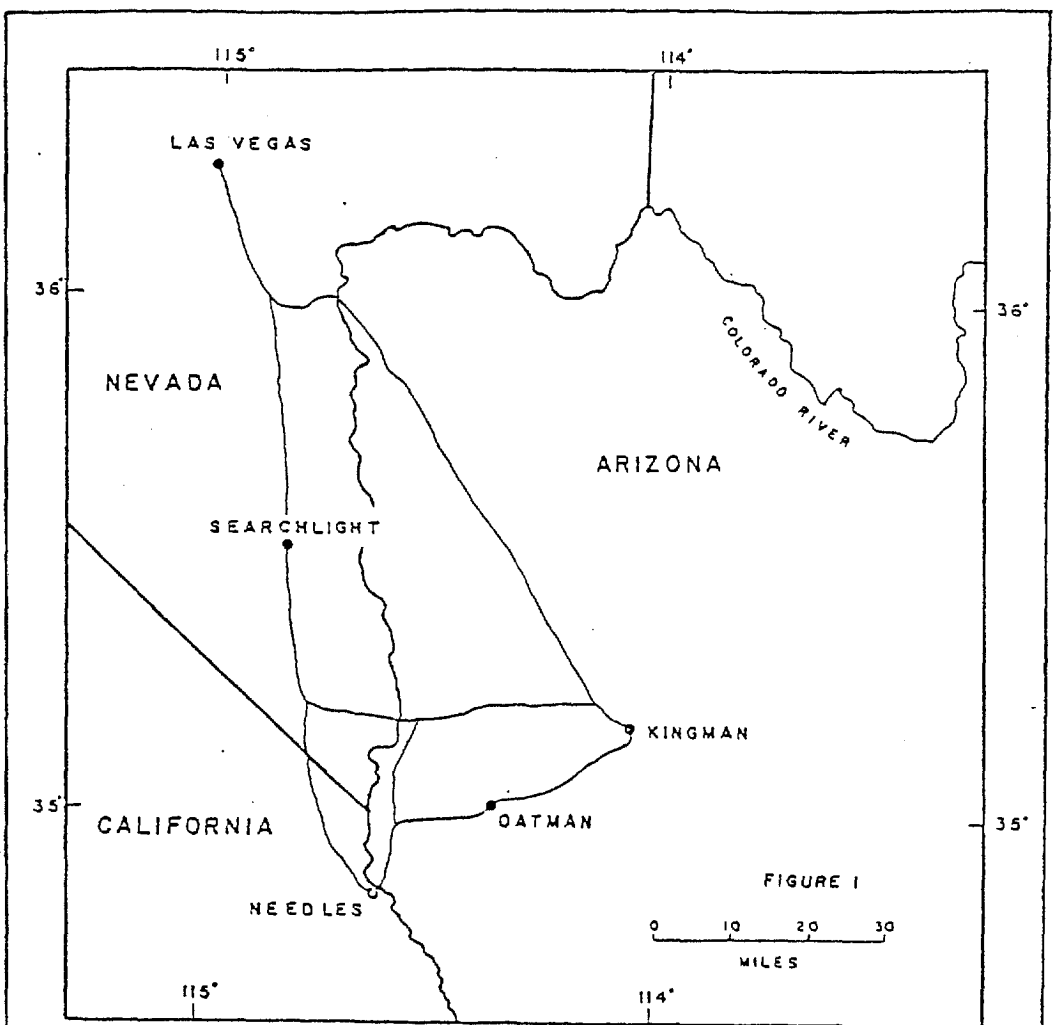
Oatman lies at the center of a trachyte-latite-rhyolite volcanic complex which contains at least one resurgent caldera. The orebodies are typical epithermal quartz-calcite ± adularia lode deposits which are very deficient in sulfur. Ore deposition has occurred within dilatant zones on faults which radiate from a common point within the complex.

Fischer-Watt Mining approached the Oatman District with an integrated exploration program utilizing four basic procedures to define the characteristics of past productive areas, the results of which were applied to unexplored portions of the vein system. These procedures, listed in their order of usefulness in defining known and prospective mineralized zones are: vein contouring, detailed alteration mapping, fluid inclusion temperature determinations, and geochemical sampling.

All known deposits were found to be located at particular points of curvature on the veins and all, irrespective of the level exposed in the hydrothermal system, exhibited a distinctive and predictable alteration signature. Fluid inclusion studies indicated boiling or nonboiling conditions during deposition, temperature of deposition at the sample point, level of exposure relative to the boiling interface and, by establishing a paleogeothermal gradient to the ore horizon, a depth control for drilling. Approximately one man year was expended in establishing these relationships before drilling was recommended.

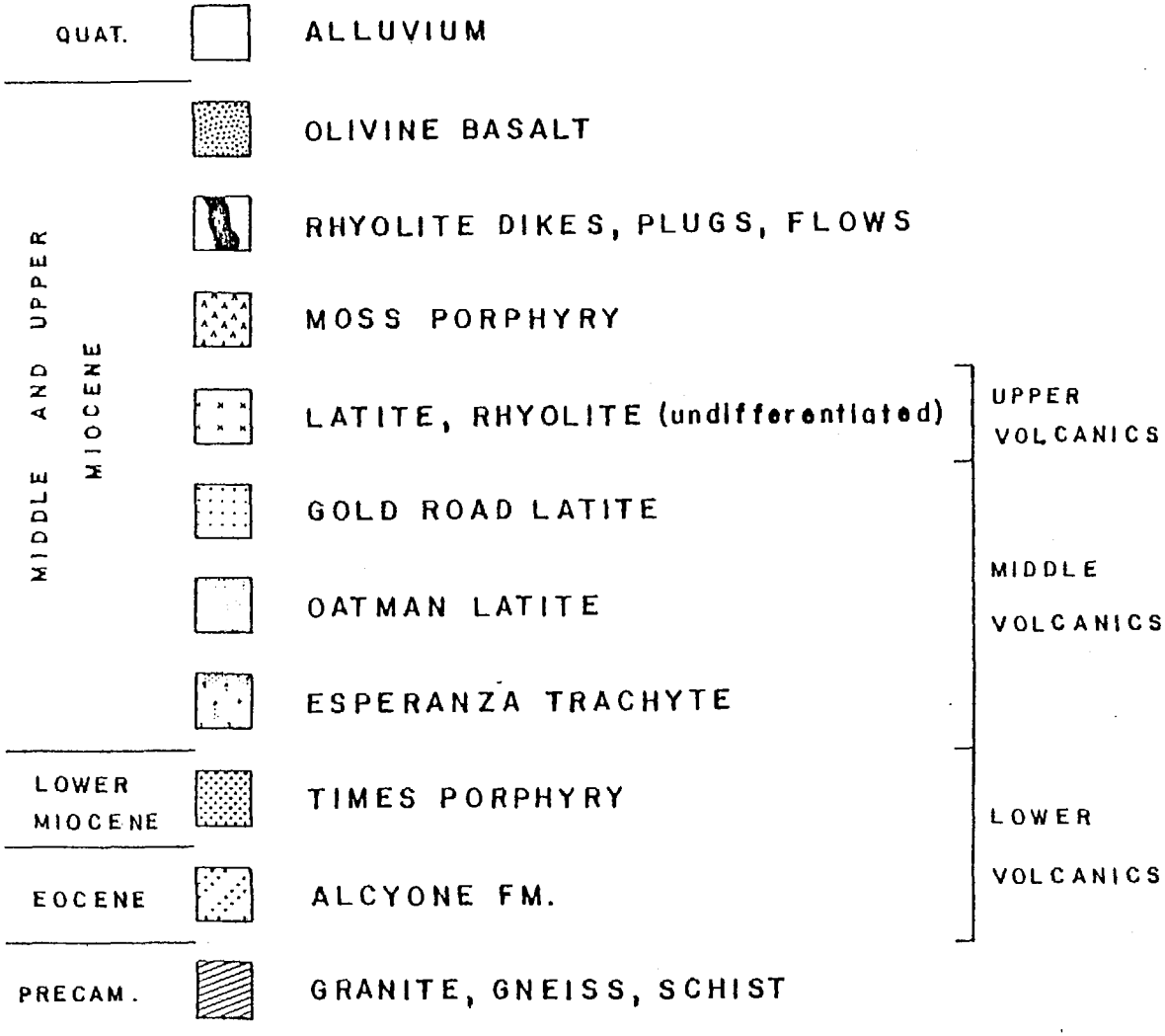
Introduction

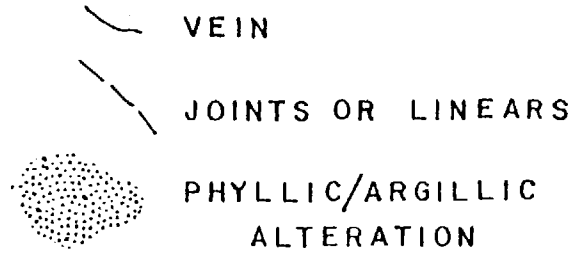
Precious metal vein deposits occurring in Tertiary volcanic terrains - the so-called epithermal vein deposits - have received little attention by American exploration groups in the last 40-50 years. Numerous factors have contributed to this, including the low price of silver and fixed price of gold, escalating labor and materials costs, and an interest in longer term, larger tonnage operations such as porphyry copper and molydenum deposits. In addition, with few exceptions, no significant precious metal vein deposit has been



LOCATION MAP

FIGURE 2 LEGEND





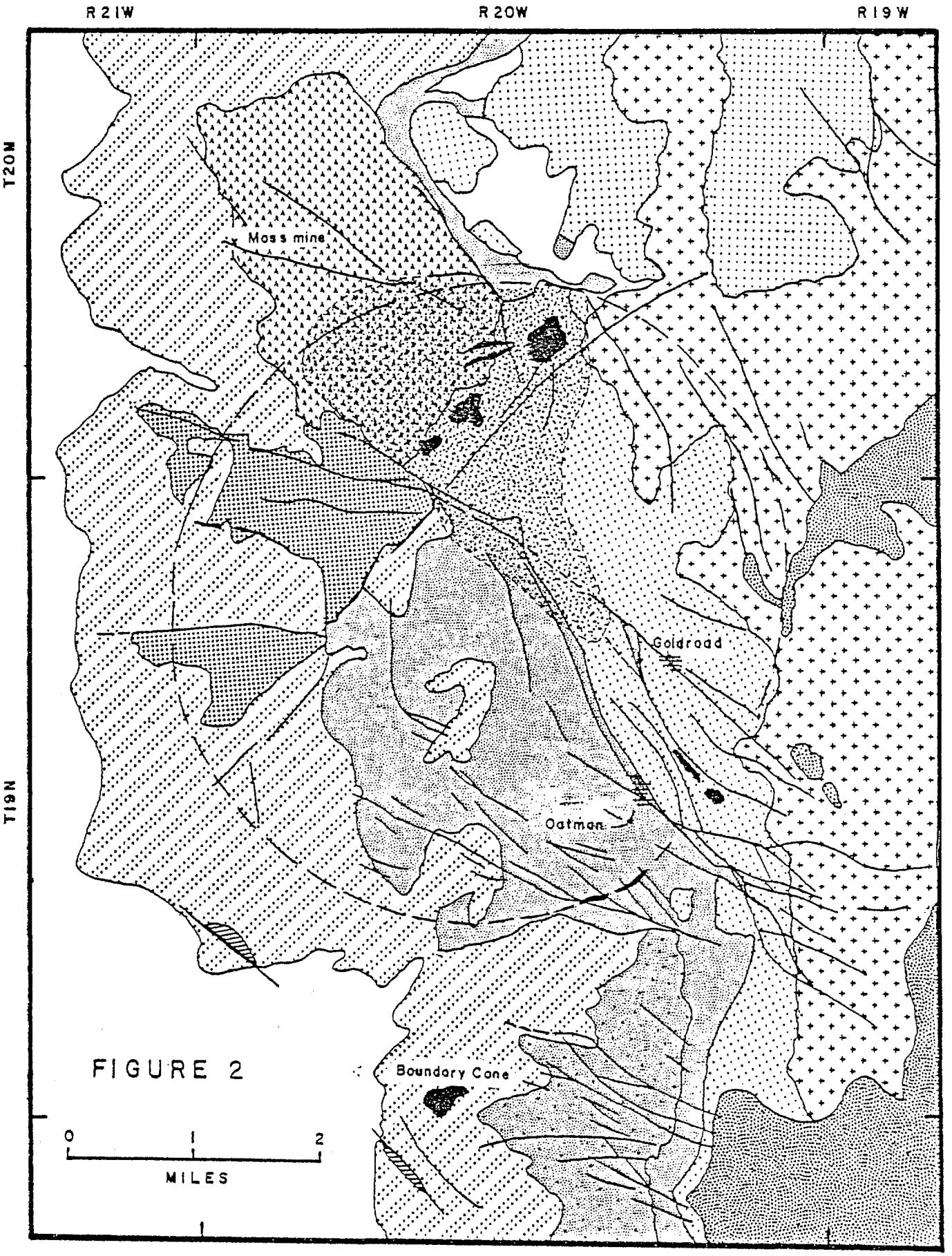
COMPILED FROM:

RANSOME (1923)

LAUSEN (1931)

THORSON (1971)

THIS REPORT



GEOLOGY AND STRUCTURE OF THE OATMAN DISTRICT

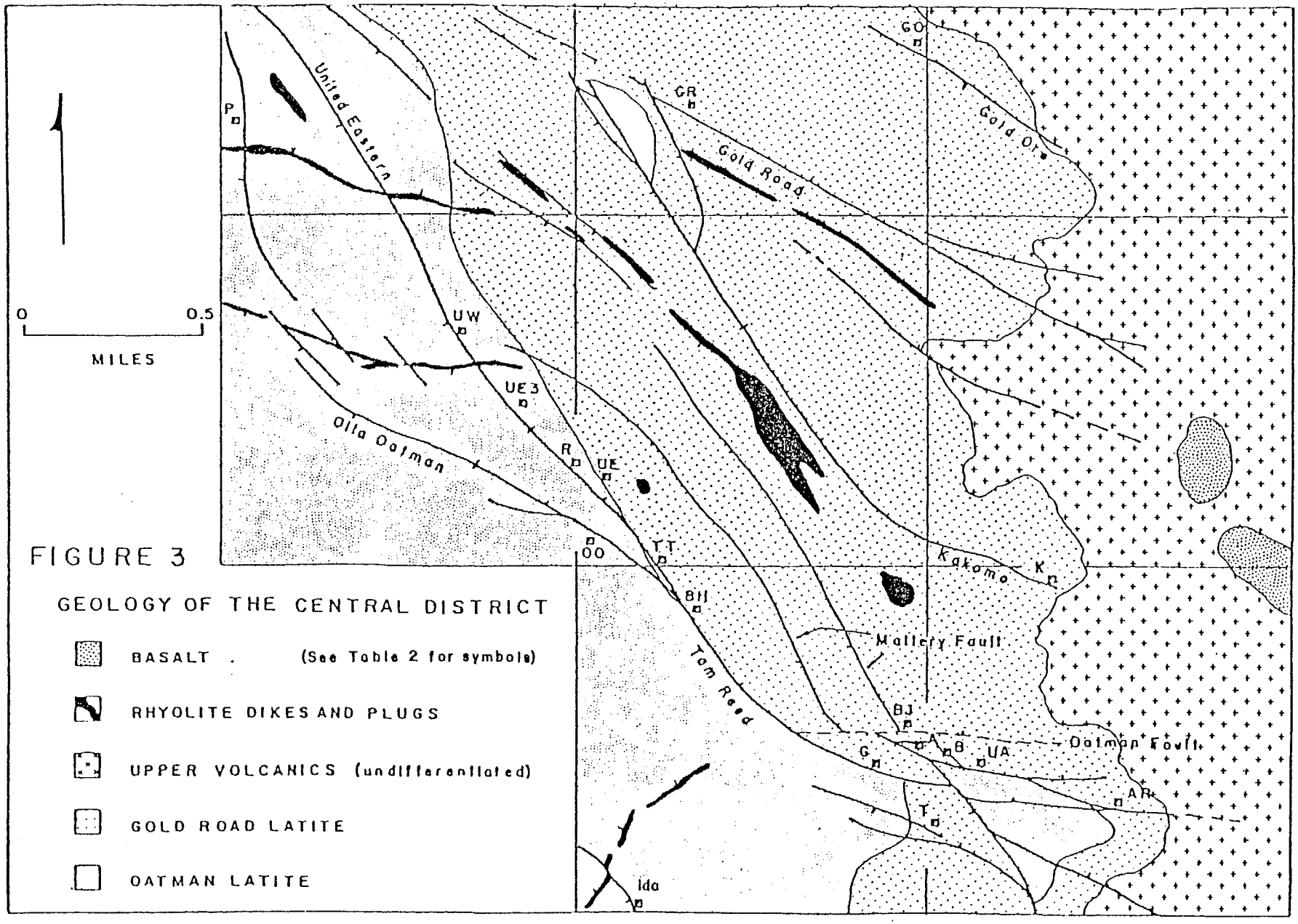


FIGURE 3

GEOLOGY OF THE CENTRAL DISTRICT

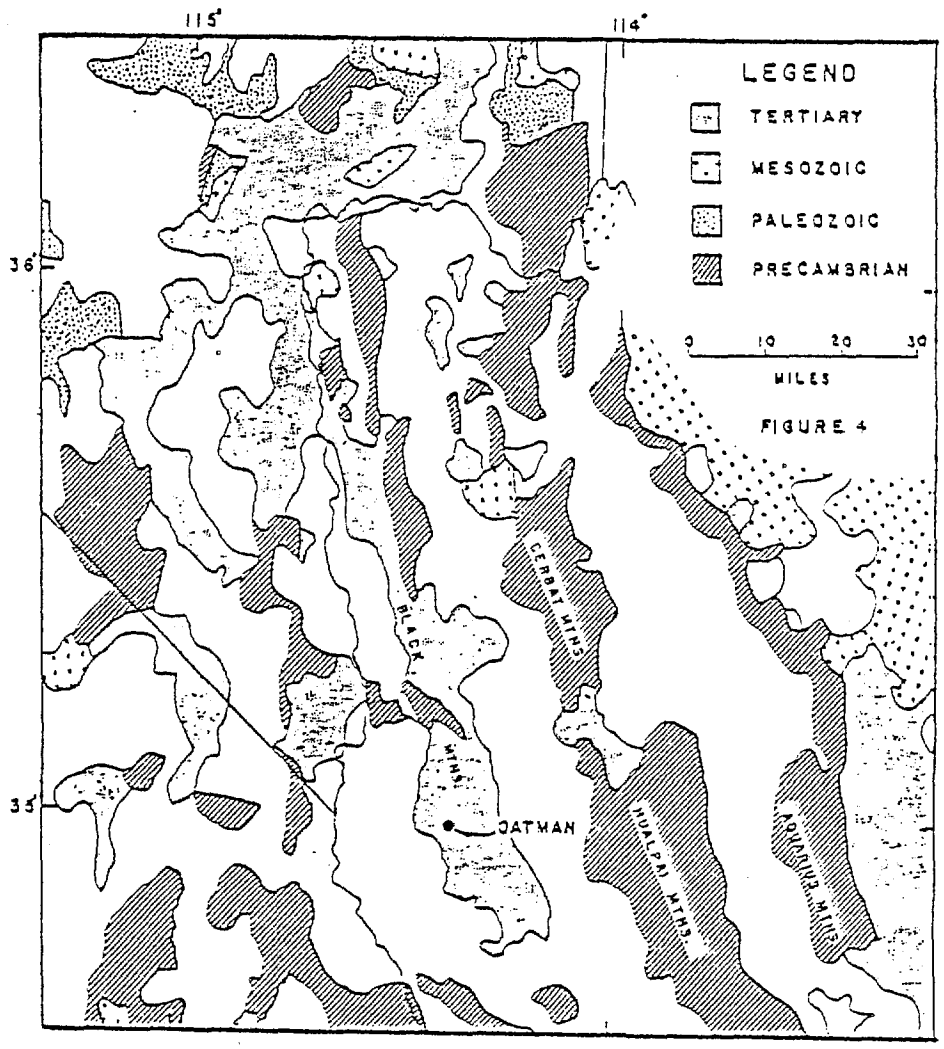
BASALT (See Table 2 for symbols)

RHYOLITE DIKES AND PLUGS

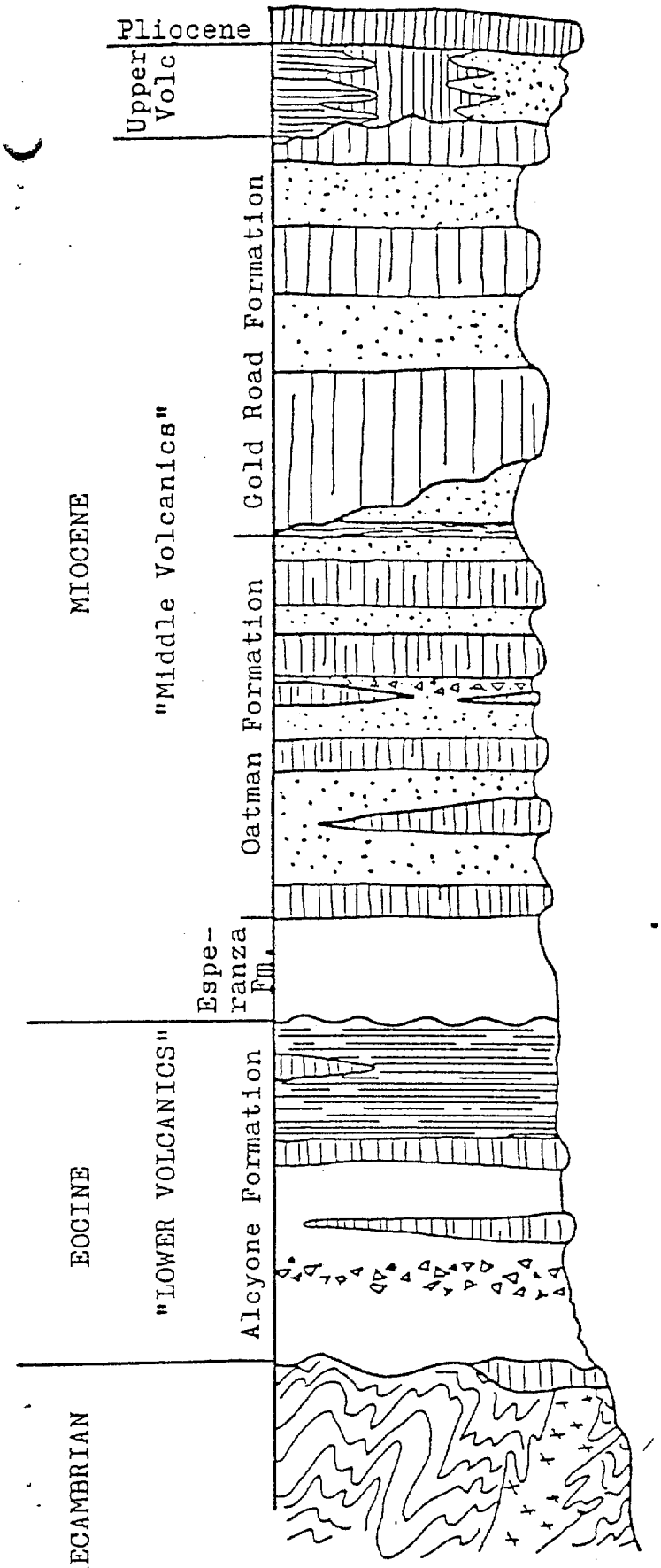
UPPER VOLCANICS (undifferentiated)

GOLD ROAD LATITE

OATMAN LATITE



REGIONAL GEOLOGY



Olivene basalt flows

Sitsgreaves rhyolitic tuffs; Cottonwood Fm., Antelope quartz latite flows; Flag Springs trachyte

Black, brown, and red biotite latite flows separated by white and grey biotite latite lithic ash flows.

Transition Zone: White coarse-grained lithic, crystal, biotite latite ash locally underlain by gree medium-grained fluvial biotite-poor arenite. Base is biotite-poor lithi crystal latite ash.

Vesicular pyroxene latite flow units (40-50' thick) separated by latitic tuffs and flow breccias.

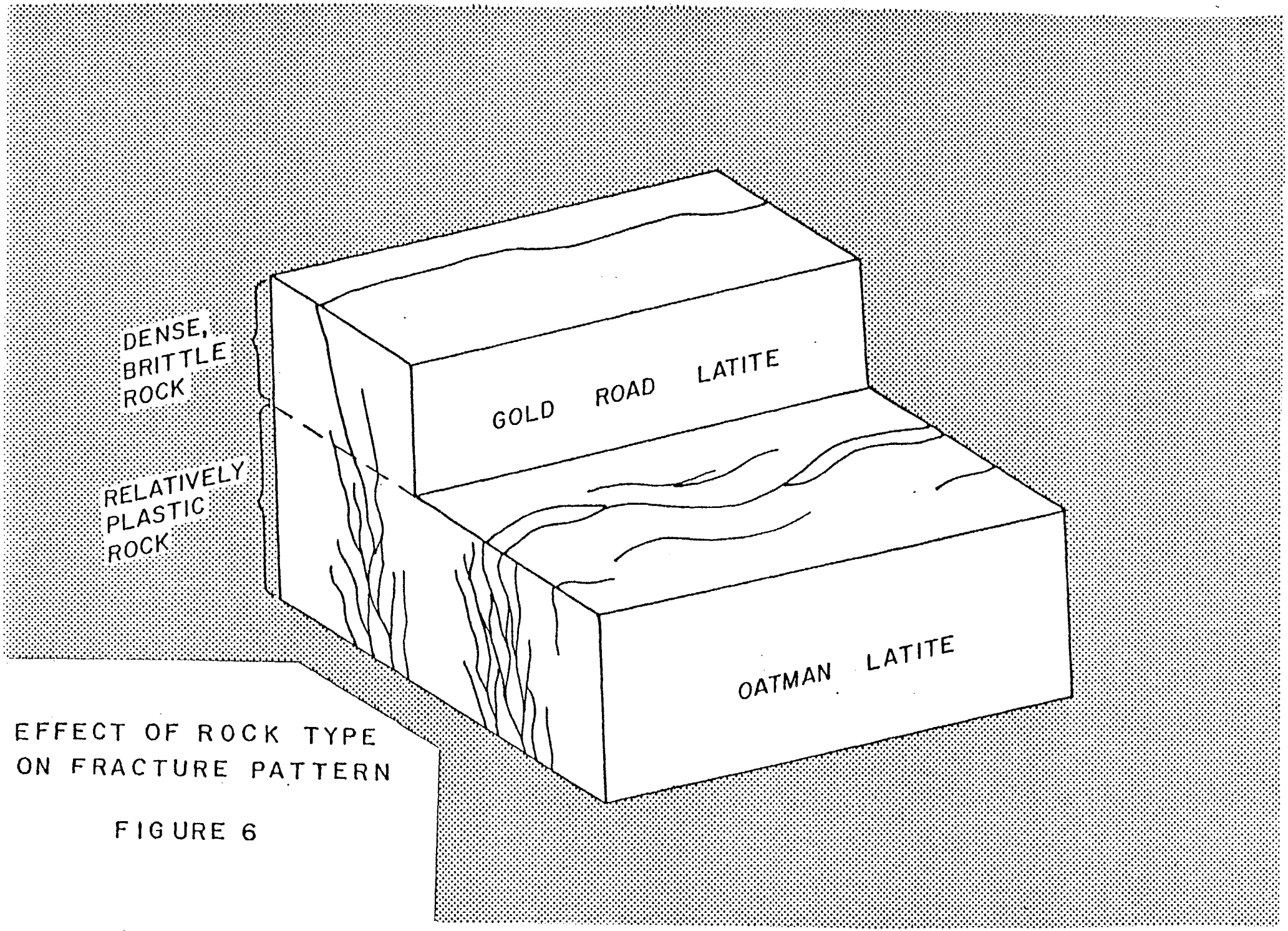
Fine-grained, flaggy, trachyte.

Thinly laminated to thick bedded green and grey trachytic welded tuffs landslide deposits, lahars, unwelded tuffs, and quartz latite flows.

Pre-Alcyone basalt.

Schist, gneiss, granite, quartzite.

FIGURE 5 GENERALIZED STRATIGRAPHY



EFFECT OF ROCK TYPE ON FRACTURE PATTERN

FIGURE 6

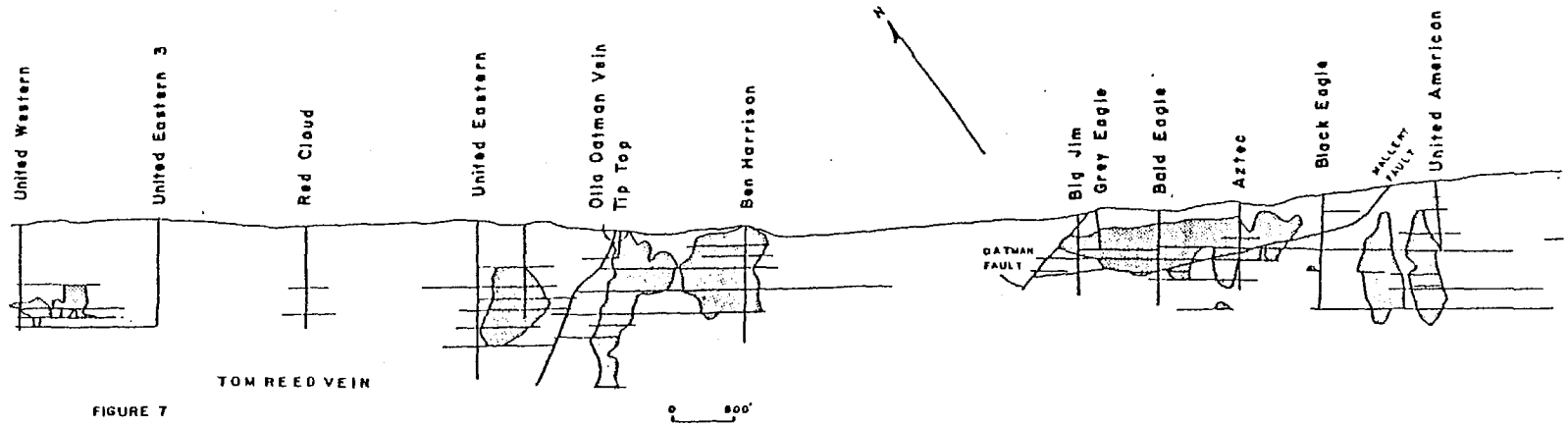
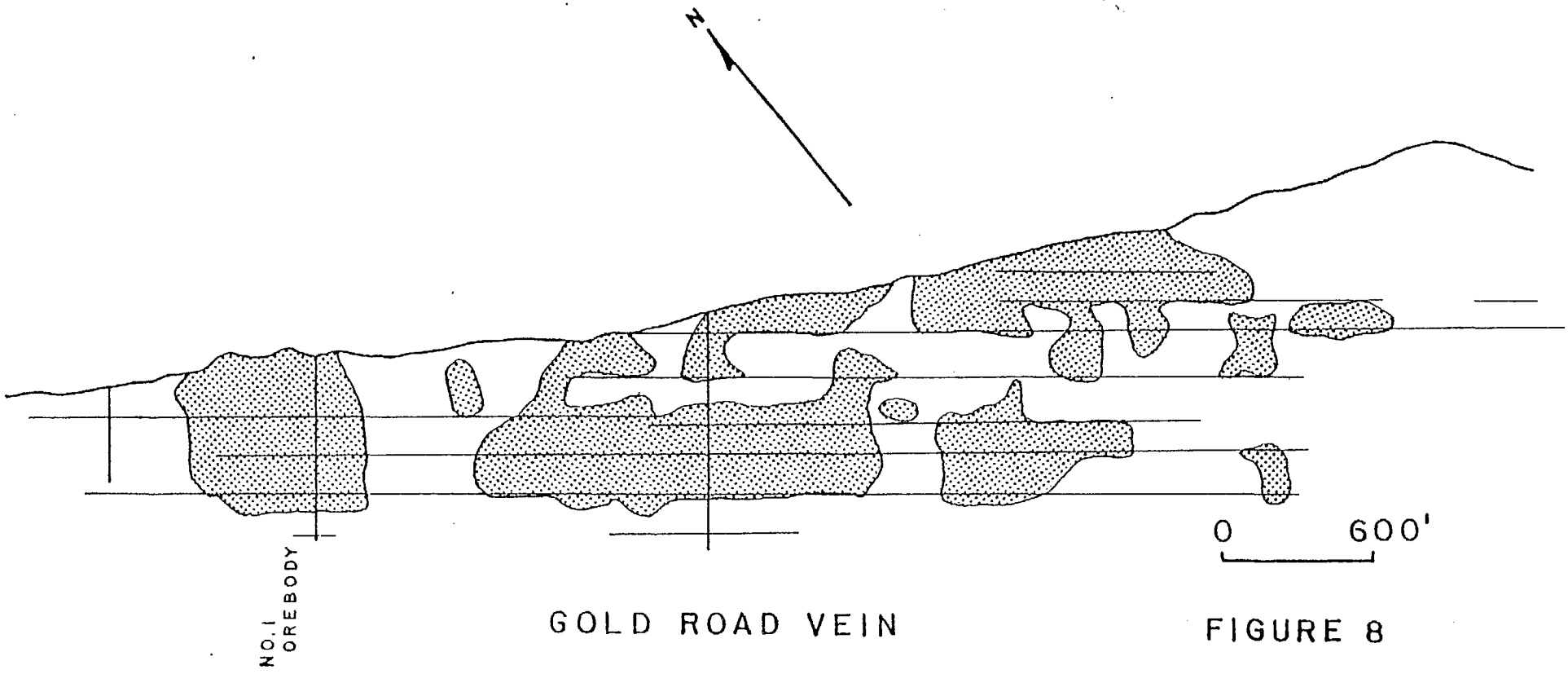
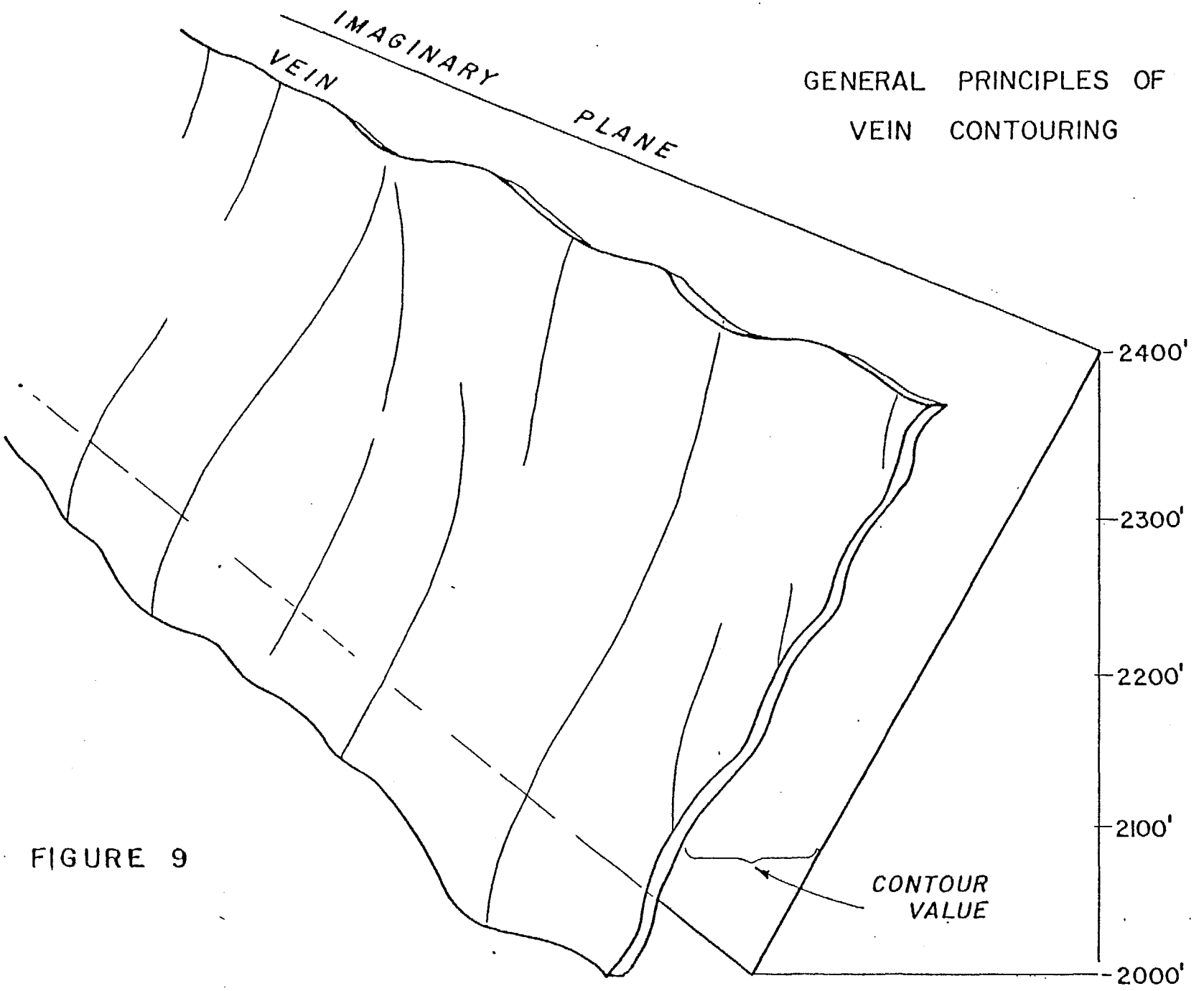

United Western
United Eastern 3
Red Cloud
United Eastern
Olla Oatman Vein
Tip Top
Ben Harrison
N
Big Jim
Grey Eagle
Bald Eagle
Aztec
Black Eagle
HALLEY FAULT
United American
OATMAN FAULT
TOM REED VEIN
0
800'

FIGURE 7



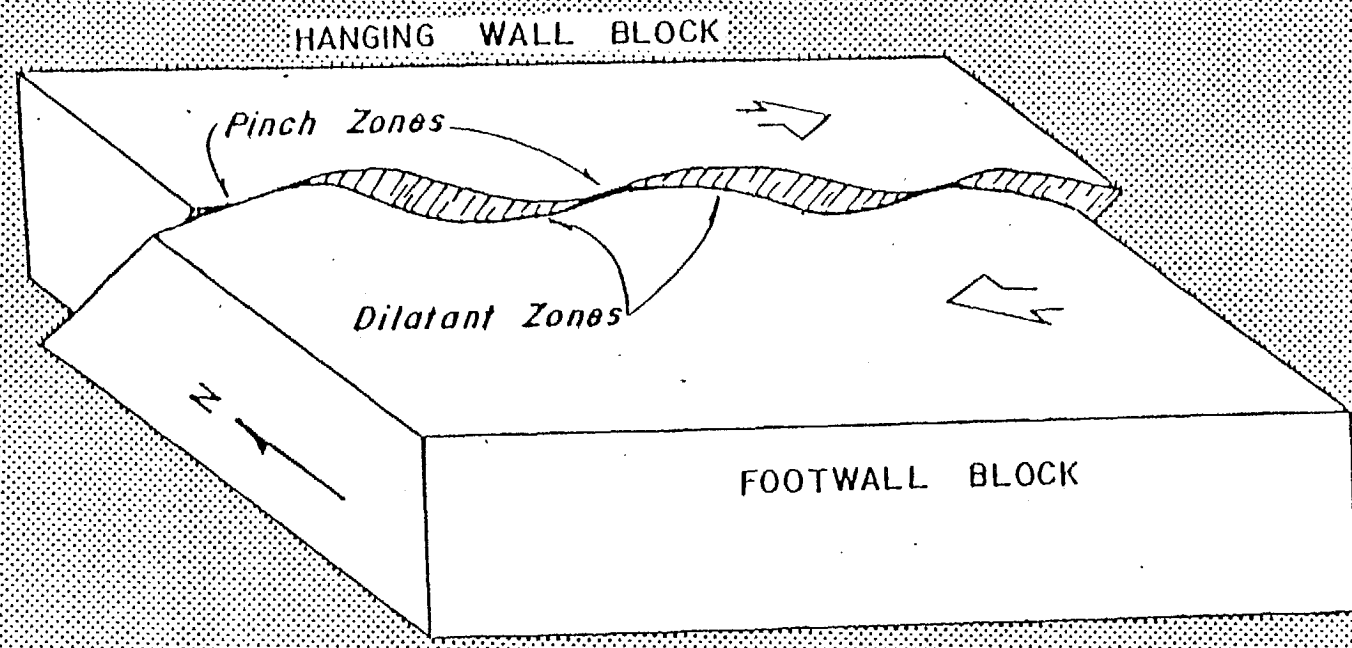
GOLD ROAD VEIN

FIGURE 8



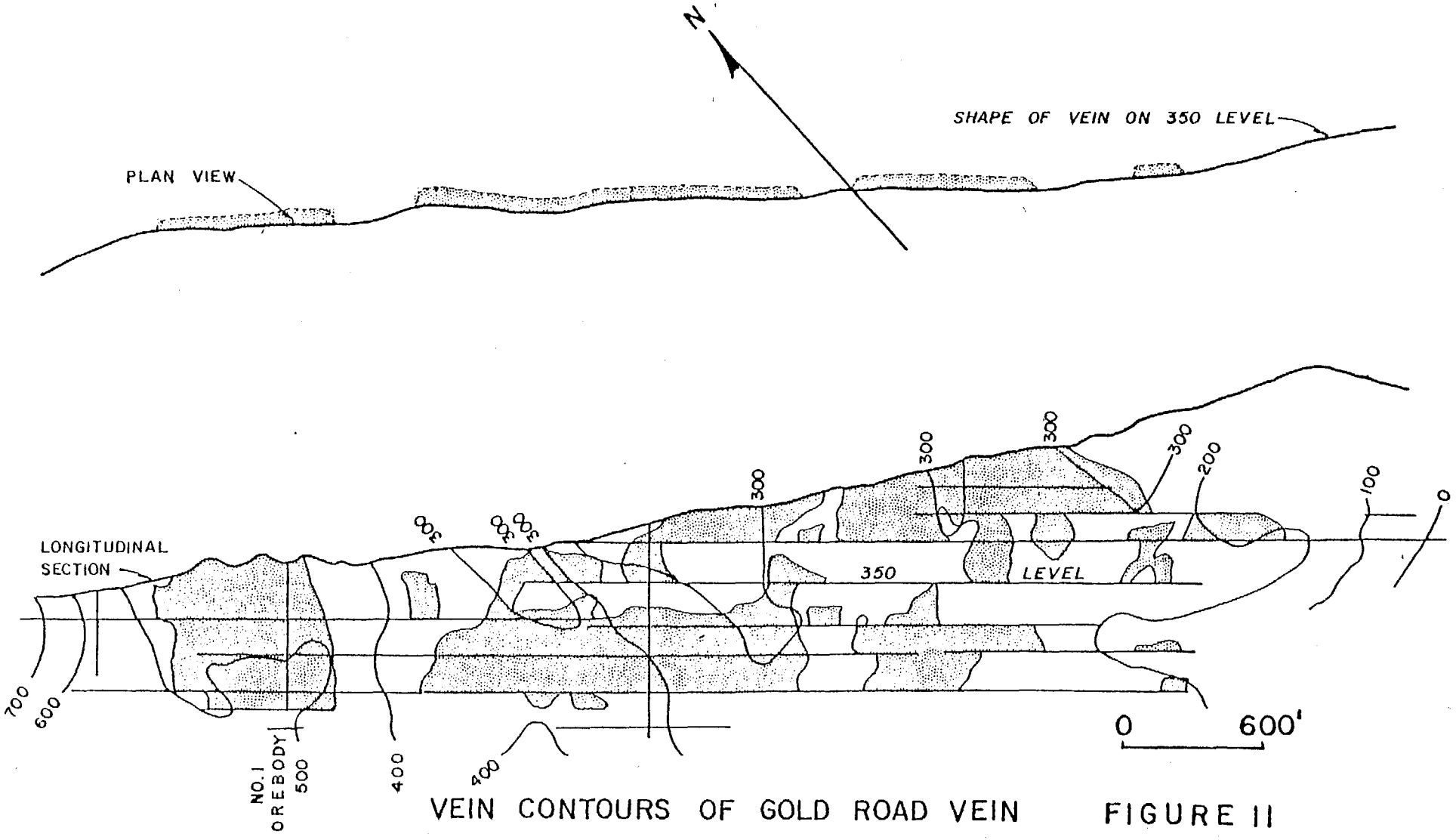
GENERAL PRINCIPLES OF VEIN CONTOURING

FIGURE 9

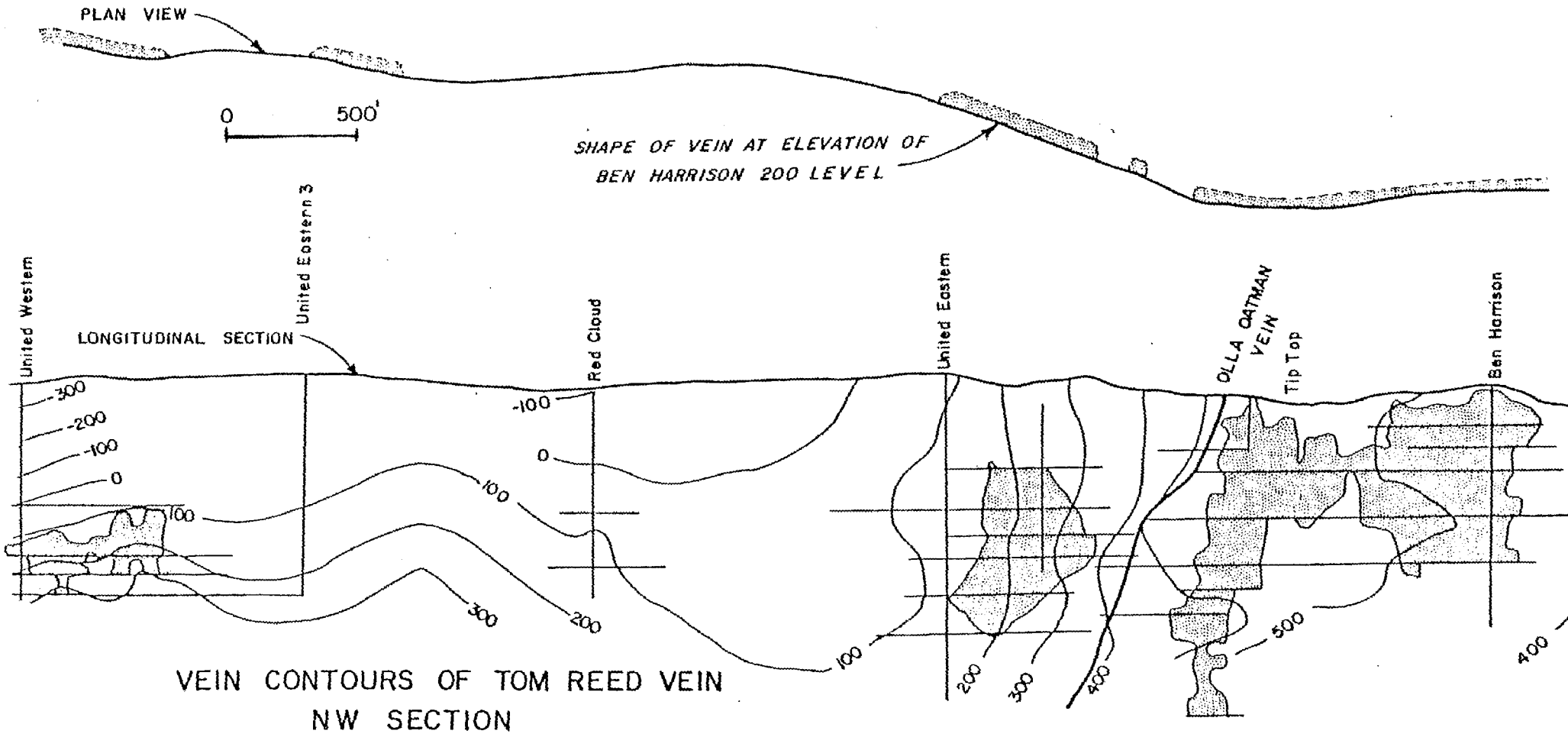


NORTHEAST ORIENTATED DILATANT ZONES PRODUCED BY RIGHT LATERAL STRIKE—SLIP MOTION

FIGURE 10

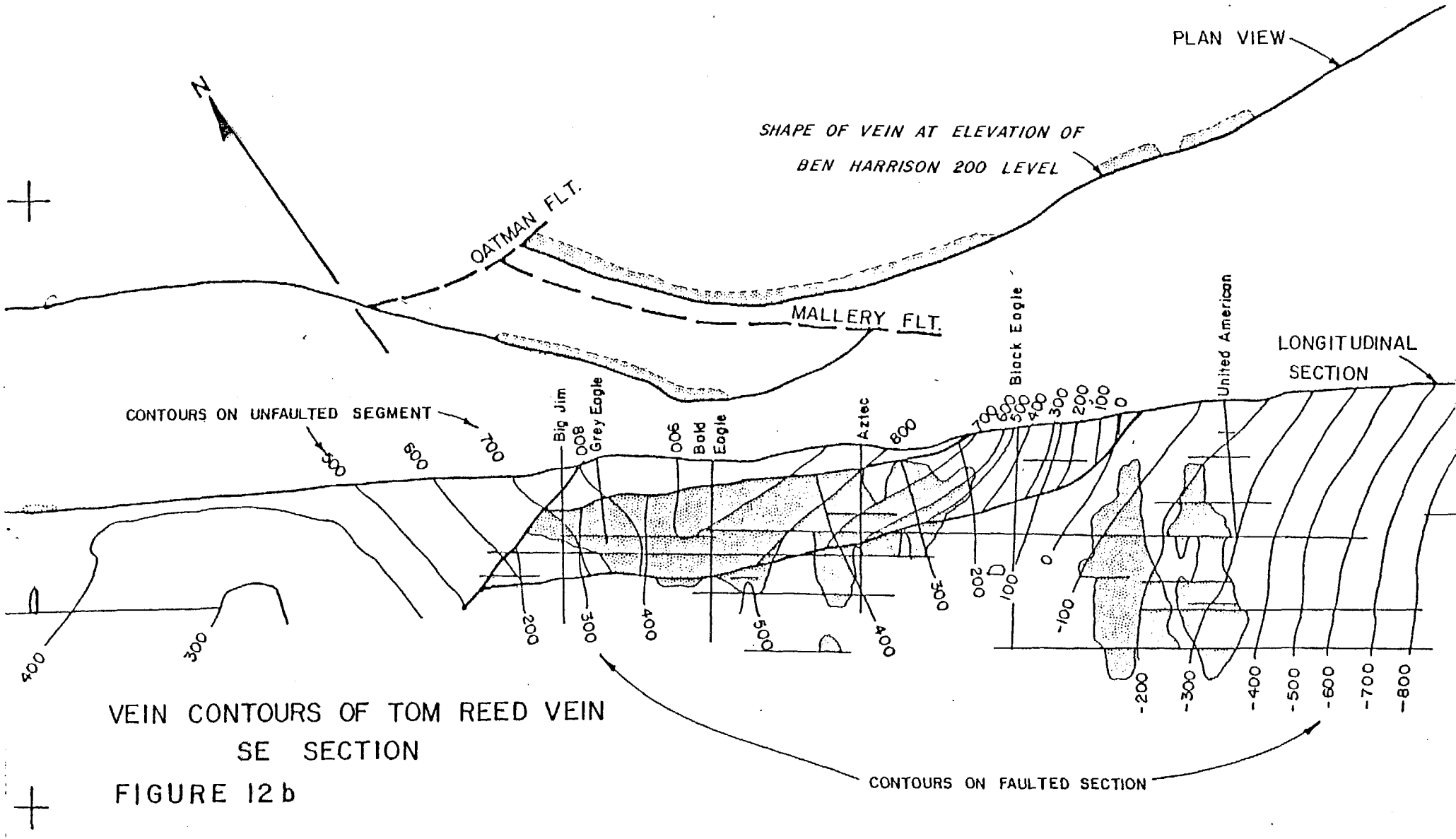


VEIN CONTOURS OF GOLD ROAD VEIN FIGURE 11



VEIN CONTOURS OF TOM REED VEIN
NW SECTION

FIGURE 12a



VEIN CONTOURS OF TOM REED VEIN
SE SECTION

FIGURE 12b

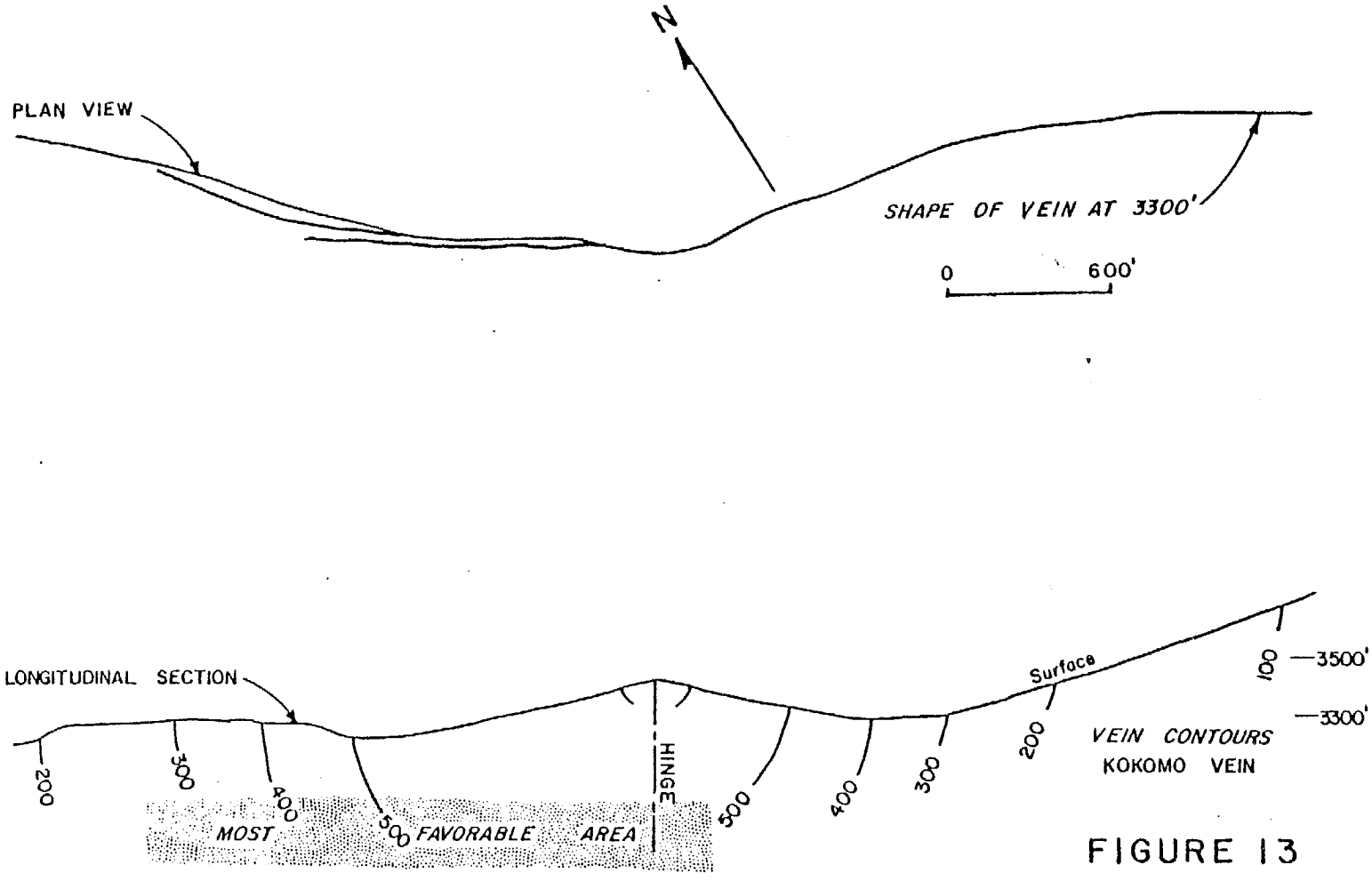

PLAN VIEW
N
SHAPE OF VEIN AT 3300'
0
600'
LONGITUDINAL SECTION
200
300
400
500
MOST FAVORABLE AREA
HINGE
500
400
300
200
Surface
100
—3500'
—3300'
VEIN CONTOURS
KOKOMO VEIN

FIGURE 13

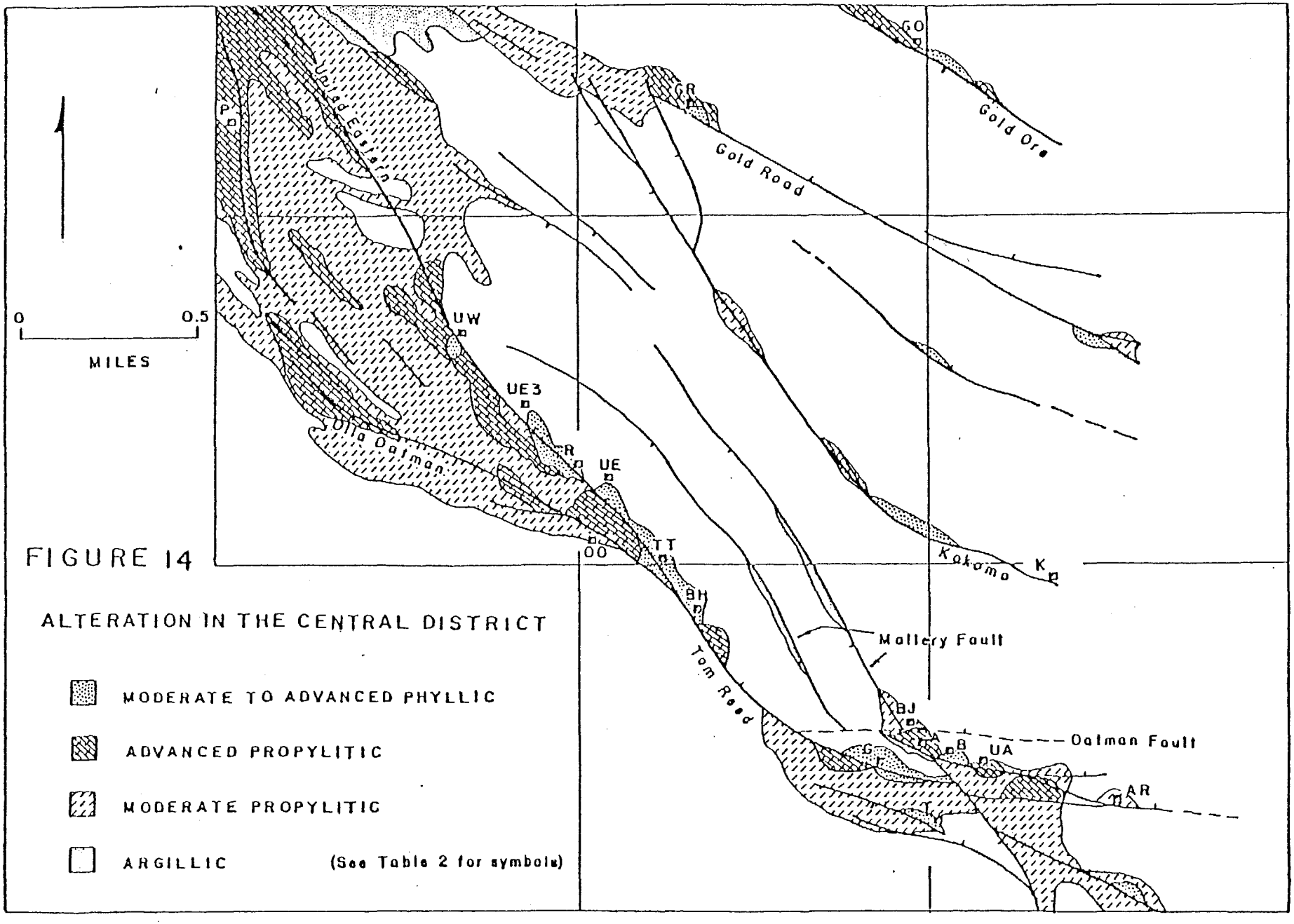
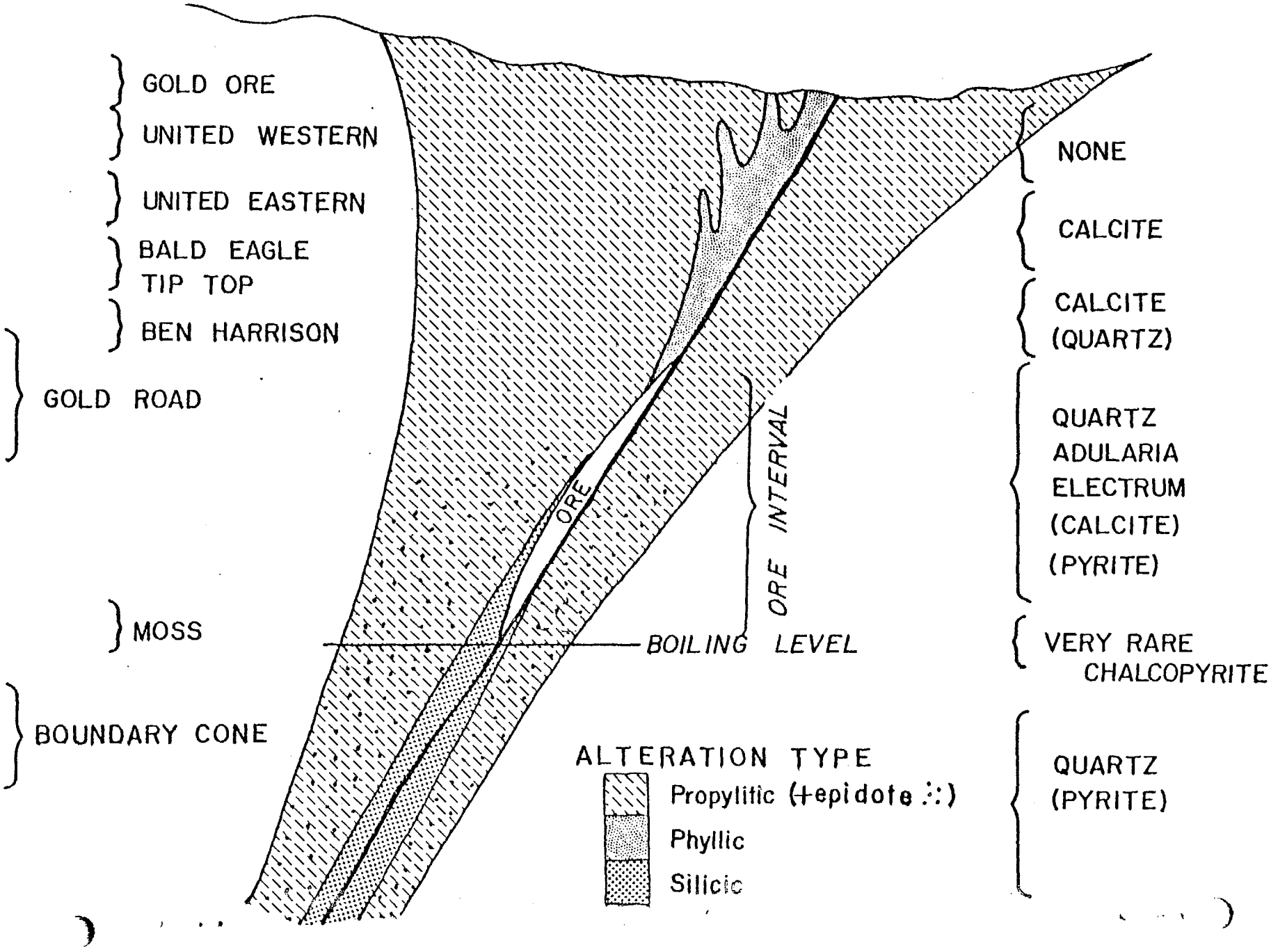

0
0.5
MILES
P
Upland Mosaic
Ulla Oatman
UW
UE3
R
UE
OO
TT
BH
Tom Road
GR
Gold Road
GO
Gold Ore
Kokomo
K
Mallery Fault
BJ
G
B
UA
Oatman Fault
AR
T
ALTERATION IN THE CENTRAL DISTRICT
MODERATE TO ADVANCED PHYLLIC
ADVANCED PROPYLITIC
MODERATE PROPYLITIC
ARGILLIC
(See Table 2 for symbols)

FIGURE 14

FIGURE 15

VEIN CHARACTERISTICS IN THE OATMAN DISTRICT



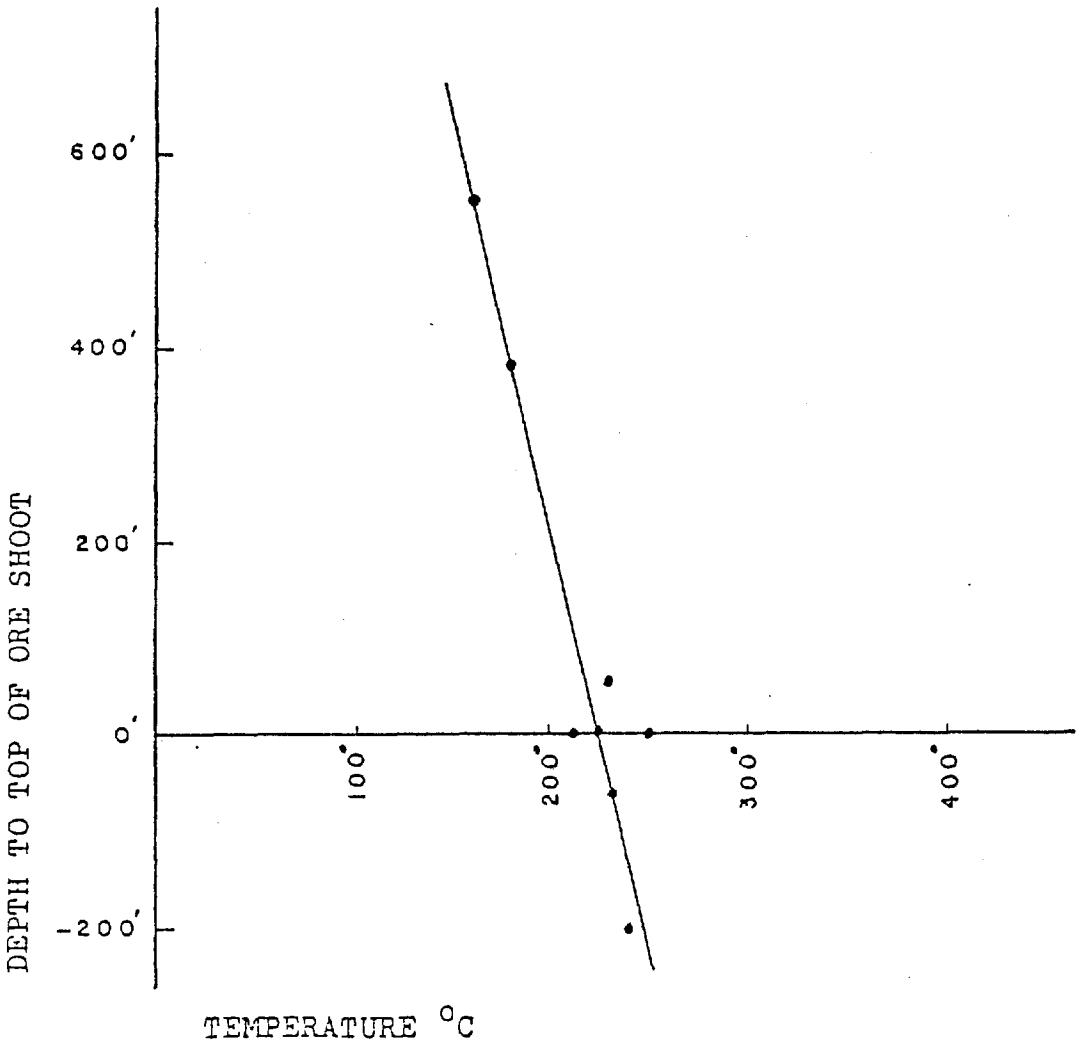


FIGURE 16 Fluid inclusion homogenization temperatures obtained on ore-stage quartz from selected points along the Tom Reed, Kokomo, and Ida veins, plotted against known depth to top of ore shoots. Several samples obtained from within mine workings. Slope is measure of paleogeothermal gradient existing at time of ore deposition.

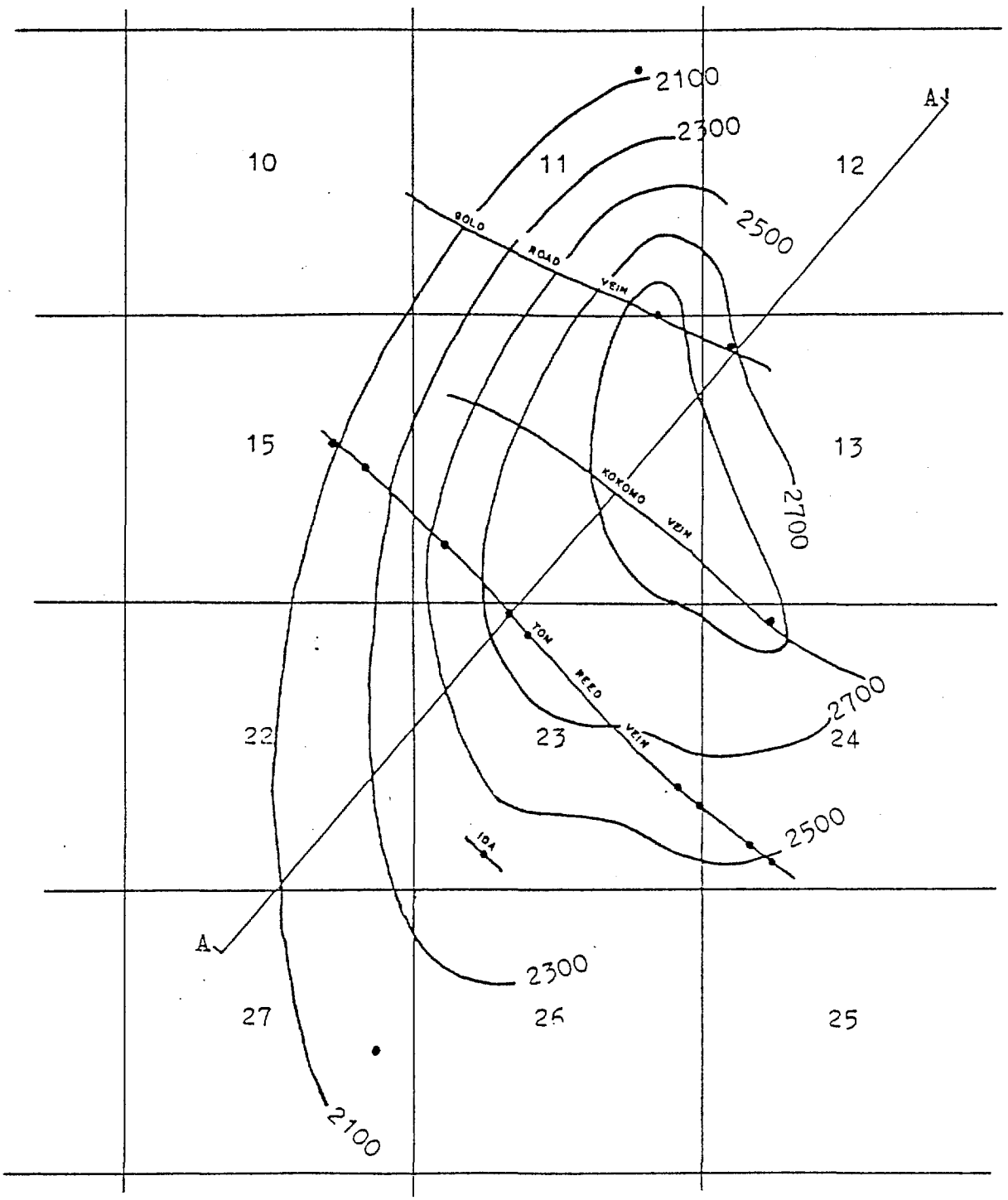


FIGURE 17 Elevations, in feet above sea level, of the tops of ore shoots.
• DATA POINT

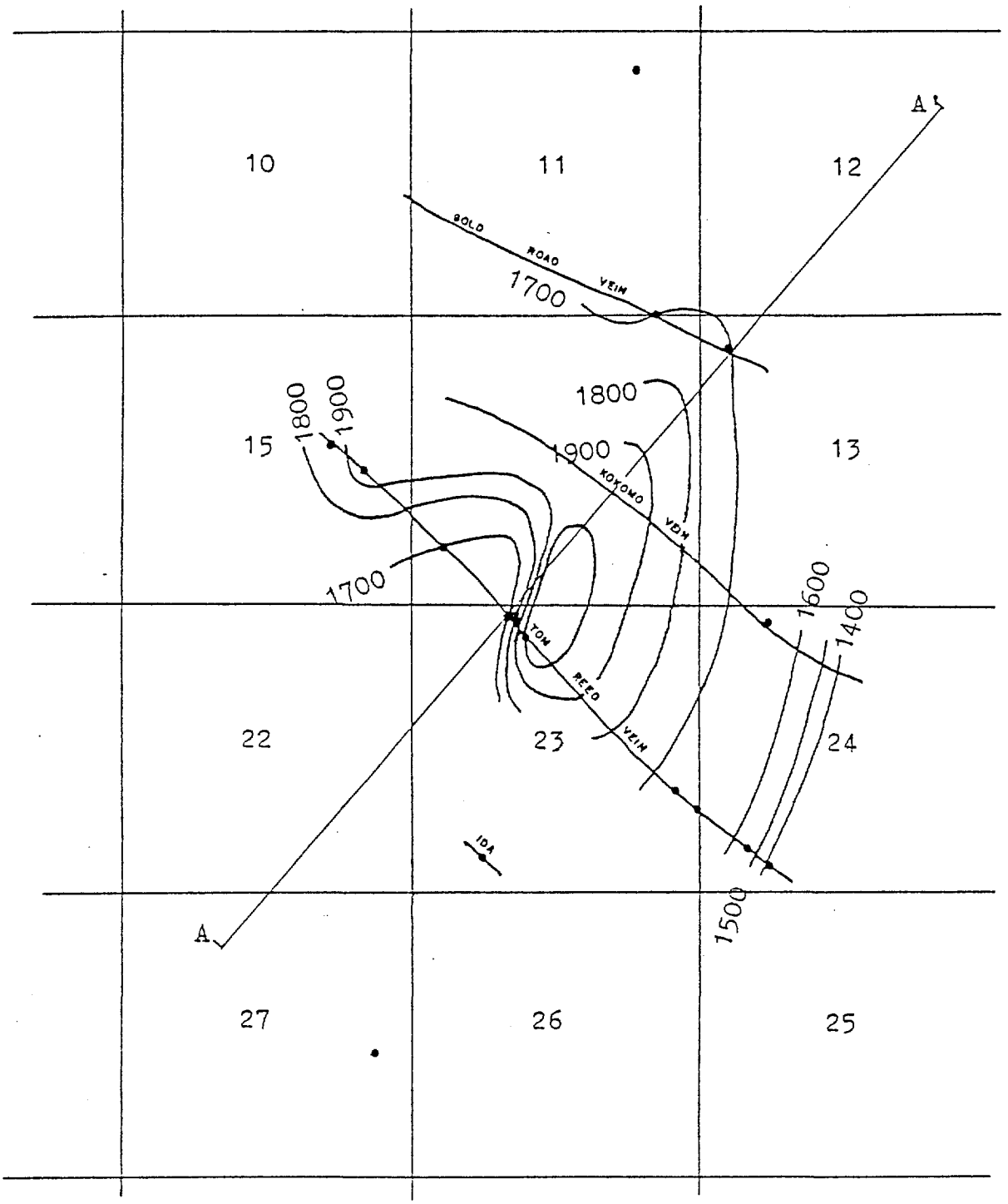


FIGURE 18 Elevations, in feet above sea level, of the bottoms of ore shoots.
• DATA POINT

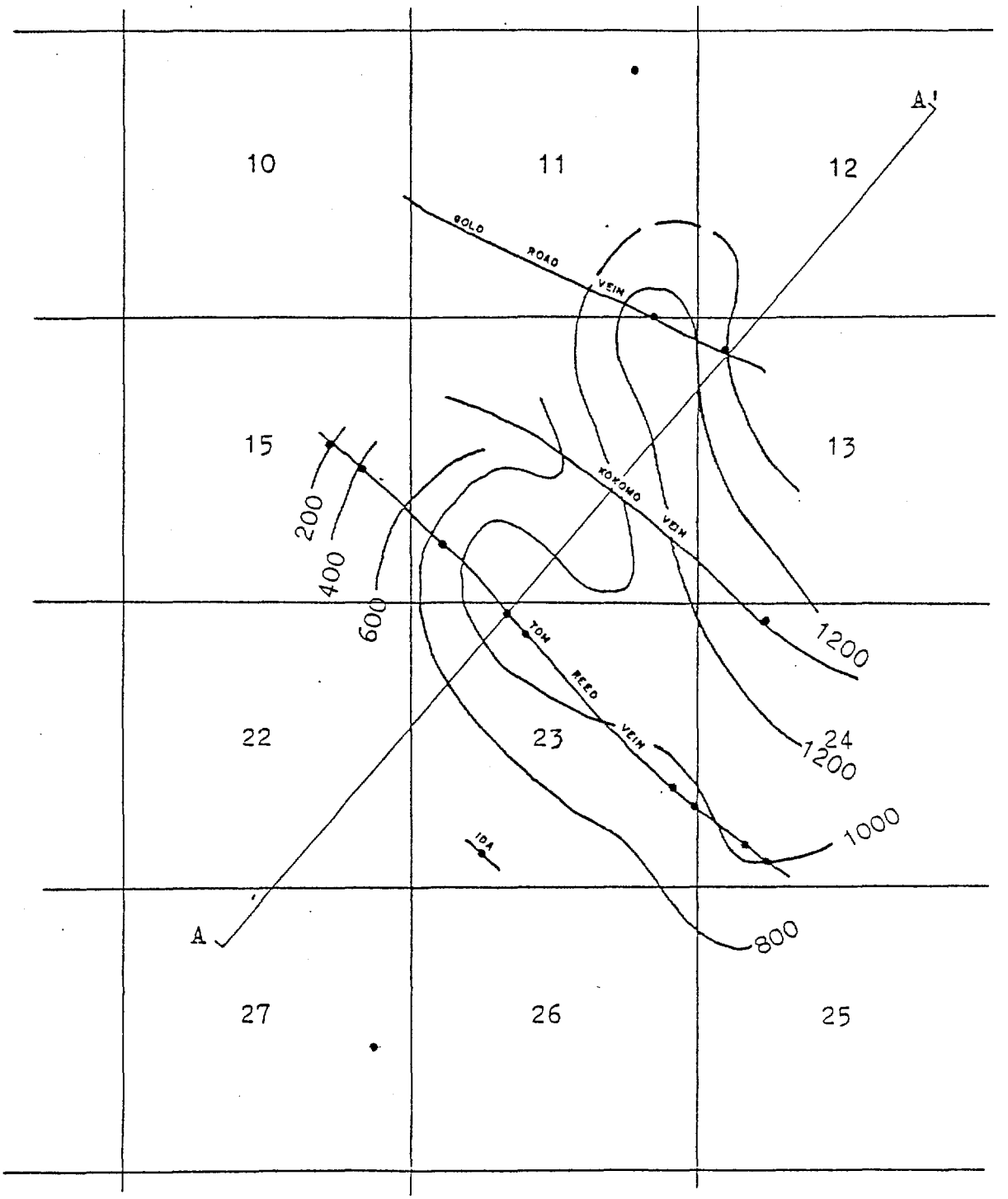


FIGURE 19 Vertical interval of ore, in feet, in the horizon of ore deposition.
• DATA POINT

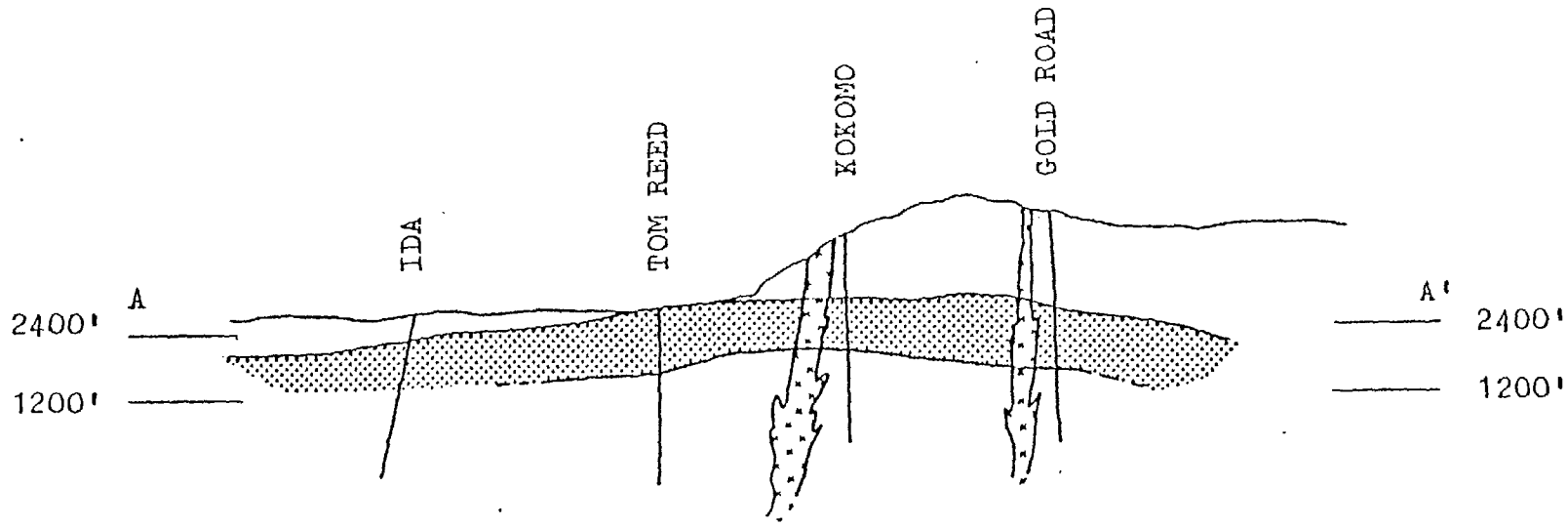


FIGURE 20 Section A-A', view N50W. Top and bottom of the horizon of ore deposition at the time of ore formation. Section is corrected for post-ore faulting and is relative to present-day topography and position of rhyolite dikes. Elevations in feet above sea level.

Table 2

SUMMARY OF OREBODY CHARACTERISTICS MINED FROM THE
TOM REED-UNITED EASTERN AND GOLD ROAD VEINS, OATMAN, ARIZONA

Orebody	Symbol Fig. 3 & 14	Tonnage	Grade O/T Au	Maximum Dimensions Length	Width	Height
United Eastern	(UE)	550,000	1.10	450	45	700
Tip Top	(TT)	250,000	±0.70	500	20	1300
Ben Harrison	(BH)	250,000	±0.70	650	20	750
Big Jim	(BJ)					
Aztec	(A)	±500,000	±0.75	1950	35	800
Black Eagle	(B)	±200,000	±0.50	350	10	1000
United American	(UA)	±140,000	±0.50	300	10	1000
United Western	(UW)	40,000	0.30	990	6	300
Gold Road	(GR)	1,500,000	0.32	6,200	22	1300
Telluride	(T) *	20,000	1.0	200	2-3	200
Argo	(AR)	none				
Olla Oatman	(OO)	none				
Red Cloud	(RC)	none				
United Eastern #3	(UE3)	none				
Pasadena	(P)	none				

* Figures are estimates

Gold Deposit description WLK

Economic Geology
Vol. 76, 1981, pp. 2176–2199

Ortiz Gold Mine Holds Down Costs