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

JDS

January 31, 1990

J.D. Sell

Quarterly Report
4th Quarter 1989

## Exploration Authorizations

### Garfield Project, Salt Lake County, Utah - Au

Nineteen days (8 field - 11 office) during the quarter were spent in reconnaissance mapping, collecting and evaluating geochemical data and preparing slides for presentation to management.

### Ochre Springs Project, Tooele County, Arizona - Au

Twelve office days were involved in evaluating and interpreting results of the past summer's drilling, culminating in a project report and proposed drill program for 1990.

### Yarnell Project, Yavapai County, Arizona - Au

Mapping of Section 23, south of the Yarnell Mine, consumed 13 (field) days.

### Yellow Jacket, Sevier County, Utah - Au

A brief report on the assay results from the hole drilled at the Yellow Jacket project was completed in one office day.

## General Exploration

### Copper Globe, San Rafael Swell, Emery Co., Utah - Cu

A one-day field examination of this oxide copper deposit. This occurrence of azurite and malacite within the eolian Navajo Sandstone does not warrant further work.

### Hammerhead, Claim Group, Millard County, Utah - Au, Pb

One day was spent in the field evaluating this Karsted terraine northwest of Milford, Utah. No encouragement was found other than the stories of the claim holder.

JDS

ASARCO

Southwestern Exploration Division

January 24, 1990

J.D. Sell

J.J. Malusa
Monthly Report
January 1990

General Exploration

Seven days spent cleaning and organizing warehouse and warehouse yard.

Project EA-0444 (field)

Field work consisted of ground magnetometry work, reconnaissance of a nearby abandoned mine, and construction of lithology cross sections.

Project EA-0444 (office)

Ground magnetometry calculations, data compilation and magnetometry map construction.

John J. Malusa

JJM:mek

JDS

ASARCO

Southwestern Exploration Division

March 1, 1990

J.D. Sell

J.J. Malusa
Monthly Report
February 1990

## Yarnell Project, Yavapai County, AZ (EA-0444)

### Field

Prepared, submitted, and wrote report on twenty-four samples for preliminary bottle roll leach test. Collected and submitted a suite of rocks for whole rock analysis. Also set up core sawing equipment and trained employee.

### Office

Continued work on magnetometry interpretation. Compilation of values from standards used during drilling program. Construction of lithological and ore zone cross sections.

### General Exploration

Gathered information and estimates for replacement vehicles.

| | Field days | Office days | Expense Account | Auto Expense |
|---|---|---|---|---|
| Feb. | 4 | 10 | $276.71 | $205.00 |
| YTD | 12 | 24 | $700.95 | $530.00 |

J.J. Malusa

J.J. Malusa

JJM:mek

cc: W.L. Kurtz

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**ASARCO**

Southwestern Exploration Division

March 28, 1990

J.D. Sell

J.J. Malusa
Monthly Report
March 1990

Yarnell Project, Yavapai County, Arizona - EA-0444

Completed reports on both magnetometry and whole rock analysis. Researched and purchased new diamond blade for sawing of core, and finished sampling core. Transported and put in assay checks for remainder of core in field.

Santa Cruz Project, Casa Grande, Arizona - EA-0075

Cleaned up barrels and took to landfill.

General Exploration, Tucson Office

Conducted literature search for gold prospects in Yavapai County, Arizona.

| | Field Days | Office Days | Expense Acct. | Vehicle Expense |
|---|---|---|---|---|
| March | 3 | 17 | $133.82 | $105.00 |
| YTD | 15 | 41 | $834.78 | $635.00 |

JJMalusa

J.J. Malusa

JJM:mek

cc: W.L. Kurtz

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# ASARCO

Southwestern Exploration Division

March 28, 1990

J.D. Sell

J.J. Malusa
Quarterly Report
1st Quarter 1990

## EXPLORATION AUTHORIZATIONS

### Yarnell Project, Yavapai County, Arizona - EA-0444

Spent 14 days in the field doing magnetometry work, collecting whole rock samples, reconnaissance of nearby prospects, preparing and transporting samples for bottle roll test, and transporting remainder of Yarnell core to assayer.

Spent 4 days at the warehouse sampling, locating a new diamond blade for the core, and training employee to cut core.

Spent 27 days in the office doing magnetometry work, whole rock analysis interpretation, compiling values from assayed standards, and constructing lithological and ore zone cross sections.

### Santa Cruz Project, Casa Grande, Arizona - EA-0075

Spent 1 day in the field cleaning up barrels and taking them to the landfill.

## GENERAL EXPLORATION

Seven days spent cleaning and organizaing warehouse and warehouse yard. One day spent on truck maintenance and gathering information about the cost of a replacement vehicle. Two days spent doing a literature search for gold prospects in Yavapai County, Arizona.

JJ Malusa

J.J. Malusa

JJM:mek

JDS

# ASARCO

Southwestern Exploration Division

April 16, 1990

FILE NOTE

J.J. Malusa's Reports
1) Ground Magnetometry
2) Whole Rock Analysis
Yarnell Project
Yavapai County, AZ

Two reports have recently been submitted by J.J. Malusa, with copies to W.L. Kurtz, on some of his work performed on the Yarnell Project, Yavapai County, Arizona.

1. Ground Magnetometry, 5 pages, 2 figures, 3 attachments (3-9-90). Malusa's conclusion was that the magnetic signature over the mineral body in its highly oxidized and altered surroundings was a magnetic low compared to the footwall granite south of the Yarnell Fault. He also gave thoughts on how to produce a more definitive map, should such a study be undertaken elsewhere.

2. Whole Rock Analysis, 3 pages, 1 table, 2 figures and 4 attachments (3-19-90). Malusa collected and compared 2 samples from the volcanic flows NE of Yarnell, 1 each from the HW and FW granites, and 2 from dikes in the FW granite. His conclusions were that the FW and HW granite is the same granite; the flows (mid-Tertiary age date) are different from the two dike rocks which in themselves are different and all three must be from a time-separated magma source. Further the andesite dike(s) tend to subparallel the Yarnell Fault whereas the diorite dike cross-cuts the Yarnell Fault at near right angles.

James D. Sell

JDS:mek

James D. Sell

cc: F.T. Graybeal
W.L. Kurtz
J.J. Malusa

JDS

# ASARCO

Southwestern Exploration Division

April 30, 1990

J.D. Sell

J.J. Malusa
Monthly Report
April 1990

General Exploration

Great Basin Symposium and Carlin Trend field trip. Met geophysical helicopter in Wickenburg. Literature search.

Patagonia Area, Arizona, EA-0165 & EA-0042

Locate and report dangerous conditions of abandoned workings.

Yarnell Project, Arizona, EA-0444

Drop off samples for X-ray diffraction, whole rock analysis and thin section work. Also, looked into possibility of illite dating of Yarnell Fault gauge.

Dixie Project, Arizona, EA-0472

Stake proposed drill hole locations.

Superior East, Arizona, EA-0010

Assist in surveying.

Santa Cruz Project, EA-0075

Assist in surveying.

| | Field Days | Office Days | Expense Acct. | Vehicle Expense |
|---|---|---|---|---|
| April | 15 | 7 | $1,392.13 | $260.25 |
| YTD | 30 | 49 | $2,226.91 | $895.25 |

John J. Malusa

JJM:mek

cc: W.L. Kurtz

JDS

ASARCO

Southwestern Exploration Division

May 31, 1990

J.D. Sell

J.J. Malusa
Monthly Report
May 1990

General Exploration

Arranged for garbage hauling and construction of core shelves for warehouse.

Reconnaissance and wrote follow-up report for two claim blocks in Turquoise District, Cochise County, Arizona. Reconnaissance and wrote report for Black Rock claim block, Little Harquahala Mountains, La Paz County, Arizona.

Thunder Mountain Project, Santa Cruz County, AZ - EA-0042

Locate old drill sites, showed them to the drillers and wrote letters to Forest Service and Department of Water Resources for drilling permits.

Yarnell Project, Yavapai County, AZ - EA-0444

Collected 200 pounds of fault gouge from Yarnell Fault and sent to Reno with the core hole ore zone intercepts. Collected gouge underground for possible K-Ar dating.

| Field Days | | Office Days | Expense Acct. | Vehicle Expense |
|---|---|---|---|---|
| May | 10 | 10 | $401.34 | $580.97 |
| YTD | 40 | 59 | $2628.25 | $1476.22 |

John J. Malusa

John J. Malusa

JJM:mek

**ASARCO**

Southwestern Exploration Division

June 27, 1990

J.D. Sell

J.J. Malusa
Monthly Report
June 1990

## General Exploration

Arranged for construction of core shelves and gravel for warehouse yard.

Truck maintenance and emissions testing for registration.

## Yarnell Project, Yavapai County, Arizona - EA-0444

Arranged for XRD, whole rock analysis and thin section work on various samples. Wrote reports for all of the previous work mentioned. Contacted AGS in regard to information pertaining to diorite dikes in Yarnell area.

## Ventura Project, Santa Cruz County, Arizona - EA-0165

Locate and flag locations for proposed holes, show locations to Forest Service and write formal letter to them for permission to drill and maintain roads. Located and built barbed wire fence around old workings.

## Thunder Mountain Project, Santa Cruz County, Arizona - EA-0042

Same as Ventura work.

| | Field Days | Office Days | Expense Account | Vehicle Expense |
|---|---|---|---|---|
| June | 7 | 13 | $ 272.65 | $ 366.60 |
| YTD | 48 | 72 | 2,900.90 | 1,842.82 |

John J. Malusa

JJM:mek

cc: W.L. Kurtz

**ASARCO**

Southwestern Exploration Division

June 27, 1990

J.D. Sell

JDS

J.J. Malusa
Quarterly Report
2nd Quarter 1990

## EXPLORATION AUTHORIZATIONS

### Yarnell Project, Yavapai County, Arizona - EA-0444

Two days in field collecting fault gouge sample and ore zone intercepts for analysis in Reno.

Fifteen days in office and at UofA doing XRD, whole rock and thin section work. Reports were written for all of the previously mentioned. Also got the UofA started on K-Ar dating illite from the Yarnell Fault.

### Thunder Mountain Project, Santa Cruz County, Arizona - EA-0042

Seven days in field locating old drill sites, marking proposed new drill sites, showing them to drillers and Forest Service. Also located and helped build barbed wire fences around old workings.

Four days in office writing letters for drill permits and associated paper work.

### Ventura Project, Santa Cruz County, Arizona - EA-0165

Three days in field locating old drill sites and flagging proposed sites. Also showed sites to Forest Service, and located/fenced old workings.

### Dixie Project, La Paz County, Arizona - EA-0472

Two days in field marking proposed drill site and interacting with helicopter EM survey. One day in office preparing for trip.

### Superior East Project, Gila County, Arizona - EA-0010

One day spent surveying.

### Santa Cruz Project, Pinal County, Arizona - EA-0075

One day spent surveying.

## GENERAL EXPLORATION

### Gleeson Reconnaissance, Cochise County, Arizona - Au

Three days in field sampling and observing two claim blocks. Three days spent in preliminary investigation and writing report. Au mineralization most likely in thin zones. No further action will be taken.

### Little Harquahala Reconnaissance, La Paz County, Arizona - Au

One day spent in preliminary investigation, two days in the field, and two days writing report. Low angle structure produces very low values, thin high angle structure produced one or two good values. No further action recommended.

### Miscellaneous

Six days spent on general bookwork, truck maintenance and on warehouse work.

Great Basin Symposium (8 days) included visit to Carlin Trend.

One day spent at Copperstone open pit, Arizona's largest gold mine.

JJM:mek

John J. Malusa

ZDS ? Jul

JDS.

ASARCO

Great Basin Exploration Division

90 M
90 R

Give more detail on your monthly reports, esp drilling info & results, as per this copy.
JDS.

sent 8/2/99 mek

July 27, 1990

RECEIVED
AUG 1 1990
EXPLORATION DEPARTMENT

TO:

FROM:

Monthly Report
July, 1990

The following report summarizes activity within my area of responsibility during the month of July, 1990:

1. Cooper Peak Project, Eureka County, Nevada (Au): Reverse-circulation drilling has been completed at 14 sites at Cooper Peak. The nine additional holes are located at the sites described in previous monthly reports and in my memo to P.G. Vikre dated 6-15-90, a copy of which was forwarded to your office. Analytical results have been received for 12 of the holes; unfortunately, no significant Au intercepts occurred in any of the drilling. Anomalous Au is somewhat widespread in the intervals drilled and correlates with silicified and leached areas of carbonate rock; however, ore grades are not present and the distribution of drill holes precludes missing any significant target at Realgar Ridge. Pending the results of the final two drill holes, a reevaluation of the project may be warranted.

2. Lodestar Project, Nye County, Nevada (Zn-Pb): All mapping and sampling at Lodestar has been completed. Although outcrop of Ordovician Hanson Creek Formation has been documented over 3 miles of strike length, the best targets, based on rock-chip geochemistry, remain centered around Section 20 which includes the Discovery Area. Reconnaissance mapping and sampling adjacent to the property did locate an impressive mass of the Mineralized Unit (MU) several miles south of the property; however, rock geochemistry was negative for Pb and Zn.

Reverse-circulation drilling began at Lodestar on July 23rd. The first four holes have been completed, shown as PDH-9, -10, -11, and -12 on my memo of 6-7-90 to P.G. Vikre. All the holes were deepened as the dolomite-MU contact occurred approximately 40 feet deeper than anticipated. Proposed drill hole 12 was continued to 350 feet because the MU was thicker at this location than shown in section. The following sequence will be used for the remainder of the Lodestar drilling: PDH-7, -13, -14, -15, -16, -4, and -6. If early analytical results or drill cuttings are favorable, PDH-8 and two alternate sites near PDH-15 and -16 will be drilled if funds are available.

JDS

**ASARCO**

Southwestern Exploration Division

August 2, 1990

much better

J.D. Sell

J.J. Malusa
Monthly Report
July 1990

Yarnell Project, Yavapai County, AZ - EA-0444

Completed reports pertaining to XRD work performed on green clay mineral and whole rock analysis of altered footwall granite. The green clay mineral was determined to be nontronite, an Fe rich montmorillonite. While the whole rock data suggests an introduction of potassium and a depletion in sodium in altered granite with respect to unaltered granite.

Thunder Mountain Project, Santa Cruz County, AZ - EA-0042

Arranged for road maintenance; excavation of mud pits and drilling supplies (i.e. wood blocks, marking pens, storage trailer and core boxes). Got drillers started on hole BB-2 which is located on the same drill site as TM-8. The hole is orientated S45°W34° and has been drilled to a depth of 446 feet as of July 31. So far the rock consists of a quartz feldspar porphyry that is highly sericitized with pyrite and chalcocite. Below 352 feet there is a different unit. This unit is a xenolithic quartz feldspar porphyry that contains less sericite and is more siliceous.

Ventura Project, Santa Cruz County, AZ - EA-0165

Same as Thunder Mountain project with the exception that drillers are working on hole V-39 which is located on the same drill site as V-1, 2, 3, & 4. The hole is vertical and has been drilled to a depth of 210' as of July 28th. So far rock encountered consist of a highly oxidized altered granodiorite down to 69 feet. From 69 to 81 feet there is an oxided andesite dike which is underlain by a brecciated zone (81 to 82 feet). From 82 to 210 the rock is vuggy unoxidized and contains up to 10% pyrite.

Expenditures for both drill holes BB-2 and V-39, as of July 25, and their locations are shown on the attachments.

| Field | Days | Office Days | Expense Account | Vehicle Expense |
|---|---|---|---|---|
| July | 12 | 8 | $274.27 | $700.00 |
| YTD | 60 | 80 | $3,175.17 | $2,413.00 |

John J. Malusa

JJM:mek

John J. Malusa

LE BB-2 PROJECT Thunder Mtn EA-0042 26th June THRU 25th July, 19__ CONTRACTOR CBC

June — July

SCRIPTION:

| | 26 | 27 | 28 | 29 | 30 | 31 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | TOTAL | PRICE | AMOUNT |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| T DRILLED | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| -12 rotary | | | | | | | | | | | | | | | | | | | X | | | | | | | | | | | | | | | |
| 2 -162 | | | | | | | | | | | | | | | | | | | | | | | | 3 | 14 | 38 | | | 13 | 28 | 54 | 150 | 18.90 | 2835.00 |

SUB TOTAL 2835.00

| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MENTING | | | | | | | | | | | | | | | | | | | 6 | 4 | | | | | 1 | | | | | | | 11 | 55.00 | 605.00 |
| NDITIONING | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| SING | | | | | | | | | | | | | | | | | | | | 4 | | | | 2 | | | | | | | | 6 | 55.00 | 330.00 |
| erburden drilling | | | | | | | | | | | | | | | | | | | 10 | | | | | | | | | | | | | 10 | 60.00 | 600.00 |
| oad work | | | | | | | | | | | | | | | 4 | 3 | | | | | | 1 | | | | | | 3 | | | | 10 | 85.00 | 850.00 |

SUB TOTAL 2385.00

| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| [redacted] | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| ourly Work | | | | | | | | | | | | | | | | 4/4 | 8/8 | 8/8 | | | | | 1 | | | | | | | | | 41 | 55.00 | 2255.00 |

SUB TOTAL 2255.00

| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| UCK RENTAL | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| LEAGE | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| ADS OF WATER | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

SUB TOTAL

| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SC. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Mobilization | | | | | | | | | | | | | | | | X | | | | | | | | | | | | | | | | 1 | 500.00 | 500.00 |

SUB TOTAL 500.00

TOTAL 7975.00

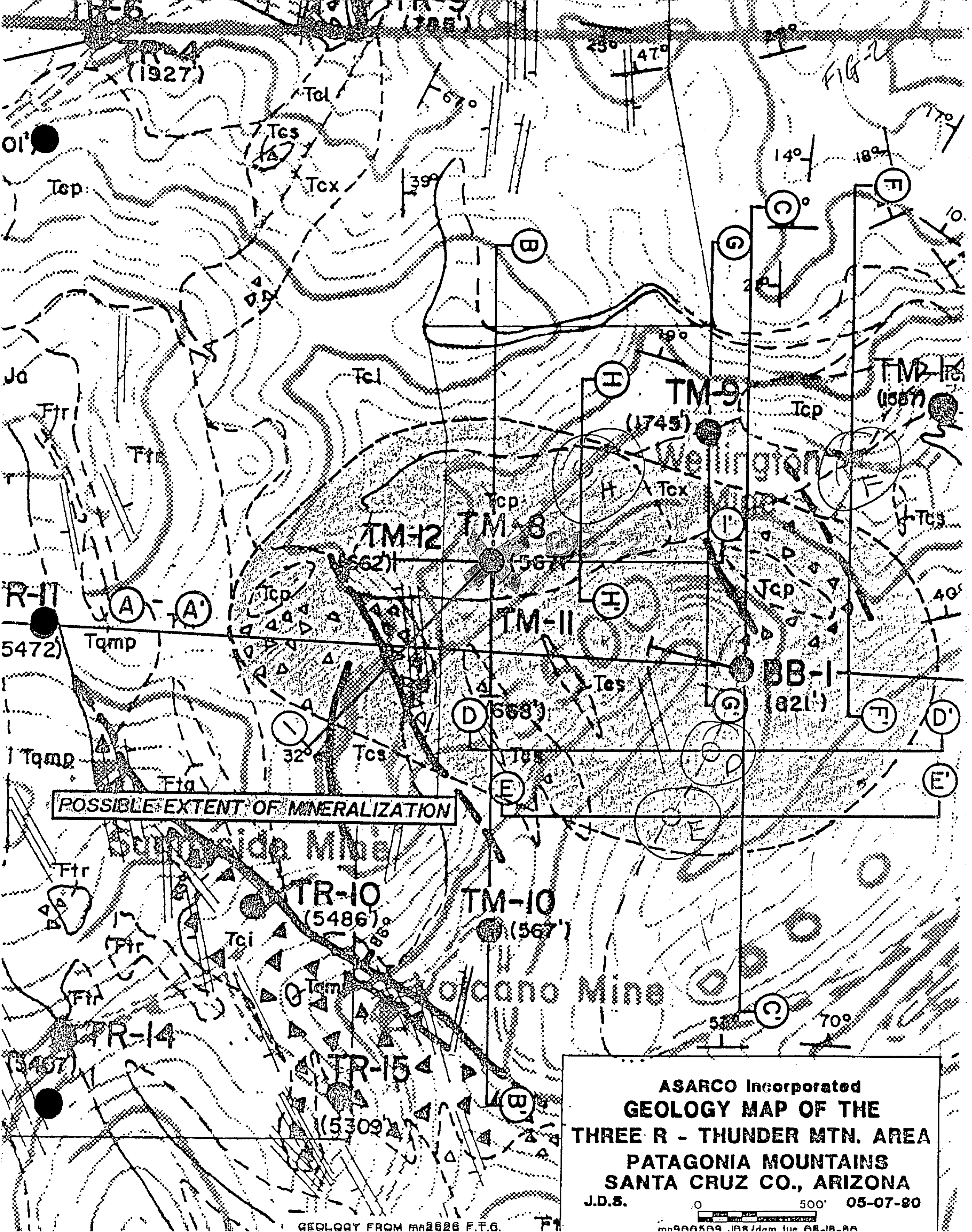


FIG 2
POSSIBLE EXTENT OF MINERALIZATION
TM-12
TM-8
TM-9
(1745')
TM-11
TM-10
(567')
DB-1
(821')
TR-10
(5486')
TR-14
TR-15
(5309')
R-11
5472)
Wellington
Volcano Mine
Tcl
Tcs
Tcx
Tcp
Tamp
Ftr
Tci
ASARCO Incorporated
GEOLOGY MAP OF THE
THREE R - THUNDER MTN. AREA
PATAGONIA MOUNTAINS
SANTA CRUZ CO., ARIZONA
J.D.S.
0
500'
05-07-90
GEOLOGY FROM mn2626 F.T.G.

HOLE V-39 PROJECT Ventura EA-0165 26th June THRU 25th July, 19 90 CONTRACTOR CBC

DESCRIPTION: ← June →|← July →

| | 26 | 27 | 28 | 29 | 30 | 31 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | TOTAL | PRICE | AMOUNT |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| FEET DRILLED | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 55 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 15 | | 40 | 55 | 17.40 | 957.00 |
| 5 feet rotary | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 60 feet total | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

SUB TOTAL 957.00

| | 26 | 27 | 28 | 29 | 30 | 31 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | TOTAL | PRICE | AMOUNT |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CEMENTING | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 1 | 1 | 55.00 | 55.00 |
| CONDITIONING | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| CASING | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 1/2 | | | 1/2 | 55.00 | 27.50 |
| overburden drilling | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 1 1/2 | | | 1 1/2 | 90.00 | 90.00 |
| Water | | | | | | | | | | | | | | | | | | | | | | | | | | 1000 | | | 1000 | | | 2000 | $5/1000 gals. | 10.00 |
| road maintenance | | | | | | | | | | | | | | | | | | | | | | 8 | 5 | | | | | 4 1/2 | | | 4 | 21.5 | $71/hour | 1535.84 |

SUB TOTAL 1718.34

| | 26 | 27 | 28 | 29 | 30 | 31 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | TOTAL | PRICE | AMOUNT |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| [redacted] | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Hourly work | | | | | | | | | | | | | | | | | | | | | | | | | 6 | 5 | | | | | | 11 | 55.00 | 605 |

SUB TOTAL 605.00

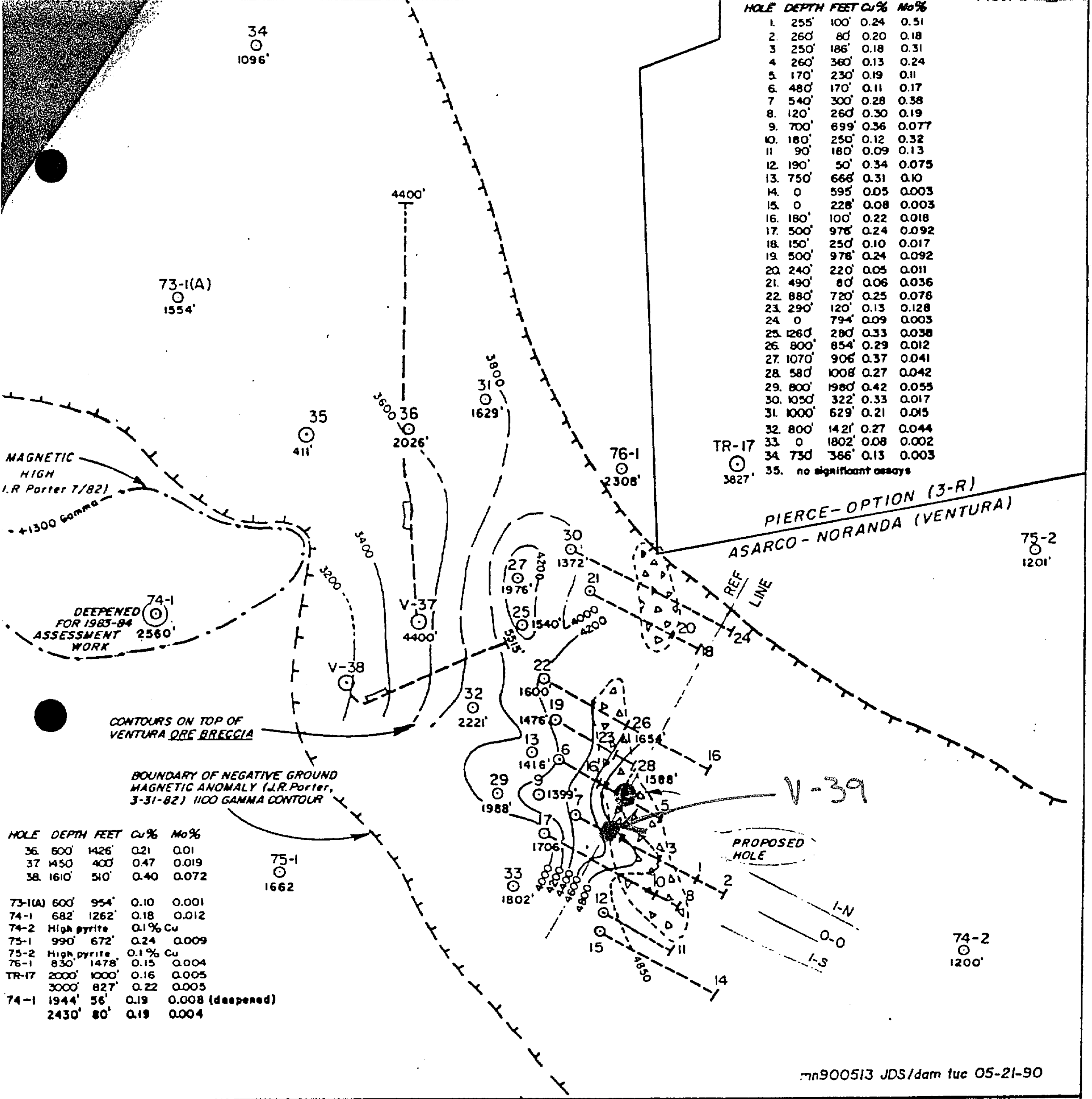
| | 26 | 27 | 28 | 29 | 30 | 31 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | TOTAL | PRICE | AMOUNT |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TRUCK RENTAL | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 8 days | $650/30 days | 160.00 |
| MILEAGE | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| LOADS OF WATER | | | | | | | | | | | | | | | | | | | | | | | | | | 1 | | | 1 | | | 40 miles | 75¢/mile | 30.00 |

SUB TOTAL 190.00

| | 26 | 27 | 28 | 29 | 30 | 31 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | TOTAL | PRICE | AMOUNT |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MISC. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| mobilization | | | | | | | | | | | | | | | | | | | | | | | | X | | | | | | | | 1 | 500 | 500 |

SUB TOTAL 500

TOTAL 3970




| HOLE | DEPTH | FEET | Cu% | Mo% |
|---|---|---|---|---|
| 1. | 255' | 100' | 0.24 | 0.51 |
| 2. | 260' | 80' | 0.20 | 0.18 |
| 3 | 250' | 186' | 0.18 | 0.31 |
| 4 | 260' | 360' | 0.13 | 0.24 |
| 5. | 170' | 230' | 0.19 | 0.11 |
| 6. | 480' | 170' | 0.11 | 0.17 |
| 7 | 540' | 300' | 0.28 | 0.38 |
| 8. | 120' | 260' | 0.30 | 0.19 |
| 9. | 700' | 699' | 0.36 | 0.077 |
| 10. | 180' | 250' | 0.12 | 0.32 |
| 11 | 90' | 180' | 0.09 | 0.13 |
| 12. | 190' | 50' | 0.34 | 0.075 |
| 13. | 750' | 668' | 0.31 | 0.10 |
| 14. | 0 | 595' | 0.05 | 0.003 |
| 15. | 0 | 228' | 0.08 | 0.003 |
| 16. | 180' | 100' | 0.22 | 0.018 |
| 17. | 500' | 978' | 0.24 | 0.092 |
| 18. | 150' | 250' | 0.10 | 0.017 |
| 19. | 500' | 978' | 0.24 | 0.092 |
| 20. | 240' | 220' | 0.05 | 0.011 |
| 21. | 490' | 80' | 0.06 | 0.036 |
| 22. | 880' | 720' | 0.25 | 0.078 |
| 23. | 290' | 120' | 0.13 | 0.128 |
| 24. | 0 | 794' | 0.09 | 0.003 |
| 25. | 1260' | 280' | 0.33 | 0.038 |
| 26. | 800' | 854' | 0.29 | 0.012 |
| 27. | 1070' | 906' | 0.37 | 0.041 |
| 28. | 580' | 1008' | 0.27 | 0.042 |
| 29. | 800' | 1980' | 0.42 | 0.055 |
| 30. | 1050' | 322' | 0.33 | 0.017 |
| 31. | 1000' | 629' | 0.21 | 0.015 |
| 32. | 800' | 1421' | 0.27 | 0.044 |
| 33. | 0 | 1802' | 0.08 | 0.002 |
| 34. | 730' | 366' | 0.13 | 0.003 |
| 35. | no significant assays | | | |

| HOLE | DEPTH | FEET | Cu% | Mo% |
|---|---|---|---|---|
| 36. | 600' | 1426' | 0.21 | 0.01 |
| 37 | 1450' | 400' | 0.47 | 0.019 |
| 38. | 1610' | 510' | 0.40 | 0.072 |
| 73-1(A) | 600' | 954' | 0.10 | 0.001 |
| 74-1 | 682' | 1262' | 0.18 | 0.012 |
| 74-2 | High pyrite | | 0.1% Cu | |
| 75-1 | 990' | 672' | 0.24 | 0.009 |
| 75-2 | High pyrite | | 0.1% Cu | |
| 76-1 | 830' | 1478' | 0.15 | 0.004 |
| TR-17 | 2000' | 1000' | 0.16 | 0.005 |
| | 3000' | 827' | 0.22 | 0.005 |
| 74-1 | 1944' | 56' | 0.19 | 0.008 (deepened) |
| | 2430' | 80' | 0.19 | 0.004 |

## EXPLANATION

V-37 4400' — ASARCO Inc. drill hole showing total depth & (—▭—) mineral intercept

76-1 2308' — Noranda drill hole (V-prefix not shown)

2026' — West Range drill hole (V-prefix not shown)

Ventura breccias, surface expression

NORTH

NOTE: Unsurveyed area, topography flown for Noranda.

DRILLING PROGRESS MAP

# VENTURA PROJECT
## Patagonia Mountains
## SANTA CRUZ COUNTY, ARIZONA

SCALE: 1" = 400'

Feb. 1983
Rev. April 1984

JDS

**ASARCO**

Southwestern Exploration Division

October 4, 1990

J.D. Sell

J.J. Malusa
Quarterly Report
3rd Quarter 1990

## EXPLORATION AUTHORIZATION

### Yarnell Project, Yavapai County, AZ - EA-0444

Four days were spent researching and writing reports pertaining to the potassic alteration (determined through whole rock analysis) and the presence of nontronite (determined through XRD) at Yarnell.

### Thunder Mountain Project, Santa Cruz County, AZ - EA-0042

Thirty-four days were spent on this project. Three core holes have been completed (hole numbers BB-2, 3 & 4). Hole BB-2 intercepted 460 ft. of 0.25% Cu and 0.18 opt Ag between 40 and 500 feet. Hole BB-3 intercepted 76 feet of 0.61% Cu between 14 and 90 feet. Hole BB-3 also intercepted 220 ft. of 0.24% Cu between 500 and 720 feet. Assay results for BB-4 are not available as of yet. Drilling has begun on another hole labelled BB-5.

### Ventura Project, Santa Cruz County, AZ - EA-0165

Eighteen days were spent on this project. Drilling is continuing on a deep vertical hole labelled V-39 which is at a depth of 1695 feet as of October 1. Ore intercepts for V-39 include 180 feet of 0.29% Cu between 20 and 200 feet, and also 460 feet of 0.23% Cu and 0.262% Mo between 200 and 660 feet.

## MISCELLANEOUS

Eight days were spent on general book work, truck maintenance and locating a new vehicle to purchase for the Exploration Department.

John J. Malusa

John J. Malusa

JJM:mek

cc: W.L. Kurtz

? NYO on this
~~[illegible]~~ MMM
participation

---

? send copy
of MMM Final
Report to
Norgold ??

JVS — [illegible] ✓

**EXXON** COAL AND MINERALS COMPANY

POST OFFICE BOX 1314 • HOUSTON, TEXAS 77251-1314

MINING COORDINATION & RESOURCE MANAGEMENT

October 25, 1990

Mr. Tench Page
Norgold Resources
4600 Kietzke Lane
Suite G 177
Reno, Nevada 89502

Dear Tench:

As per our earlier conversation(s), this letter will serve as formal notification of your participation in the 1992 Joint Society of Economic Geologists (SEG) / Society of Mining, Metallurgy, and Exploration (SME) geology program, at the Annual Meeting of the SME, a member society of the American Institute of Mining, Metallurgy and Petroleum Engineers, Inc. (AIME). The meeting will be held in Phoenix, Arizona from Monday February 24 through Thursday February 27, 1992. Technical sessions will be at the Phoenix Civic Plaza and SME Headquarters will be at the adjacent Hyatt Regency. There will be a one day field trip to the Jerome massive sulfide camp on Friday the 27th. This trip will be sponsored by the SEG with support from SME.

The focus of the program is quite broad and sessions are planned to cover general topics, specific deposits, description, and operational support geology. Both theoretical and/or practical aspects will be covered on porphyries, skarns, bulk mineable gold, SMS, and VMS deposits in the cordillera form Chile to Alaska. Thirty six papers are anticipated and thirty two authors, including yourself, have indicated a desire to provide a presentation.

Your paper on the *Yarnell Gold Deposit - Arizona* will form an important technical contribution to the members of the two societies and the overall success of the program. We thank you in advance for your support. Please provide a proposed title and sign and date the enclosed Speaker Form and return to A. J. Erickson, Jr, in the envelope provided, at your earliest convenience, hopefully no later than December 1, 1990.

You will be contacted directly by the SME and provided with a Suggestion to Authors guide, Abstract form, and appropriate Preprint forms for the Preprint Manuscript. Preprints tend to average about ten typed pages, including illustrations and bibliography, but their is no set minimum or maximum. Preprints are an important source of technical information interchange, and are in heavy demand by the membership. If the author desires the preprint will be reviewed for possible publication by the SME in other of its technical publications. Preprints also serve as a distillation of information on the topic at the time and hence serve as a basis for more extensive publications by the author at a later date. Your preparation of the preprint is therefore strongly urged.

Key dates are as follows:

| | |
|---|---|
| · December 1, 1990 | Speaker Form to AJE, Jr., Houston |
| · August 1, 1991 | Abstract due SME, Headquarters, Denver |
| · November 1, 1991 | Preprint Manuscript due SME, Headquarters, Denver |
| · February 24 - 27, 1992 | Oral Presentation, Phoenix |

All of these dates are extremely important particularly the August 1, 1991 date as abstracts are needed for advance program printing. (Abstracts require only a minimal effort.) Please abide by these dates, or if possible supply the appropriate item in advance of the stated date.

Again, we thank you for your support.

A. J. Erickson Jr.

A. J. (Joe) Erickson, Jr.
Program Cochairman - SEG

for Dieter A. Krewedl

Dieter A. Krewedl
Program Cochairman - SME

# SPEAKER FORM

SEG / SME
1992 Annual Meeting
February 24 - 27
Phoenix, Arizona

A. J. Erickson, Jr.
Exxon Coal and Minerals Company
2401 South Gessner
Houston, TX 77063-2005

The title of the paper I/we wil be presenting at the 1992 Annual Meeting in Phoenix will be: THE GEOLOGY AND GOLD MINERALIZATION OF THE YARNELL MINE YAVAPAI CO, ARIZONA

The author(s) will be: TENCH PAGE, MARK MILLER

The paper will be presented by: ______

I/we will ____/will not ____ be providing a manuscript for Preprint publication.

Signed: [signature]

Print Name: MARK MILLER

Date: 11-13-90

copper, gold and arsenic soil anomalies that were

**ASARCO**

JDS — This has NY approval for publication?

Southwestern Exploration Division

July 19, 1991

JDS — be sure and do so

yes, for AGS field trip but will call FTG on revised, more formal presentation. JD

M.A. Miller

Yarnell Paper Request
AGS Digest 19
Proterozoic Geology &
Ore Deposits of Arizona

7/23 FTG says revised manuscript must be sent to NY for review. MAM has been notified. JD

Karl Karlstrom, co-editor of the planned volume 19, has returned the manuscript with a number of suggested correction, clean-up, additions. Ed DeWitt, the other co-editor, is also sending his comments. See Karl's letter for other details.

You need to:

1. Call Bema and secure permission to have the paper published. You might send them a copy of the original paper and tell them that it is being revised.

2. Determine if Bema wants to co-author paper. Revise acknowledgements to reflect Bema's ownership/lease.

3. If all is go, secure DeWitt's and all other comments, add in, clean up, revise, rewrite, etc. and republish in the GSA style-format which they want this camera ready copy to be in.

4. J.D. Sell to review final draft prior to printing.

5. Send copy to Bema, T. Page (Norgold), etc. and send original camera ready copy to Karlstrom.

James D. Sell

James D. Sell

JDS:mek
Att.

cc: W.L. Kurtz (w/o att.)

JDS — This has NY approval for publication?

**ASARCO**

Southwestern Exploration Division

July 19, 1991

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James D. Sell

James D. Sell

JDS:mek
Att.

cc: W.L. Kurtz (w/o att.)

**ASARCO**

Southwestern Exploration Division

July 19, 1991

M.A. Miller

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AGS Digest 19
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James D. Sell
James D. Sell

JDS:mek
Att.

cc: W.L. Kurtz (w/o att.)

NORTHERN ARIZONA UNIVERSITY

DEPARTMENT OF GEOLOGY

July 15/91

Mark Miller
ASARCO

ASARCO Incorp
JUL 1 7 1991
SW Exploration

Dear Mark,

I am sorry to have taken so long getting back to you. Your paper was sent to me while I was in Mexico, on sabbatical, and has only just recently "surfaced". I hope you have not given up on me, and that you will be able to make necessary revisions so that this paper can be published.

I have asked Ed Dewitt to give this a quick second review. I suggest you wait until you get his review, then put in the recommended changes (his and mine) that you agree with (ones that you feel improve the paper). The next step is to print in double column format (following the style of the GSA Bulletin). If this is a problem for you, I may be able to help. We need a camera-ready copy by August 15 (or before if possible). Camera-ready means that whatever you send us gets photographed and printed in the AGS Digest. I have enclosed sheet that specifies type fonts, margins etc. Please call me, or Ed Dewitt, if questions arise. Ed or I will do an

PO Box 6030 Flagstaff, AZ 86011-6030 (602) 523-4561

editorial check of the camera-ready copy as soon as we get it from you (hence our desire to get it before Aug 15).

The paper is in good shape and will be a good contribution to AGS 19 (Table of Contents enclosed). I personally would be interested in having you add a section (or paragraphs) with your interpretations of the age, tectonic setting, and genesis of the ore. Perhaps the age suggests the deposit is related to Laramide igneous activity - does this possibility fit with the geochemistry of the deposit and regional setting? what age are the dikes? Are they post-Precambrian (ie. unfoliated?). what is the slip on the fault - a reverse fault? and was it related to Precambrian or Laramide deformation?? Even speculations are useful; you know more about the deposit than anyone else and ~~have~~ can at least give us some of the possibilities.

Please give me a call and let me know if you can make the revisions and produce the double-column manuscript, and how soon you can do this. Again, I apologize for my ~~sl~~ having slowed up the process.

Best regards

Karl Karlstrom

# PROTEROZOIC GEOLOGY AND ORE DEPOSITS OF ARIZONA

Karl E. Karlstrom and Ed DeWitt,
Editors

Arizona Geological Society Digest 19
1991

Format Guidelines for AGS digest #19
"Proterozoic Geology and Ore Deposits of Arizona"

Checklist

Text: 10 font, Times Roman

Title: Times-Roman, 14 font, bold____

Name: Times-Roman, 12 font, bold____
Address: Times-Roman, 10 font, plain-italicized____

First Order Section Headings: Times-Roman, 10 font, bold, all caps____
Second Order Section Headings: Times-Roman, 10 font, bold____
Third Order Section Headings: Times-Roman, 10 font, underlined____
Are the sections in order of importance____

Citations ("and others" not "et al")____

Citations of figures "(Fig. 1)" not "(Figure 1)"____
In text: "Figure 1" not "Fig. 1"____

Measurements: m, km, cm, etc.____

Ga, Ma: Billion, Million years before present____
b.y., m.y.: Billion, Million year durations____

Margins: .8 inch left; .75 inch top, bottom; .65 inch right (first page use 1" for top and bottom)____
Columns: 3.4 inches wide____
Center space: .25 inches between columns____

Figure captions indented: 5 spaces then first line____

Figure captions Times-Roman, 10 font, bold____

Figure captions don't occur before mention in text____

Do citations match the references____

References Times-Roman, 10 font, first line indented 5 spaces____

Are references in the proper format (GSA format writes out complete journal name)____

Citations for papers in this volume not listed in references cited: correct format - (Bryant and Wooder this volume)______________________________________________

All other format questions: try to match GSA Bulletin double column format_________

Do not number pages________________________________________________

# ARIZONA GEOLOGICAL SOCIETY DIGEST 19
# PROTEROZOIC GEOLOGY AND ORE DEPOSITS OF ARIZONA

Final Schedule

1. Before July 15, 1991 - submit revised paper in double column, camera-ready format (see attached guidelines) for final editorial check.

2. Before August 15, 1991 - Final (editor-approved, camera-ready) copy due. We will submit final papers to the printer at this time.

# ARIZONA GEOLOGICAL SOCIETY
# DIGEST 19, 1991

## TABLE OF CONTENTS

## FIELD TRIP GUIDE

ASPECTS OF THE GEOLOGY, FAULTING,

AND GOLD MINERALIZATION AT THE

YARNELL DEPOSIT

YAVAPAI COUNTY, ARIZONA

A FIELD GUIDE

Mark Miller -
ASARCO
602-792-3010

Call to see if he would
be interested in submitting
this for Digest 19.

M.A. Miller
J.D. Sell
November 1990

ASARCO
P.O. Box 5747
Tucson AZ 85703

## ABSTRACT

Mining?

The Yarnell deposit, located in the Weaver District of Yavapai County, Arizona is a structurally controlled hydrothermally altered zone that hosts economic gold mineralization. The deposit is hosted by a Precambrian granite and mineralization occurs within and surrounding a low angle fault structure known as the Yarnell Fault. The hanging wall of the fault has been extensively fractured and altered to sericite (phyllic alteration). Gold mineralization is associated with iron oxides and the development of multiple quartz veins and quartz stockwork. The footwall of the fault is phyllicly altered, but unmineralized with respect to gold. The Yarnell Fault Zone (YFZ) continues both northeast and southwest from the main deposit and, where exposed, contains gold. However, the thickness of the zone and associated alteration envelope diminish away from the orebody. Ninety-six reverse circulation holes and four diamond drill holes outline a mineral inventory of plus four million tons at 0.055 opt gold. Estimated recovery by column leaching exceeds 70%. An additional 2.7 million tons at 0.017 opt gold occurs in a low grade zone above the mineralized zone.

you do not use this abbreviation much in the paper and can do without it all together if you wish

Yarnell Fault is not a registry name

note - small "f" for faults follows USGS convention.

## LOCATION AND HISTORY

The Yarnell Gold Deposit is located in the Weaver Mining District on the southwest side of the Weaver Mountains, Yavapai County, Arizona (Figure 1). ~~The deposit is situated very close to the drainage divided between the Yarnell/Peoples Valley watershed and the Congress Valley watershed.~~ The deposit is one mile south of the Town of Yarnell. U.S. Highway 89 is within 300' from the downdip extent of the known economic deposit. Elevations within the deposit range from 4650' to 5100' above MSL and the climate is conducive for year round operation.

Historical production for the Yarnell Deposit was derived from underground and limited production from the open cut on the top of the hill. Winslow Mining Company operated the property from 1939 through 1942 and mined the majority of the 200,000 tons which is the total estimated production. Average grade of the ore was reported to be 0.2-0.3 opt gold mined exclusively from the Yarnell Fault Zone. The mine closed in 1942 due to L-208; the Federal gold mine closure order.

Asarco's interest in the property was initiated in 1988 when Norgold Resources, a Canadian company, published the results of rock chip sampling from the implied width of the mineralized zone. The resultant grade suggested a bulk tonnage open pit target. Asarco examined and sampled the property confirming Norgold's results. A letter of agreement was signed with Norgold in late January 1989 for an exploration option on the property. A mapping and detailed rock chip

? better word?

sampling program was completed at which time a nine hole drill program began. Drilling results confirmed the bulk tonnage open pit potential of the deposit. Three phases of drilling were completed totalling 25,662 feet. This consisted of 96 reverse circulation and four diamond drill holes (twins to the reverse circulation holes) which completed the drilling program.

capital "G" implies formal name. Informal name would be granite at Yarnell

## GEOLOGY

The Yarnell gold deposit occurs within a granite/granodiorite intrusive body informally called the Yarnell Granite (Anderson 1989). The granite intrudes a sequence of metavolcanics and metasedimentary rocks of the Bradshaw Mountains Group. Xenoliths and roof pendents of country rock are common with the granite and probably resulted from "stoping" and "rafting" as the granite intruded. ~~A recently completed PhD dissertation by~~ Anderson (1989) describes the Yarnell Granite as follows:

& Anderson (1984)

??

be consistent, use either Yarnell Granodiorite (following Anderson 1984) or granodiorite of Yarnell (following DeWitt, 1989) I suggest the latter

> "The Yarnell Granodiorite (new formal name), is a foliated, coarse-grained porphyritic granodiorite to monzogranite, .... The Yarnell Granodiorite follows the northwest edge of the Stanton-Octave metavolcanic-metasedimentary screen to as far north as Wilhoit, where dikes of unfoliated Yarnell Granodiorite intrude foliated granodiorite of the Wilhoit batholith .... The Yarnell Granodiorite is distinctly coarse-grained and weakly foliated, with large pinkish-tan K-feldspar phenocrysts in an equigranular matrix with biotite, plagioclase, uncommon hornblende, and abundant sphene .... Chemically the Yarnell body is metaluminous high-K, calc-alkaline, high Fe-Ti and high-total alkali rock ...."

The granite has not been dated, but

Anderson (1984) places the age of the Yarnell pluton in the 1730-1710 Ma range. based on lithologic similarity to ~~[illegible]~~ dated granites in Arizona

Table 1 compares the three samples of granodiorite (DeWitt, 1989) with samples taken at the Yarnell Mine. DeWitt's sample #72 was collected about one mile north of the mine area, sample #73 about one mile west, and sample #74 at the base of Weaver Mountain. Malusa's samples were collected in the freshest granite in the hanging wall and footwall of the Yarnell Fault.

need sentence interpreting the geochem. data. Do you find that analyses are similar (especially alkalis) and this pluton seems to be fairly uniform in composition

Table 1. Major Element Chemistry - Yarnell Pluton

| | Granodiorite (DeWitt) | | | Biotite Granite (Malusa) | |
|---|---|---|---|---|---|
| | 72 | 73 | 74 | HW | FW |
| $SiO_2$ | 67.4 | 66.3 | 65.1 | 70.0 | 69.8 |
| $Al_2O_3$ | 14.5 | 14.1 | 14.3 | 14.3 | 14.4 |
| $Fe_tO_3$* | 4.98 | 5.45 | 6.65 | 4.76 | 5.02 |
| MgO | 1.17 | 1.22 | 1.52 | 1.00 | 1.10 |
| CaO | 2.57 | 2.84 | 3.43 | 2.60 | 2.30 |
| $Na_2O$ | 3.08 | 3.10 | 3.14 | 3.20 | 3.10 |
| $K_2O$ | 4.18 | 4.33 | 3.78 | 4.10 | 3.90 |
| $TiO_2$ | 0.80 | 0.79 | 1.02 | 0.70 | 0.85 |
| $P_2O_5$ | 0.27 | 0.34 | 0.39 | 0.45 | 0.55 |
| MnO | 0.12 | 0.11 | 0.13 | 0.11 | 0.13 |
| Total | 99.07 | 98.58 | 99.72 | 101.22 | 101.15 |

*$Fe_tO_2$, total iron as $Fe_2O_3$

This ¶ seems out of place here - could perhaps go a bit later

DIKES

The Yarnell fault is cut by and associated with several types of dikes that are dioritic, felsic and andesitic in composition. Diorite dikes are found in both hanging wall and footwall of the Yarnell ~~Fault~~ fault. The most prominent dioritic dike trends N10°W and dips 80°SW and crosses the Yarnell ~~Fault~~ fault, but it does not offset nor is it offset by the fault. Andesitic and felsic dikes are proximal and subparallel to the Yarnell ~~Fault~~ fault and have been found only in the footwall of the structure. curious

The Yarnell Granite is bordered on the southeast by mafic metavolcanics and metasedimentary rocks of the Bradshaw Mountains Group. Mid-Tertiary flows of andesitic and basaltic composition cap the hills and ridges north and northeast of the deposit.

this ¶ could easily follow previous discussion of granodiorite at Yarnell.

ALTERATION (Figures 2 & 3)

Alteration at the Yarnell ~~Gold~~ gold ~~Deposit~~ deposit varies from propylitic to potassic. The strongest alteration is centered within the Yarnell ~~Fault~~ fault ~~Zone~~ zone and decreases outward in intensity into the footwall and hanging wall.

Propylitic Zone - This zone is characterized by chlorite, epidote, minor calcite veining (in the unoxidized footwall) with weak sericitic dusting and replacement by sericite along biotite edges and/or on plagioclase feldspars. In the hanging wall, the propylitic zone may extend up to 100' beyond the phyllic envelope. In the footwall, the propylitic zone is thinner and is usually marked by calcite gash veins.

Phyllic Zone - Biotite and plagioclase have been completely altered to sericite (Table 4, Honea 1990). Secondary iron oxides as limonite, goethite, hematite and leucoxene characterize the oxidized portion of this zone. The unoxidized portion (which occurs in the footwall of the structure) is characterized by extensive silica flooding and sericite which gives the rock a distinctly green color. The phyllic zone extends 30-100' into the hanging wall above the potassic zone and 10-45' into the footwall.

Potassic Zone - Alteration is strongest within the YFZ. Abundant secondary quartz, chalcedony, adularia and clays occur within this highly crushed and tectonized zone. X-ray diffraction studies by Malusa on the clay size fraction of the fault zone suggest the material is fine grained sericite (illite) and adularia. The potassic zone outward from the YFZ is defined by adularia occurring as phenocrysts and selveges to the quartz veins. The altered zone is noted 50-80' above the fault and up to 25' below.

striking

## STRUCTURE

The principal feature that localizes and controls alteration and gold mineralization is the Yarnell Fault Zone (~~YFZ~~); a N30-50°E, 30-50°NW dipping structure wholly contained in the Yarnell Granite. This zone is composed of strong gouge, mylonite, micro-breccia (tectonically derived), quartz veins and chalcedonic replacement within a 3 - 7+ foot zone. There is abundant clay in the zone probably as a result of the fault gouge. A sample of illite from the fault (Shafiqullah, 1990) gave an age of 69 million years; +/- 1.6 million years. This date is probably indicative of regional cooling and uplift and suggests that the mineralization is no younger than the illite date. Tertiary extension (detachment style faulting) i~~s not related~~ to ~~this~~ This deposit is apparently not related to

The fault has been traced two miles to the southwest where it disappears under the valley alluvium. The fault can be traced to the northeast 1500' from the top of Yarnell hill before it is concealed by debris from the volcanic cap and valley fill which consists of large unmineralized Yarnell granite boulders.

The sheared and crushed zone of the Yarnell Fault complex varies from five to eighty feet in thickness within the drilled part of the deposit. As the structure is followed downdip and along strike the entire zone thins to less than ten feet. The alteration envelope and mineralization also diminish in thickness with the associated thinning of the Yarnell Fault.

There are numerous sub-parallel fractures in the hanging wall that appear to mimic the fault. There are also several northeast-~~trending~~ striking quartz veins that have been mapped on the surface in the hanging wall of the Yarnell ~~structure~~ fault. These structures appear to flatten and "roll" in the underground exposures and may merge with the Yarnell Fault at depth. This orientation suggests a listric nature to these ~~structures~~ veins. The felsic dikes as mapped on the surface sub-parallel the Yarnell Fault in both strike and dip and show similar but much restricted alteration and mineralization. This may represent a "halo" to the main Yarnell deposit.

## MINERALIZATION AND OCCURRENCE

Gold mineralization is associated with several stages of quartz, iron sulfides and oxides (pyrite, specularite). Base metal sulfides have been seen in polished section and ~~implied~~ from trace element geochemistry. Copper minerals (azurite and malachite) are associated with quartz/hematite veins in the underground workings.

their presence inferred

## QUARTZ

Quartz occurs associated with the Yarnell Fault as discrete veins and stockwork. Quartz veins also occur subparallel to the fault.

Paragenesis of the quartz suggests that the Yarnell F ~~fault~~ and subsidiary structures were the earliest event with silica flooding from these structures into the surrounding rocks. Successive movement along the fault and fault-related structures crushed and sheared the quartz. There has also been some remobilization of silica into the YFZ as banded chalcedonic quartz. At least four generations of quartz veining have been identified.

1. Early grey quartz associated with specularite in vugs parallel to quartz veins.

2. Dark grey quartz with some brecciation in the vein; dark color is probably due to fine grained specularite.

3. Lighter grey quartz with disseminated limonite pseudomorphic after pyrite; usually on the margins of the vein.

These three generations of quartz are usually seen as small veins up to 1/4" thick, commonly up to a half inch, and have been noted up to three inches thick in drill core.

4. White quartz has been recognized in at least two stages. These veins appear to cross cut all of the other stages. The white quartz veins have been measured from six inches to one foot in drill core and up to twenty feet thick in the field. These veins will consistently assay from 0.01 to 0.8 opt gold. Visible gold occurs in similar looking veins in diamond drill holes.

IRON OXIDES

Iron oxides occur within this deposit and all are intimately associated with gold mineralization.

Limonite pseudomorphic after pyrite is very common in the oxidized phyllic zone. It occurs as discrete crystals or as intergrowths associated with quartz veins. Polished sections show native gold locked within and at the edges of limonite pseudomorphs.

Goethite occurs as fracture/vein filling and fracture coatings. Goethite also occurs as discrete patches associated with pseudomorphs. The total amount of iron oxides (principally limonite and goethite)

varies dramatically ~~increase~~ within the zone, (and ~~[illegible]~~ composes) up to 4-5% * of the zone.

Hematite is very common within the Yarnell F ~~fault~~ and, when intersected in drill holes, turns the cuttings brick red. Hematite is associated with the highest gold grade and visible gold occurrences. Hematite is also associated with pyrite cubes, especially close to the Yarnell fault. The occurrence of hematite usually indicates increased grade; greater than 0.03 opt gold.

Visible gold is associated with quartz stockwork in association with grey quartz and quartz/specularite veins. The higher gold assays are related to quartz stockwork with adularia. Higher gold assays are also related to the occurrence of hematite and limonite pseudomorphic after pyrite. The highest grade assays are directly related to the Yarnell Fault and abundant (+10%) red hematite and quartz. This was the zone that the old time miners were following and ranged from .01-1.0 opt gold.

Base metals, copper, lead and zinc, occur in the geochemical regime in recent soil within and around Yarnell deposit. Secondary copper as malachite and azurite is associated with late stage quartz/hematite veins. (ref? pers. comm, 19??)

Rasmussen completed a 15 element geochemical ~~geochemistry~~ survey over and around the deposit. The survey was designed to continuously sample rock and soils from the hanging wall zone through the footwall into fresh granite. Samples were collected from rejects of the ~~these~~ reverse circulation holes that tested through the hanging wall and footwall zone and from the main haulage adit that was driven in the hanging wall.

Table 2 compares the values in the drill hole rock geochemistry from that of the soil surveys. Copper values (average) range from a low of 3.7 ppm in hole YM-6, to a high of 28.4 ppm from soil in the hanging wall. Lead and zinc also ~~reflect~~ have? low ppm values.

Table 2. Comparison of Trace Elements
(ppm values) in Main Ore Zone rotary cuttings
and Hanging Wall-Footwall soil samples.

where are these from? HW? FW? YFZ?

| | Ore Zone, Rotary Cuttings ppm | | | HW Soils | FW Soils |
|---|---|---|---|---|---|
| | YM-6 | YM-26 | YM-50 | ppm | ppm |
| No. of Samples | 3 | 4 | 5 | 53 | 61 |
| Cu, average | 3.7 | 18.4 | 17.0 | 28.4 | 19.4 |
| Cu, high | 5.0 | 36.4 | 26.1 | 55.4 | 30.0 |
| Cu, low | 2.6 | 5.1 | 8.7 | 16.3 | 11.5 |
| Pb, average | 7.9 | 69.1 | 8.5 | 24.6 | 21.1 |
| Pb, high | 10.7 | 255.0 | 11.7 | 58.5 | 34.9 |
| Pb, low | 5.9 | 4.7 | 7.1 | 14.5 | 12.5 |
| Zn, average | 28.8 | 59.6 | 41.8 | 86.8 | 60.3 |
| Zn, high | 36.4 | 124.0 | 57.0 | 270.0 | 124.0 |
| Zn, low | 24.1 | 34.3 | 34.8 | 33.7 | 30.3 |

"B" ~~refers to what~~ (the "B" zone)

## MINERAL INVENTORY

Ninety six reverse circulation holes have defined a mineral inventory for the deposit. Gold ~~which~~ occurs in two zones. The main zone (B) is 20 - 155' thick and is closely coincident to the Yarnell Fault. The mineral inventory for the "B" zone is 4.1 million tons at .051 opt gold using a 0.02 opt gold cutoff. The mineral inventory is outlined on the attached geologic map. The "A" zone occurs above the "B" and contains a mineral inventory of 2.7 million tons at .017 opt gold using a 0.01 cutoff. Overall stripping ratios varies from 1.7 to greater than 3.0 ~~waste/ore~~ depending upon the economic parameters.

Waste/ore

## METALLURGY

Numerous bottle roll tests and column leach tests were completed on the deposit. A fifteen ton sample was mined from the ore zone exposed in the open cut to provide a run of mine ore for column leach testing. Results of the column testing are summarized on Table 3.

Table 3. Column Leach Data

| 80% Passing Size | Column Size | Leach Time Days | Head Assay Opt | Tail Assay Opt | Extraction |
|---|---|---|---|---|---|
| 6 inch | 24" dia. x 18 ft. | 111 | 0.046 | 0.022 | 52.2% |
| 2 inch | 15" dia. x 18 ft. | 102 | 0.051 | 0.015 | 70.6% |
| 3/8 inch | 12" dia. x 18 ft. | 79 | 0.055 | 0.013 | 76.4% |

Cyanide consumptions ranged from 0.56 to 0.79 pound per ton ~~or~~ of ore. Consumption rates were fairly constant throughout the leaching cycles. The ten pounds of lime and cement (3/8 inch feed) per ton of ore added to the ore charges as the columns were filled was sufficient to maintain protective alkalinity at above pH 10.5 throughout the test period.

Flotation/Fine Grind/cyanide leach tests were conducted on the Yarnell composite sent to Tucson from McClelland Labs. This head sample of 35 pounds assayed 0.031 opt Au and 2.35% Fe.

In the two flotation tests, ground to -200 mesh, the recoveries were 75%-76% in the final concentrate and 79%-80% in the rougher concentrate.

In the two fine grind/cyanide leach tests, also ground to -200 mesh, the recoveries were 97% in 22 hours of agitated leach. The cyanide consumption was 0.21 pounds per ton or ore and the lime was 3.3 pounds per ton or ore.

The trade-off between high recovery by fine grinding agitated leach and lower recovery by coarse crush/heap leach is a matter of economics.


## ACKNOWLEDGEMENTS

Appreciation is extended to the staff and management of ASARCO Incorporated and Norgold Resources for permission to publish this paper. A number of company reports were used and we would collectively thank those who contributed to the project. We would also thank Bill Gay, Steve Keehner, John Malusa, Tench Page and Jim Rasmussen for their contributions.



M.A. Miller
J.D. Sell


November 1990

we could use either a sample location map, or a brief idea of location of samples

Yarnell Project

Petrographic Descriptions - Russ Honea

Thin Section Location

| | | Primary Minerals % | | | | Secondary Minerals % | | | | | | Silica % | | Iron Oxides % | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sample No. | Alteration Zone | Plagio-clase | Micro-cline | Quartz | Biotite | Sericite | Clay | Chlorite | Calcite | Epidote | Leuco-xene | Quartz/ Adularia | Chalce-dony/Opal | Hematite/ Magnetite | Limonite/ Pyrite(Fresh) | Goethite | Fe Oxide (Undiff.) |
| 150 | Fresh (Weathered) | 25 | 50 | 16 | 7 | 6 | - | 1+ | - | 3 | - | - | - | 1/1 | - | - | - |
| 151 | Fresh (Unweathered) | 25 | 45 | 18 | 10 | - | 3 | 3 | - | - | - | - | - | - | -/<1 | - | - |
| 152 | Weak | 30 | 44 | 15 | 9 | 9 | - | - | - | 2* | <1 | - | - | - | - | - | 1+ |
| 162 | Weak | 28 | 38 | 20 | 8 | 18 | - | - | - | - | 1 | 4 | - | - | - | 3+ | - |
| 163 | Weak/Moderate | (35) | 40 | 15 | (8) | 17 | - | - | - | -1 | 1 | 3 | - | - | 1+/- | - | 3 |
| 164 | Weak/Moderate | (32) | 43 | 16 | (6) | 16 | - | - | - | - | 2 | 2 | - | - | - | - | 1+ |
| 165 | Moderate | (44) | 29 | 20 | (5) | 28 | - | - | - | - | <1 | 5 | - | <1 | - | 2 | - |
| 166 | Moderate | (30) | 55 | 10 | (3) | 8 | - | - | - | - | 1 | 15 (Veins) | - | 2 | - | 2 | - |
| 154 | Mod.Unoxidized | (35) | 45 | 12 | (6) | 20 | 4 | 2 | - | - | 1 | - | - | 1 | -/2 | - | - |
| 155 | Mod. Oxidized | (35) | 41 | 12 | (10) | 20 | - | - | - | - | 1 | - | - | - | - | 1** | 2 |
| | Moderate: Yarnell Fault Zone | | | | | | | | | | | | | | | | |
| 157 | Syenite? | (27) | 66 | 3 | (2) | 2 | 3 | 2 | - | - | <1 | - | - | - | - | 1 | 2+ |
| 161 | Potassic Rims | (24) | 66 | 5 | (2) | 7 | - | - | - | - | 1 | 10/15 | - | <1 | - | - | - |
| 158 | Quartz Stockwork | (36) | 40 | 15 | (8) | 27 | - | - | - | - | 1 | 5 | - | - | - | 2 | 3+ |
| 159 | | (38) | 28 | 25 | (7) | 35 | 2 | - | - | - | 1*** | 15 | - | - | - | - | 2 |
| 160 | | (20) | 62 | 12 | (5) | 10 | 10 | - | - | 1* | <1 | 22 | <1/<1 | - | - | 2 | 4 |
| 161 | Syenite? | (24) | 66 | 5 | (2) | 7 | - | - | - | - | 1 | 10/15 | - | <1 | - | - | - |
| 167 | Mod. | (38) | 32 | 20 | (7) | 20 | - | - | - | - | 2 | 3 | - | - | - | 3 (Hm) | - |
| 168 | Mod./Silic? | (39) | (33) | 20 | (6) | 12 | - | - | - | - | 1 | 4 | - | 1 | 1 | 2 | - |

(27) - Original Mineral Now altered to Sericite

*(Clinozoisite)
**Pseudomorphs
***Rutile

TABLE 4

## REFERENCE


Anderson, P., 1989, Stratigraphic framework, volcanic-plutonic evolution, and vertical deformation of the Proterozoic volcanic belts of Central Arizona, p. 57-147 in Jenny, J.P., and Reynolds, S.J., 1989, Geologic evolution of Arizona : Tucson, Arizona Geological Society Digest 17, 866 pages.

DeWitt, E., 1989, Geochemistry and tectonic polarity of Early Proterozoic (1700-1750 ma) plutonic rocks, north-central Arizona, p. 149-163, in Jenney, J.P., and Reynolds, S.J., 1989, Geologic evolution of Arizona : Tucson, Arizona Geological Society Digest 17, 866 pages.

Honea, R.M., 1990, Various Petrographic Studies - Internal Reports to Asarco.

Shafiqullah, M., Personal Communication, 1990.

Rasmussen, Jim, pers comm —

## Field Trip Stops Figure 2, Table 4

directions needed regarding how to start trip. Ie. proceed from Yarnell, N along highway ---, etc.

Stop (1) Fresh Unaltered ~~Granite -~~ The road cut shows typical examples of weathered Yarnell granite surrounding unweathered core. Petrographic descriptions of the weathered vs. unweathered intrusive ~~is~~ are ~~virtually~~ identical (Table 4).

(2) Propylitic Zone - We have moved from unaltered rock into weak propylitic alteration. Note the sericitic sheen and greenish "tint" to the plagioclase feldspars. The crumbly, decomposed weathering is characteristic of this zone. The haulage adit is driven across dip and ends at the Yarnell Fault. This also connects with additional underground workings (now inaccessible from caving).

(3) Phyllic Zone - The small adit driven into the phyllic alteration sub-parallels the strike of the Yarnell Fault zone. Note the absence of biotite, the complete sericitization of the plagioclase feldspars; abundant iron oxides, and limonite pseudomorphic after pyrite and silification as veining and silica flooding.

(4) This stop traverses along the drainage and follows the strike (N30-40°E 25-30°NW) of the Yarnell Fault. The two near vertical shafts explore the thickness of the mineralized zone. A sample taken from the shaft assayed .23 opt Au. Note the greenish silicified rock on the small dump above the shafts. This is from the unoxidized phyllic zone in the footwall of the Yarnell ~~structure~~ fault. Further up the drainage and along the northwest hillside the Yarnell Fault is exposed in small workings. The small adit at the head of the drainage is driven along the strike of the Yarnell Fault and used to connect with the main haulage tunnel. This is now badly caved and inaccessible. Note the highly fractured rock in the hanging wall of the fault and the amount of iron oxide that occurs within the mineralized zone. The amount of fracturing plus iron oxide is typical of the ore zone.

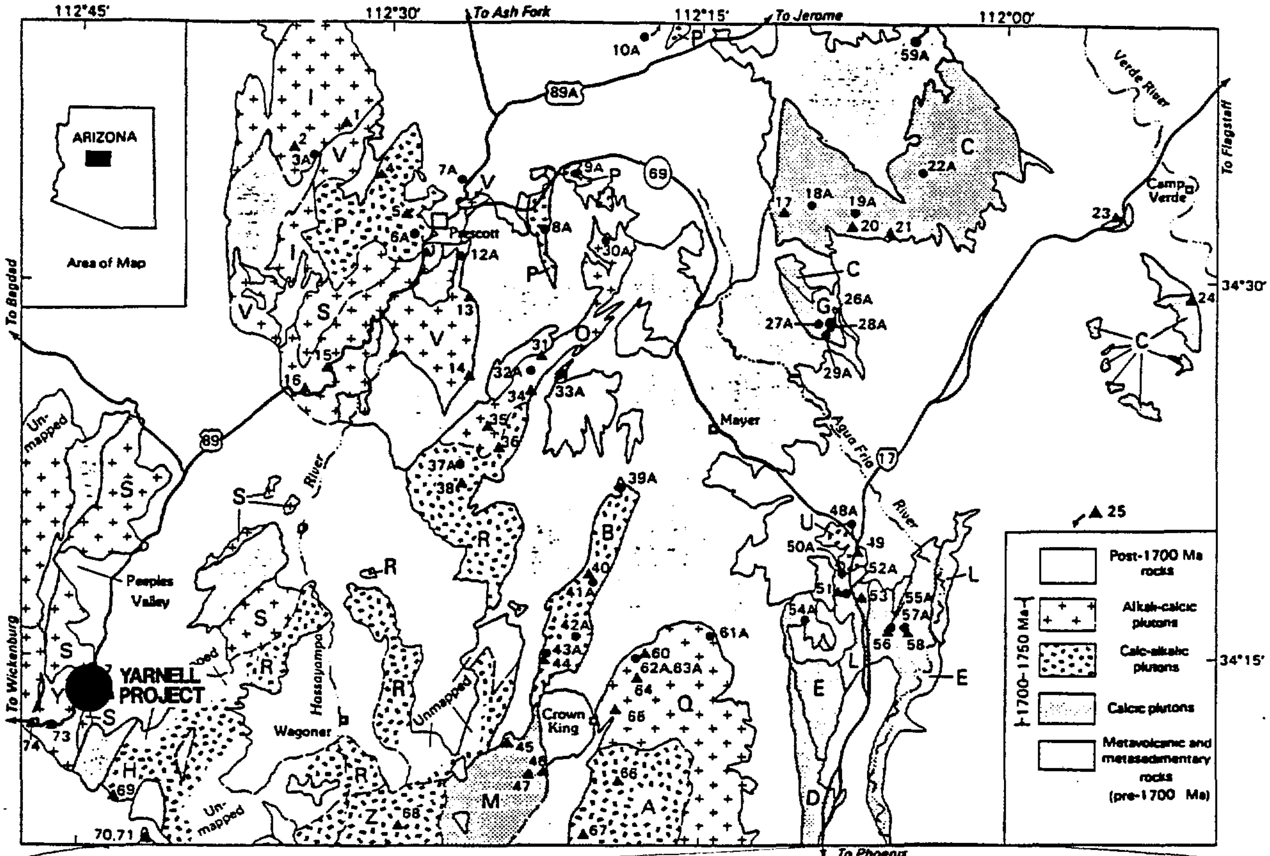
(5) Weathered diorite dike is exposed along the road. The dike trends N10°W dipping 80°SW. This dike crosses the Yarnell Fault. The greenish brown soil is typical of the weathering of the dike.

(6) Some of the larger quartz veins are exposed in the drill roads and road cuts. We are also standing on the outcrop of the upper altered zone. Underground, the quartz vein steepens and then appears to flatten, possibly merging into the Yarnell Fault at depth.

(7) The best surface exposure of the Yarnell ~~F~~fault ~~Z~~zone and hanging wall structures is the open cut. High grade gold mineralization is confined to a 4-6' zone which assays 0.1-0.5 opt gold. Potassic alteration in the form of adularia occurs within this zone and in the footwall of the Yarnell ~~F~~fault. Note the large amount of hematite and hematitic staining in the fault zone. The few timbers sticking up through the muck are from underground stopes that were "daylighted" by the open cut.

(8) This stop is in the oxidized footwall of the Yarnell ~~F~~fault. The rocks are phyllicly altered and quartz veining is evident parallel to the structure. These rocks are weakly anomalous (— opt gold) with respect to gold.

# FIGURE 1

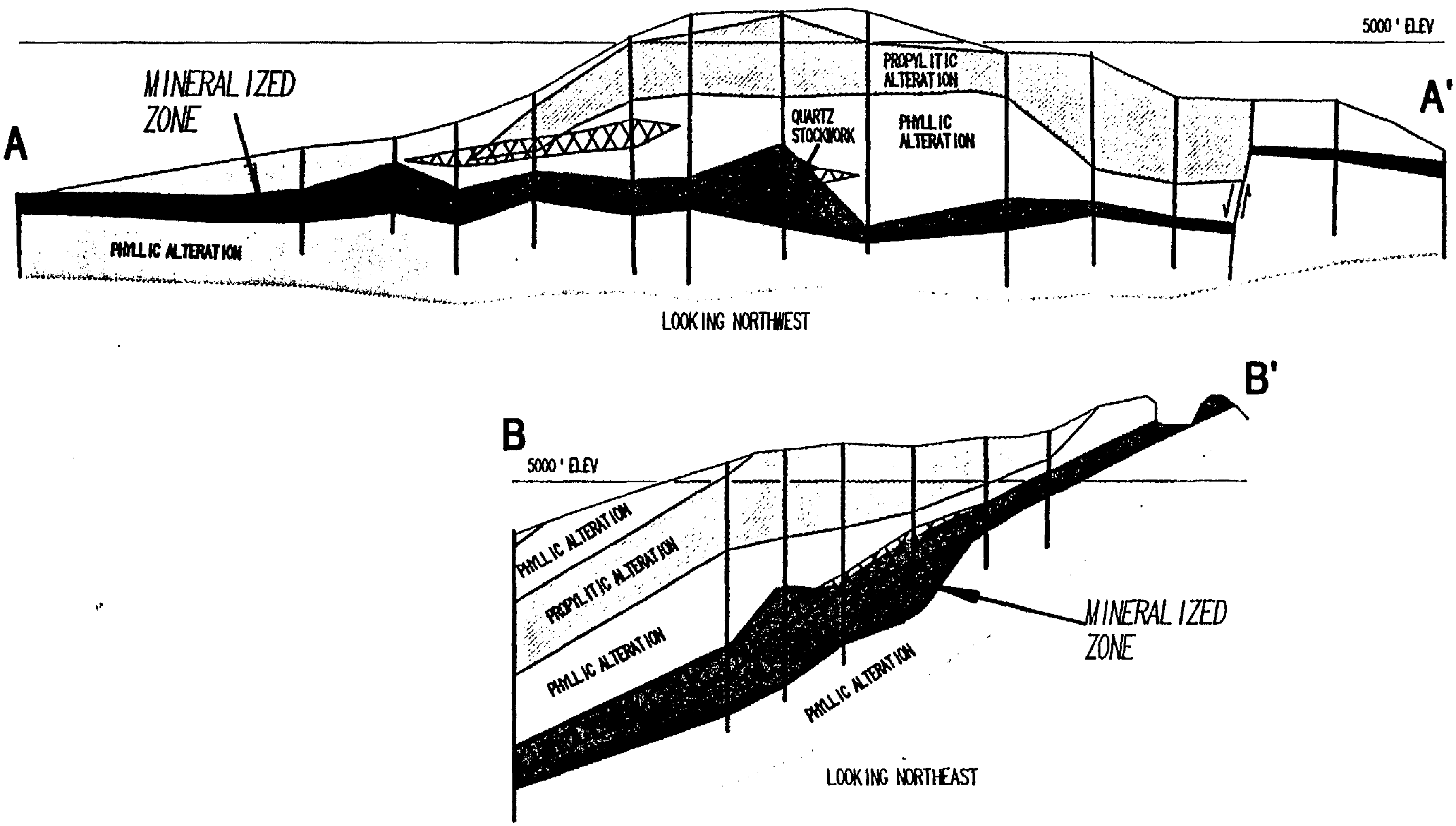



Simplified geologic map of the Prescott area, ~~north-central Arizona,~~ showing Early Proterozoic and post-Early Proterozoic rock units. Data from Krieger (1965, 1967), Anderson (1972), Anderson and Creasey (1958, 1967), Anderson and Blacet (1972a, 1972b, 1972c), DeWitt (1976, 1979), Jerome (1956), Light (1975), Hook (1956), Pflafker (1956), Wolfe (1983), and unpublished reconnaissance mapping by the author. All contacts, whether depositional, intrusive, or fault-related, are shown by the same kind of line. The Early Proterozoic metamorphic units (both pre- and postplutonic) consist of volcanic and sedimentary protoliths intruded by gabbroic masses. Sample numbers without an A are from this study. Sample numbers with an A are published and are from: Lee, 1984 (3A and 7A); Anderson and Blacet, 1972b (12A, 18A, 19A, 22A, 26A, 27A, 28A, 29A, 32A, 33A, and 37A); Anderson, 1972 (48A, 50A, 52A, 54A, 55A, and 57A); Krieger, 1965 (6A, 8A, 9A, 10A, and 30A); Anderson and Creasey, 1958 (59A); Blacet, 1968 (39A, 41A, 42A, 43A, and 62A), and Vrba, 1980 (61A and 63A). A, granodiorite of Lane Mountain; B, Brady Butte Granodiorite; C, tonalite of Cherry; D, quartz diorite of Bland; E, Badger Spring Granodiorite; G, granophyre of Cherry; H, granite of Rich Hill; I, granite of Iron Springs; L, Bumblebee Granodiorite; M, granodiorite of Minnehaha; O, Crooks Canyon Granodiorite [north]; P, Prescott Granodiorite; Q, Crazy Basin Quartz Monzonite; R, Crooks Canyon Granodiorite [south]; S, granodiorite of Wilhoit; U, granodiorite of Big Bug Creek; V, Government Canyon Granodiorite; Y, granodiorite of Yarnell; Z, granodiorite of Hozoni Ranch.

Figure 1. Yarnell ~~P~~ P roject and regional geologic map of north-central Arizona (DeWitt, 1989, p. 150)

incorporate into new Fig. caption

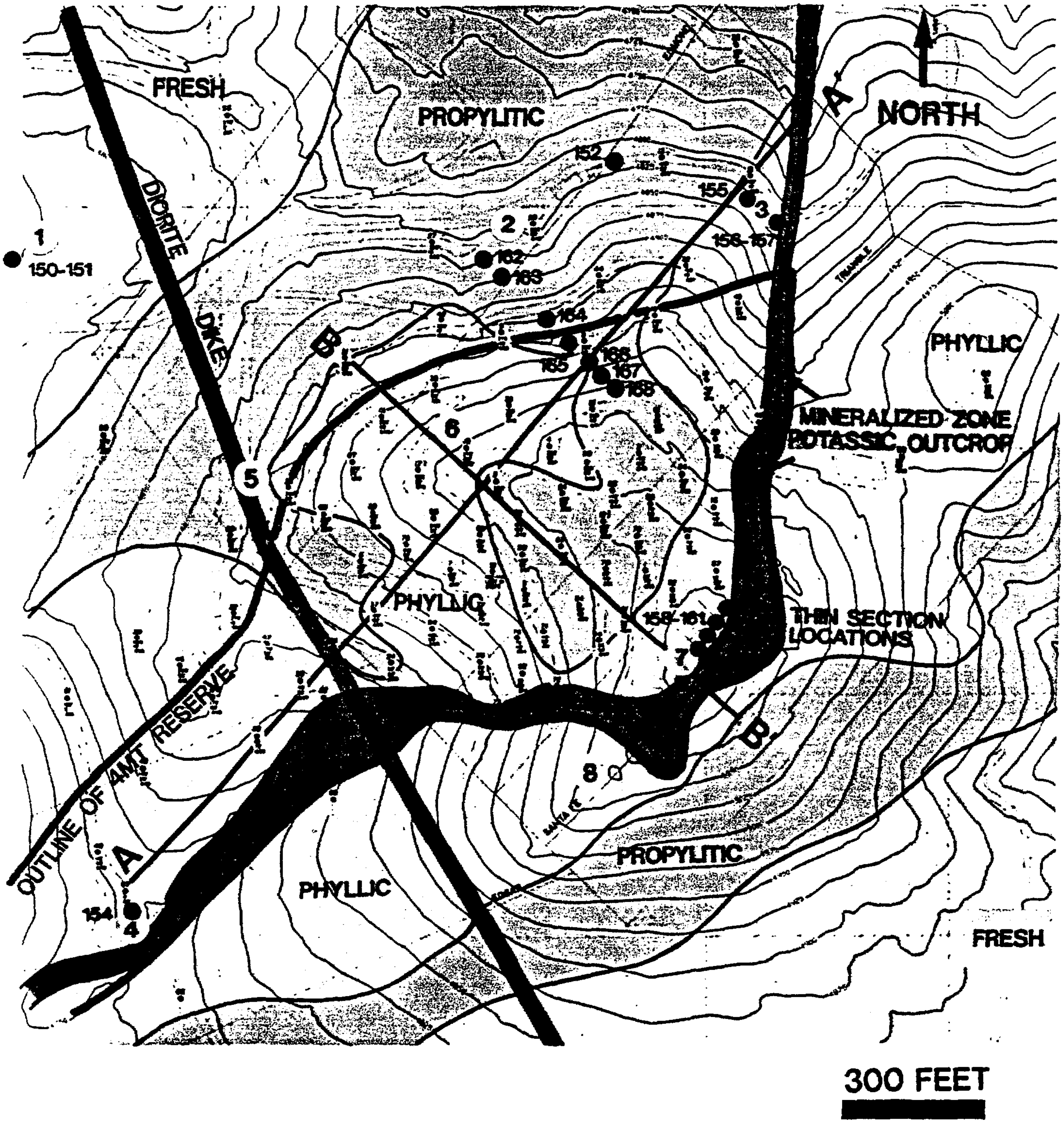
**YARNELL PROJECT**
**INDEX and GEOLOGY MAP**




# YARNELL PROJECT
# GEOLOGIC SECTIONS

FIGURE 3

FIGURE 2




YARNELL PROJECT
GEOLOGY

**ASARCO**

Southwestern Exploration Division

July 19, 1991

M.A. Miller

Yarnell Paper Request
AGS Digest 19
Proterozoic Geology &
Ore Deposits of Arizona

Karl Karlstrom, co-editor of the planned volume 19, has returned the manuscript with a number of suggested correction, clean-up, additions. Ed DeWitt, the other co-editor, is also sending his comments. See Karl's letter for other details.

You need to:

1. Call Bema and secure permission to have the paper published. You might send them a copy of the original paper and tell them that it is being revised.

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4. J.D. Sell to review final draft prior to printing.

5. Send copy to Bema, T. Page (Norgold), etc. and send original camera ready copy to Karlstrom.

James D. Sell

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# Geology and mineralization at the Yarnell gold deposit, Yavapai County, Arizona

MARK A. MILLER *Asarco Inc., P. O. Box 5747, Tucson, AZ 85703*
TENCH C. PAGE *Consultant, 13935 Chamy Drive, Reno, NV 89511*
JAMES D. SELL *Asarco Inc., P. O. Box 5747, Tucson, AZ 85703*

## ABSTRACT

The Yarnell gold deposit, located in the Weaver mining district of Yavapai County, Arizona is found within a structurally-controlled hydrothermally-altered zone that occurs within a 1700 Ma granodioritic intrusive. Both potassic and sericitically altered rock that occur around and above the low-angle northeast striking Yarnell fault are known to host economic gold mineralization; a wider envelope of weakly-altered (propylitic?) rock also occurs in this area. During mineralization, strong sericitization accompanied several stages of quartz ± adularia veining, stockwork formation, and localized silica flooding and potassic replacement, in association with deposition of specularite, pyrite (now oxidized) ~~by meteoric waters~~), and gold. The footwall of the fault is also sericitically altered but poorly mineralized. Mineralization along the Yarnell fault continues both northeast and southwest from the main deposit although the thickness of the zone and associated alteration envelope diminish away from the orebody. A sample of undeformed illite taken from the Yarnell fault zone was K/Ar dated at 69 ± 1.6 Ma.

Ninety-six reverse-circulation holes and four diamond drill holes outline a bulk-minable mineral reserve of 4.1 million tons at 0.051 opt gold. An additional 2.7 million tons at 0.017 opt gold occurs in a low grade zone above and subparallel to the main mineralized zone. Total calculated mineral inventory stands at 6.8 million tons at a grade of 0.038 opt gold with a waste to ore ratio of 1.45:1. Column leach tests indicate that cyanide heap leach gold recoveries should exceed 70%.

## LOCATION AND HISTORY

The Yarnell gold deposit, located in the Weaver mining district on the southwest side of the Weaver Mountains, Yavapai County, Arizona (Fig. 1), is one mile south of the town of Yarnell. U.S. Highway 89 passes at one point to within 300 feet of the downdip extent of the known economic deposit. Elevations within the area of the deposit range from 4650 to 5100 feet above MSL and the climate is conducive for year round operation.

Historic production from the Yarnell deposit was principally from underground but included limited production from the open cut on the top of Yarnell hill. Winslow Mining Company operated the property from 1939 through 1942 and mined the majority of the 200,000 tons which is the total estimated production. Average grade of the ore was reported to be 0.2 to 0.3 opt gold. The mine closed in 1942 due to the Federal gold mine closure order.

The Yarnell property was leased by Norgold Resources Inc. in 1988 and joint ventured with Asarco in the same year. Asarco completed three phases of drilling totaling 25,662 feet in 96 reverse-circulation and 4 diamond drill holes that resulted in identification of the gold reserve. Bema Gold Inc. now holds the property as a result of their acquisition of Norgold Resources Inc. in early 1991.

## REGIONAL GEOLOGIC SETTING

The Yarnell gold deposit occurs within a granite/granodiorite intrusive body formally called the Yarnell granodiorite by Anderson (1989) and designated the granodiorite of Yarnell by DeWitt (1989). The intrusive occurs within a sequence of metavolcanics and metasedimentary rocks of the Bradshaw Mountains Group of Anderson (1989) (Fig. 1). Xenoliths and roof pendants of country rock are common and probably resulted from stoping and rafting during intrusion. Anderson (1989) describes the Yarnell granodiorite as follows:

> "a foliated, coarse-grained porphyritic granodiorite to monzogranite . . . . (that) follows the northwest edge of the Stanton-Octave metavolcanic-metasedimentary screen to as far north as Wilhoit, where dikes of unfoliated Yarnell Granodiorite intrude foliated granodiorite of the Wilhoit batholith . . . . The Yarnell Granodiorite is distinctly coarse-grained and weakly foliated, with large pinkish-tan K-feldspar phenocrysts in an equigranular matrix with biotite, plagioclase, uncommon hornblende, and abundant sphene . . . . Chemically the Yarnell body is metaluminous high-K, calc-alkaline, high Fe-Ti, and high total-alkali rock . . . . "

The Yarnell granodiorite has not been dated, but Anderson (1989) places the age of the Yarnell pluton in the 1730 to 1710 Ma range based on lithologic similarity to other dated granites in Arizona.

Table 1 compares the major element chemistry of three samples of the Yarnell granodiorite reported by DeWitt (1989) with two samples of relatively fresh granodiorite taken from both above and below the Yarnell fault in the vicinity of the deposit. DeWitt's samples, taken one mile north of the mine area (#72), one mile to the west (#73), and more than five miles distant at the base of Weaver Mountain (#74), although slightly less silicic, are geochemically similar to those samples collected by Malusa (1990a) and suggest general uniformity of composition within the Yarnell pluton.

The Yarnell deposit is less than a mile from the intrusive contact with PreCambrian mafic metavolcanic and metasedimentary rocks. Mid-Tertiary flows of andesitic and basaltic composition unconformably overlie both the intrusive and metamorphic rock and flow remnants cap the hills and ridges to the north and northeast of the deposit.

## LOCAL GEOLOGY

### Rock types

The Yarnell gold deposit is structurally controlled and wholly contained within the granodiorite at Yarnell. Petrographic studies by Honea (1990) and Page (1989) were used to identify rock types and alteration characteristics of the deposit.

The granodiorite at Yarnell is generally uniform in composition within the area of the deposit, contains microcline as the dominant K-feldspar, lacks hornblende and is generally granitic in composition (note the higher silica content of the Malusa samples in Table 1). Other felsic intrusive rocks that occur within the area of the deposit, though volumetrically of small significance, have been identified petrographically and include rocks of syenitic composition (Table 2). These may represent either a late differentiate of the main intrusive, a separate intrusive phase, or an altered variant of the original host rock. Both the geometry and origin of these more felsic rocks are obscured by the alteration common to the area of the deposit although some are known to occur in small volume as lenses subparallel to the Yarnell fault.

**Table 1. Major element chemistry of the Yarnell pluton, Yavapai County, AZ**

| | Granodiorite (DeWitt) | | | Biotite Granite (Malusa) | |
|---|---|---|---|---|---|
| | # 72 | # 73 | # 74 | HW | FW |
| $SiO_2$ | 67.4 | 66.3 | 65.1 | 70.0 | 69.8 |
| $Al_2O_3$ | 14.5 | 14.1 | 14.3 | 14.3 | 14.4 |
| $Fe_tO_3$* | 4.98 | 5.45 | 6.65 | 4.76 | 5.02 |
| MgO | 1.17 | 1.22 | 1.52 | 1.00 | 1.10 |
| CaO | 2.57 | 2.84 | 3.43 | 2.60 | 2.30 |
| $Na_2O$ | 3.08 | 3.10 | 3.14 | 3.20 | 3.10 |
| $K_2O$ | 4.18 | 4.33 | 3.78 | 4.10 | 3.90 |
| $TiO_2$ | 0.80 | 0.79 | 1.02 | 0.70 | 0.85 |
| $P_2O_5$ | 0.27 | 0.34 | 0.39 | 0.45 | 0.55 |
| MnO | 0.12 | 0.11 | 0.13 | 0.11 | 0.13 |
| Total | 99.07 | 98.58 | 99.72 | 101.22 | 101.15 |

* $Fe_tO_3$ is total iron as $Fe_2O_3$.

Restricted amounts of andesitic to dioritic rock are found as dikes and sills of the area. The largest of these approaches 50 feet in thickness, trends N10 W and dips 80 SW; this dike neither offsets or is offset by the Yarnell fault and is not generally mineralized. Smaller discontinuous sills of similar composition occur subparallel to the Yarnell fault zone.

Small amounts of coarse pegmatite occur above mineralized rock and near the crest of Yarnell hill; lack of exposure precludes identification of the geologic setting in which these rocks formed.

## Structure

Structural relations within the Yarnell deposit area have been generally identified during reconnaissance and mapping of both underground and field exposures and from logging of core. Only the most obvious and important structural elements that relate to mineralization are considered.

The most distinctive structural element within the deposit area is the N 30-50 E striking, 30-50 NW dipping Yarnell fault (Figs. 2 and 3). The zone varies from three to more than seven feet in thickness and consists of intensely sheared and hydrothermally altered gouge, mylonite, and micro-breccia that commonly localized quartz veining. Within the deposit area, broken and sheared rock related to the fault may persist for more than 80 feet into the hanging wall of the fault, but locally thins to less than ten feet both along strike and downdip of the known deposit.

Several northwest dipping, northeast striking quartz veins occur along hanging wall structures and have been mapped both on the surface and where they have been mined from underground; the steeper veins appear to flatten and roll, may merge with the Yarnell fault at depth, and are suggestive of a listric configuration.

Many of the fractures within the hanging wall are oriented subparallel to and mimic the trend of the underlying Yarnell fault. Felsic dikes, as mapped in the footwall, also subparallel the Yarnell fault in both strike and dip and show similar but much restricted alteration and mineralization.

Intensity of alteration and mineralization conform closely to areas of greatest permeability provided by structural disruption along the Yarnell fault and within the hanging wall rocks. The Yarnell fault has been traced two miles to the southwest where it disappears under desert pediment, and to a point 1500 feet to the northeast from the top of Yarnell hill where it is concealed by alluvium and debris from hills and ridges to the north and east.

**Alteration**

Hypogene alteration associated with the Yarnell gold deposit varies from weak propylitic to sericitic to potassic (Figs. 2 and 3). The strongest alteration is centered about the Yarnell fault zone and decreases outward in intensity into the footwall and hanging wall. Petrographic studies examining alteration characteristics have been completed by Page (1989) and Honea (1990 - Table 2).

Weak propylitic alteration is characterized by formation of minor chlorite, epidote, and calcite (as preserved in the unoxidized footwall) with weak sericitic dusting and replacement by sericite and iron oxides along biotite edges and within plagioclase feldspars. Weak propylitic alteration commonly persists for more than 100 feet above the sericitic envelope and locally contains small quartz veinlets. In the footwall, the weak propylitic zone is thinner and is usually marked by calcite gash veins. This alteration assemblage grades directly into sericitic alteration towards the deposit. Strongly propylitic alteration (ie. total replacement of biotites by chlorite, etc.) has not been identified within rocks related to mineralization at Yarnell.

Sericitic alteration is characterized by complete replacement of biotite and plagioclase by sericite and may contain quartz veinlets and/or stockwork. Specularite and/or pyrite commonly form in conjunction with replacement of biotite by sericite. Strong sericitic alteration extends from 30 to more than 100 feet into the hanging wall above the potassic zone and 10 to 45 feet into the footwall.

Potassic alteration is strongest adjacent to the Yarnell fault where abundant quartz-adularia veins and veinlets, silica flooding, and sericite occur within the highly crushed and tectonized rock; x-ray diffraction studies (Malusa, 1990) suggest that the clay size fraction of the fault zone is primarily fine-grained sericite ± illite and adularia. Chalcedony locally occurs as infill in fractures and vugs within the fault zone but is thought to have formed following hypogene mineralization. The potassic zone outward from the Yarnell fault zone is defined where adularia occurs as phenocrysts within and selvages to quartz stockwork and quartz veinlets and is often accompanied by potassic replacement within preexisting feldspars. Hand specimens from this alteration zone commonly contain pink selvages and rimming within the proximity of and along quartz veinlets. Potassic alteration is generally restricted to sericitically altered and/or silica flooded rock and may occur as much as 50 to 80 feet into the hanging wall of the Yarnell fault, and up to 25 feet below the fault.

Both sericitic and potassic altered zones within the hanging wall have been oxidized by meteoric waters following their formation. Unaffected altered rocks occur below the Yarnell fault, contain fresh pyrite and specularite, and are distinctively green-hued (due to sericite) in respect to hanging wall rocks.

## MINERALIZATION STYLE AND OCCURRENCE

### Description

Gold mineralization is associated with several stages of hypogene quartz with iron sulfides (predominantly pyrite) and iron oxides (predominantly specularite). The specularite and pyrite associated with quartz veins was apparently either remobilized from within the host rock and/or introduced by the hydrothermal fluids. Trace amounts of base-metal sulfides and arsenopyrite have been seen in polished section and trace amounts of copper minerals including azurite and malachite occur in association with quartz-hematite veinlets found within the deepest part of the underground workings. Minor amounts of manganese oxide (including psilomilene) and titanium oxide (leucoxene) are also associated with mineralization. Pseudomorphs of goethite after pyrite, and earthy goethite and hematite are common within the hanging wall rocks, along the main Yarnell fault zone and locally within fractures below the Yarnell fault.

Crosscutting and textural relationships suggest that the Yarnell fault and subsidiary structures provided the pathways for hydrothermal fluids which flooded through these structures and into the surrounding rocks. Successive movements along the Yarnell fault are interpreted to have crushed, sheared, and possibly remobilized quartz, sericite, and associated iron minerals. Lack of shear and/or brecciation within the small amounts of banded chalcedonic quartz observed within the fault zone suggest that chalcedony deposition occurred following latest fault movements possibly as the hydrothermal system waned. Goethite psudomorphs after pyrite and earthy iron-oxides may have formed as a result of the influx of meteoric waters after the period of hypogene mineralization.

### Quartz veins

At least five generations of hypogene quartz veining have been identified through both petrographic and megascopic study of core and rock samples.

1. Early grey quartz associated with specularite in vugs parallel to quartz veins.

2. Dark grey quartz with some brecciation in the vein; dark color is probably due to fine-grained specularite.

3. Lighter grey quartz with disseminated limonite pseudomorphic after pyrite commonly found along the margin of the vein.

These three generations of quartz usually occur as fine-grained small veinlets on the order of 0.25 inches thick, less commonly are 0.5 inches thick, and have been noted up to 3 inches thick in drill core. At least one generation of grey quartz with specularite and grey quartz with pyrite are associated with low to moderate contents of gold (including some visible gold).

4 and 5. White quartz veins; generally coarser grained with local cockscomb texture.

There are at least two stages of white quartz both of which appear to cut across the first three generations of quartz. The white quartz veins have been measured from less than 0.25 inches to over 1 foot in drill core; one exposure in the field has an apparent thickness that approaches twenty feet. White quartz veins consistently are of significant to high gold content and visible gold has been identified from within these veins.

**Gold occurrence**

Gold is generally found associated with iron oxides (some pseudomorphic after pyrite) and/or quartz veining. Total combined iron-oxide and iron-sulfide mineral concentrations are generally low (Table 2) and only very locally exceed 4 to 5% beyond the immediate mineralized Yarnell fault. Economic grades and widths of gold mineralized rock occur within both the potassic and sericitic altered zones; within weakly altered rock similar grades occur only within occasional thin quartz veinlets.

Examination of core shows that coarse visible gold is associated with quartz stockwork containing grey quartz and quartz-specularite veins that occur relatively high in the hanging wall of the deposit; geochemical analysis of these rocks indicated only low to moderate gold content (less than 0.04 opt gold) and may suggest erratic distribution of gold from within this part of the deposit. Moderate to high gold content is commonly related to quartz stockwork with adularia, and to occurrences of earthy red hematite and pseudomorphs of pyrite. Highest gold content (up to 1 opt) is related to abundant red hematite and quartz that occurs along the Yarnell fault. This zone accounted for most of the historic production.

Polished section studies (Honea, 1990) were used to reveal the setting of native gold within mineralized rocks. The polished sections show native gold peripheral to and/or within goethite pseudomorphs after pyrite, and in association with grains of quartz. Native gold is also associated with goethite that occurs as fracture/vein filling, fracture coatings, and as discrete patches associated with pseudomorphs after pyrite.

**Geochemistry**

A geochemical survey (Rasmussen, 1990) was designed to systematically sample rock and soils. Samples were collected from rejects of two reverse-circulation drill holes, from the main haulage adit that is located within the hanging wall near the center of the deposit, and from soils collected from over the hanging wall and footwall of the deposit. These were analyzed for a 15-element geochemical suite that included Ag, Au, As, Bi, Cd, Hg, Sb, Se, Te, Cu, Mo, Pb, Zn, Ga, and Tl.

Geochemical results indicate that mildly anomalous, occasionally sporadic variances in base metals and other trace-elements (notably Cu, Pb, Zn, Mo, As, Te) occur within the area of the deposit. The current data base and review is insufficient to draw conclusions concerning their distribution.

Silver analyses, where available, indicate that silver content is closely associated with gold and eight ore-grade samples average at an approximate 2:1 gold to silver ratio. Small amounts of native silver associated with goethite occur within polished sections (Honea, 1990).

## MINERAL INVENTORY

Ninety-six reverse circulation drill holes have defined a mineral inventory for the deposit. The gold inventory is contained within two zones. The main zone is 20 to 155 feet thick and is closely coincident to the Yarnell fault. The mineral reserve within this zone is 4.1 million tons at 0.051 opt gold using a 0.02 opt gold cutoff. This reserve is outlined on the attached geologic map and sections (Figs. 2 and 3). A lower grade zone occurs above and subparallel to the main zone and contains 2.7 million tons at 0.017 opt gold using a 0.01 opt gold cutoff. The two zones together inventory at 6.8 million tons at a grade of 0.038 opt gold with a 1.45:1 waste to ore ratio.

## METALLURGY

Numerous bottle roll tests and column leach tests were completed on the deposit. A fifteen ton sample was mined from the ore zone exposed in the open cut to provide a run of mine sample for cyanide column leach testing. Results of the column testing are summarized in Table 3.

**Table 3. Column leach data**

| 80% Passing size | Column size | Leach Time Days | Head Assay Opt Au | Tail Assay Opt Au | Extraction |
|---|---|---|---|---|---|
| 6 inch | 24" dia. X 18 ft. | 111 | 0.046 | 0.022 | 52.2% |
| 2 inch | 15" dia. X 18 ft. | 102 | 0.051 | 0.015 | 70.6% |
| 3/8 inch | 12" dia. X 18 ft. | 79 | 0.055 | 0.013 | 76.4% |

Cyanide consumptions ranged from 0.56 to 0.79 pounds per ton and consumption rates were fairly constant throughout the leaching cycles. The ten pounds of lime and cement (at 3/8 inch feed) per ton of ore added to the ore charges as the columns were filled was sufficient to maintain protective alkalinity at above pH 10.5 throughout the test period.

Flotation and fine-grind cyanide leach tests were conducted by Asarco on a composite sample prepared by McClelland Laboratories of Sparks, Nevada. This 35 pound sample assayed at 0.031 opt Au and 2.35% Fe. In the two flotation tests, ground to -200 mesh, the recoveries were 75 to 76% in the final concentrate and 79 to 80% in the rougher concentrate. In the two fine-grind cyanide leach tests, also ground to -200 mesh, the recoveries were 97% in 22 hours of agitated leach. The cyanide consumption was 0.21 pounds per ton of ore and the lime used was 3.3 pounds per ton of ore.

## DISCUSSION

The Yarnell gold deposit is similar to, yet also unique, when compared to other mineral occurrences of west-central Arizona. The 69 Ma K/Ar age obtained from undeformed illite (Shafiqullah, 1990) suggests that mineralization and the Yarnell fault structure is of Laramide or earlier age. Fault displacements are elusive as there are no known marker horizons. The pre-Tertiary age of faulting tentatively suggests that fault development occurred primarily in response to compressional forces. No fluid inclusion data is available for the Yarnell deposit. The lack of a strong epithermal trace-element suite (Hg, As, Sb), combined with a hypogene mineral assemblage compatible with formation at moderate depths within a relatively high-temperature environment suggests that ore deposition occurred within a primarily mesothermal and/or deep epithermal environment. Cretaceous intrusives such as the intrusive at Bagdad are known to occur within the general region and some are related to precious metals deposits that are peripheral to the intrusive centers (Titley, 1986). The more felsic dikes and sills found within the area of the Yarnell deposit may suggest that mineralization at Yarnell is peripheral to a deep-seated intrusive.

The Yarnell gold deposit has similar characteristics to other deposits of the district (ie. Congress, Alvarado, and Octave). They all occur in felsic to intermediate intrusive rocks, are located in low-angle fault zones, and are principally gold-rich precious metals deposits. Yarnell differs in that alteration and mineralization is more extensive and that quartz was not confined primarily to narrow veins. Data available from the Congress deposit indicates that base-metal contents (particularly Pb) are higher and that the Au:Ag ratio is more nearly 1:2 as compared to very minor base-metal content and a 2:1 Au:Ag ratio at Yarnell. The reason for these differences is probably related to the environment of ore deposition and evolution of the hydrothermal fluids.


## ACKNOWLEDGEMENTS

Appreciation is extended to the staff and management of Asarco Inc., Norgold Resources Inc., and Bema Gold Inc. for permission to publish this paper. A number of company reports were used and we would collectively thank those who contributed to the project. We would also thank Bill Gay, Steve Keehner, John Malusa, and Jim Rasmussen for their contributions.

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Rasmussen, J. D., 1990, Internal Reports to Asarco.

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TABLE 2

# Yarnell Project

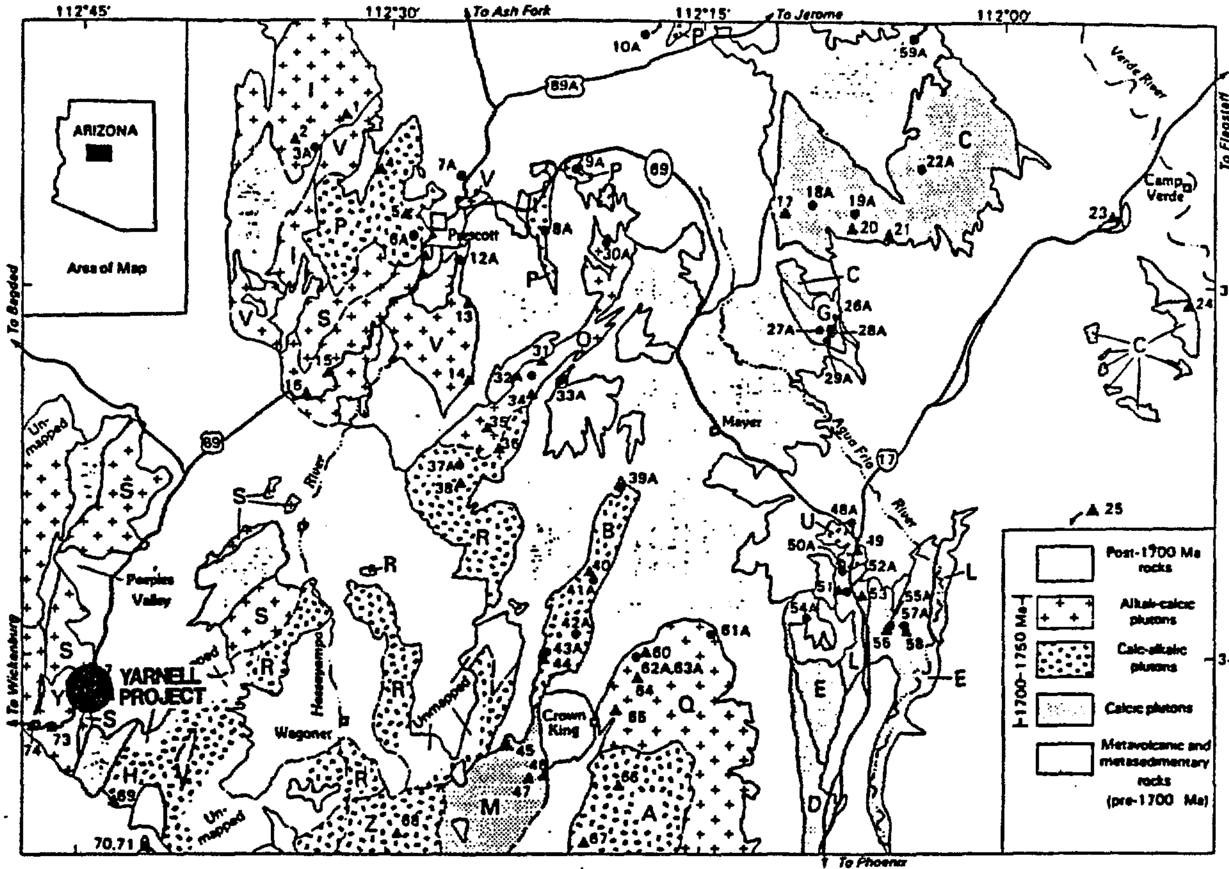
## Petrographic Descriptions - Russ Honea

| Thin Section Sample No. | Alteration Zone | Primary Minerals %: Plagio-clase | Primary Minerals %: Micro-cline | Primary Minerals %: Quartz | Primary Minerals %: Biotite | Secondary Minerals %: Sericite | Secondary Minerals %: Clay | Secondary Minerals %: Chlorite | Secondary Minerals %: Calcite | Secondary Minerals %: Epidote | Secondary Minerals %: Leuco-xene | Silica %: Quartz/ Adularia | Silica %: Chalce-dony/Opal | Iron Oxides %: Hematite/ Magnetite | Iron Oxides %: Limonite/ Pyrite(Fresh) | Iron Oxides %: Goethite | Iron Oxides %: Fe Oxide (Undiff.) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 150 | Fresh (Weathered) | 25 | 50 | 16 | 7 | 6 | - | 1+ | - | 3 | - | - | - | 1/1 | - | - | - |
| 151 | Fresh (Unweathered) | 25 | 45 | 18 | 10 | - | 3 | 3 | - | - | - | - | - | - | -/<1 | - | - |
| 152 | Weak | 30 | 44 | 15 | 9 | 9 | - | - | - | 2* | <1 | - | - | - | - | - | 1+ |
| 162 | Weak | 28 | 38 | 20 | 8 | 18 | - | - | - | - | 1 | 4 | - | - | - | 3+ | - |
| 163 | Weak/Moderate | (35) | 40 | 15 | (8) | 17 | - | - | - | -1 | 1 | 3 | - | - | 1+/- | - | 3 |
| 164 | Weak/Moderate | (32) | 43 | 16 | (6) | 16 | - | - | - | - | 2 | 2 | - | - | - | - | 1+ |
| 165 | Moderate | (44) | 29 | 20 | (5) | 28 | - | - | - | - | <1 | 5 | - | <1 | - | 2 | - |
| 166 | Moderate | (30) | 55 | 10 | (3) | 8 | - | - | - | - | 1 | 15 (Veins) | - | 2 | - | 2 | - |
| 154 | Mod. Unoxidized | (35) | 45 | 12 | (6) | 20 | 4 | 2 | - | - | 1 | - | - | 1 | -/2 | - | - |
| 155 | Mod. Oxidized | (35) | 41 | 12 | (10) | 20 | - | - | - | - | 1 | - | - | - | - | 1** | 2 |
| | Moderate: Yarnell Fault Zone | | | | | | | | | | | | | | | | |
| 157 | Syenite? | (27) | 66 | 3 | (2) | 2 | 3 | 2 | - | - | <1 | - | - | - | - | 1 | 2+ |
| 161 | Potassic Rims | (24) | 66 | 5 | (2) | 7 | - | - | - | - | 1 | 10/15 | - | <1 | - | - | - |
| 158 | Quartz Stockwork | (36) | 40 | 15 | (8) | 27 | - | - | - | - | 1 | 5 | - | - | - | 2 | 3+ |
| 159 | | (38) | 28 | 25 | (7) | 35 | 2 | - | - | - | 1*** | 15 | - | - | - | - | 2 |
| 160 | | (20) | 62 | 12 | (5) | 10 | 10 | - | - | 1* | <1 | 22 | <1/<1 | - | - | 2 | 4 |
| 161 | Syenite? | (24) | 66 | 5 | (2) | 7 | - | - | - | - | 1 | 10/15 | - | <1 | - | - | - |
| 167 | Mod. | (38) | 32 | 20 | (7) | 20 | - | - | - | - | 2 | 3 | - | - | - | 3 (Hm) | - |
| 168 | Mod./Silic? | (39) | (33) | 20 | (6) | 12 | - | - | - | - | 1 | 4 | - | 1 | 1 | 2 | - |

(27) - Original Mineral Now altered to Sericite

*(Clinozoisite)
**Pseudomorphs
***Rutile

FIGURE 1




Simplified geologic map of the Prescott area, north-central Arizona, showing Early Proterozoic and post-Early Proterozoic rock units. Data from Krieger (1965, 1967), Anderson (1972), Anderson and Creasey (1958, 1967), Anderson and Blacet (1972a, 1972b, 1972c), DeWitt (1976, 1979), Jerome (1956), Light (1975), Hook (1956), Pflafker (1956), Wolfe (1983), and unpublished reconnaissance mapping by the author. All contacts, whether depositional, intrusive, or fault-related, are shown by the same kind of line. The Early Proterozoic metamorphic units (both pre- and postplutonic) consist of volcanic and sedimentary protoliths intruded by gabbroic masses. Sample numbers without an A are from this study. Sample numbers with an A are published and are from: Lee, 1984 (3A and 7A); Anderson and Blacet, 1972b (12A, 18A, 19A, 22A, 26A, 27A, 28A, 29A, 32A, 33A, and 37A); Anderson, 1972 (48A, 50A, 52A, 54A, 55A, and 57A); Krieger, 1965 (6A, 8A, 9A, 10A, and 30A); Anderson and Creasey, 1958 (59A); Blacet, 1968 (39A, 41A, 42A, 43A, and 62A), and Vrba, 1980 (61A and 63A). A, granodiorite of Lane Mountain; B, Brady Butte Granodiorite; C, tonalite of Cherry; D, quartz diorite of Bland; E, Badger Spring Granodiorite; G, granophyre of Cherry; H, granite of Rich Hill; I, granite of Iron Springs; L, Bumblebee Granodiorite; M, granodiorite of Minnehaha; O, Crooks Canyon Granodiorite (north); P, Prescott Granodiorite; Q, Crazy Basin Quartz Monzonite; R, Crooks Canyon Granodiorite (south); S, granodiorite of Wilhoit; U, granodiorite of Big Bug Creek; V, Government Canyon Granodiorite; Y, granodiorite of Yarnell; Z, granodiorite of Hozoni Ranch.

Figure 1. Yarnell Project and regional geologic map of north-central Arizona (DeWitt, 1989, p. 150)

ref in text

YARNELL PROJECT
INDEX and GEOLOGY MAP

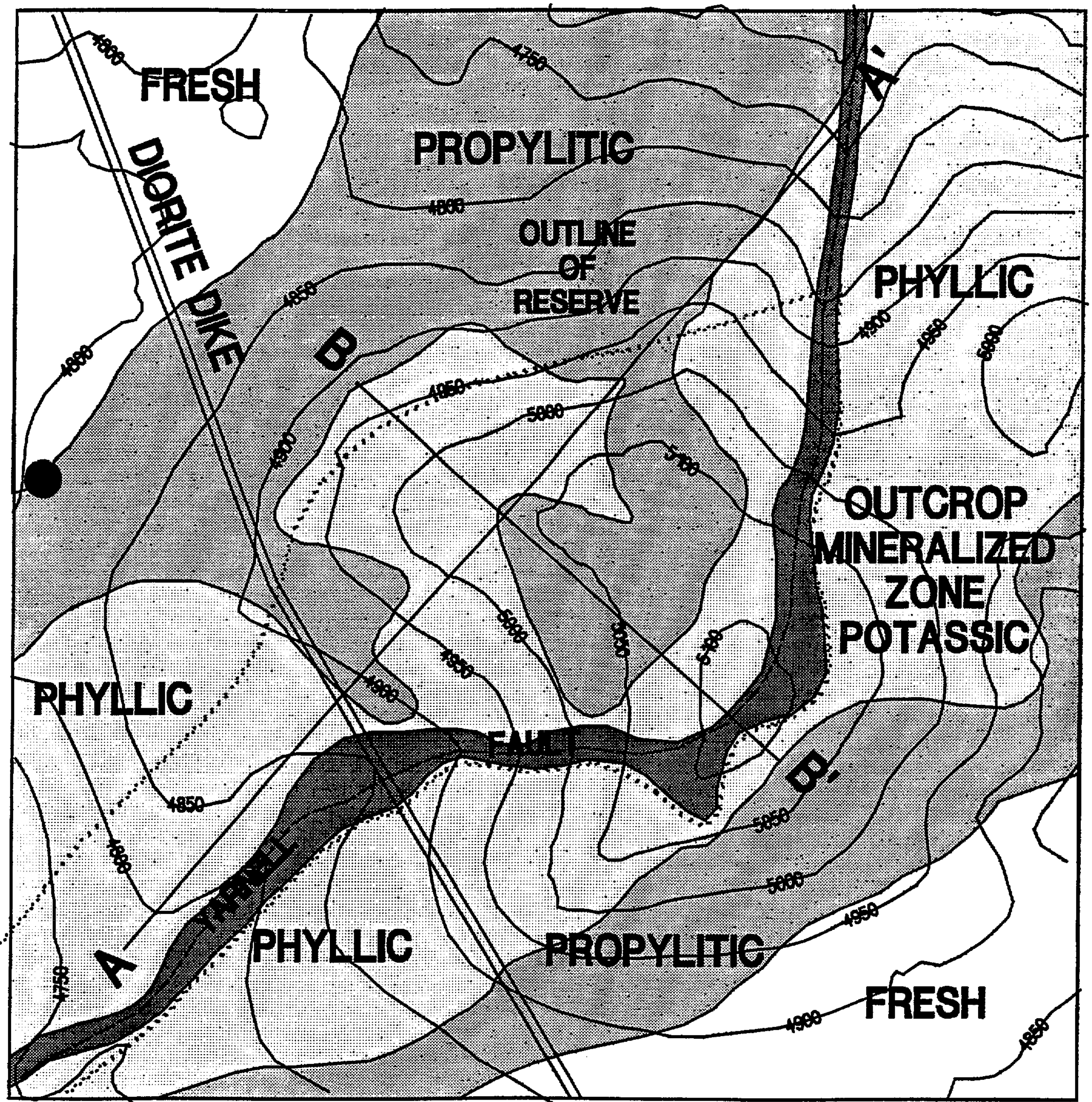
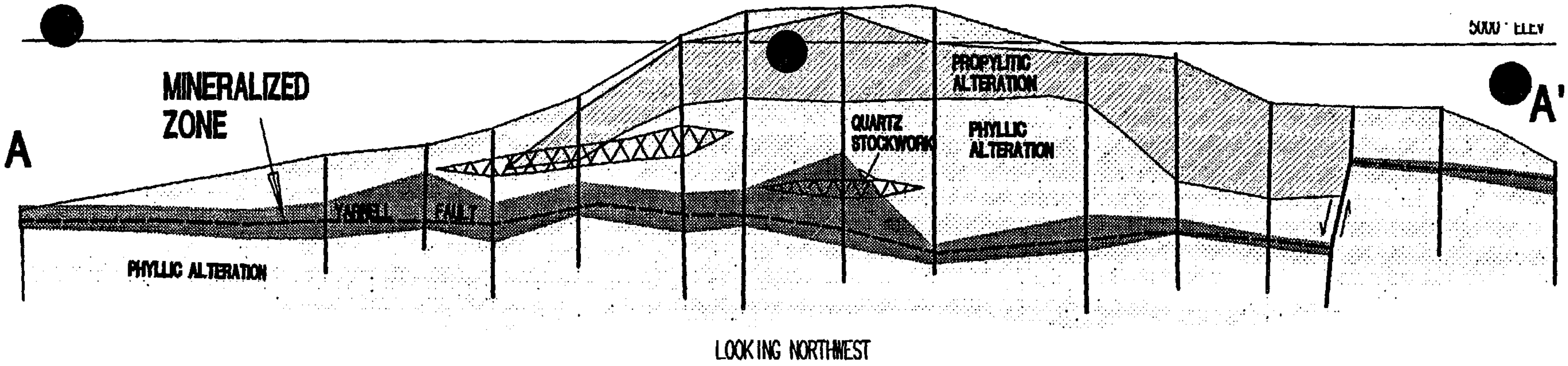
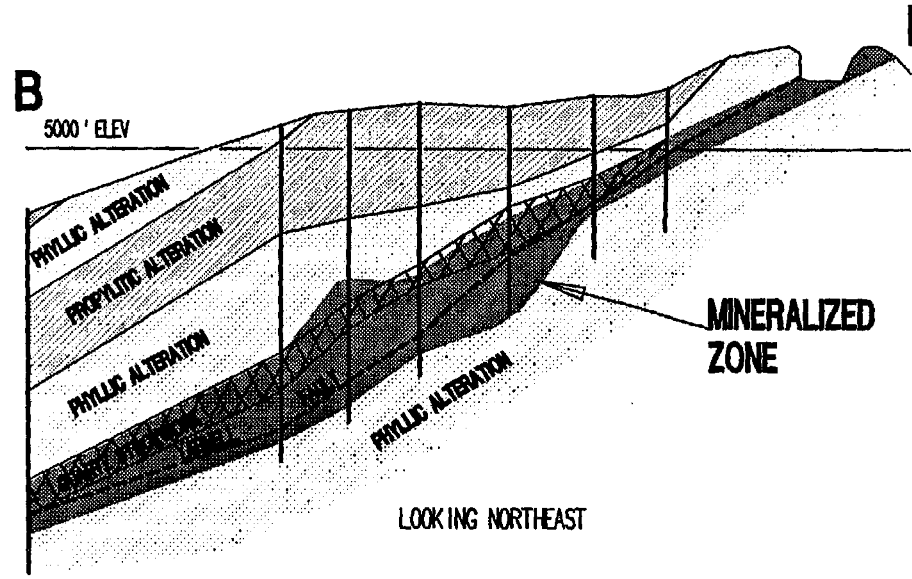

FRESH
PROPYLITIC
DIORITE DIKE
OUTLINE OF RESERVE
PHYLLIC
B
A'
OUTCROP MINERALIZED ZONE POTASSIC
PHYLLIC
FAULT
B'
A
PHYLLIC
PROPYLITIC
FRESH
4800
4750
4850
4900
4950
5000
5050
5100

Fig 3




# YARNELL PROJECT GEOLOGIC SECTIONS

JDS

# ASARCO

**Exploration Department**
Southwestern United States Division
James D. Sell
Manager

August 12, 1991

Dr. F.T. Graybeal, Chief Geologist
ASARCO Incorporated
180 Maiden Lane
New York, NY 10038

Abstract - SME-AIME
Phoenix, 1992
Paper - AGS Digest 19,
1991

Dear Dr. Graybeal:

I submit for approval the abstract of the paper on Yarnell to be submitted for presentation and preprint to the SME-AIME National Meeting in Phoenix, Arizona in February 1992.

I also submit the paper on Yarnell to be submitted to the Arizona Geological Society, Tucson, Arizona, for inclusion in Digest 19, Proterozoic Geology and Ore Deposits of Arizona.

I would appreciate your comments and critique, and your clearing the papers through the Asarco Publications Committee.

Sincerely,

James D. Sell

James D. Sell

JDS:mek
Atts.

cc: W.L. Kurtz (w/o atts.)
M.A. Miller (w/o atts.)

ASARCO Incorporated P.O. Box 5747 Tucson, Az 85703-0747
1150 North 7th Avenue FAX (602) 792-3934 Phone (602) 792-3010

) US — NWMN ✓

**EXXON** COAL AND MINERALS COMPANY

POST OFFICE BOX 1314 • HOUSTON, TEXAS 77251-1314

MINING COORDINATION & RESOURCE MANAGEMENT

October 25, 1990

Mr. Tench Page
Norgold Resources
4600 Kietzke Lane
Suite G 177
Reno, Nevada 89502

Dear Tench:

As per our earlier conversation(s), this letter will serve as formal notification of your participation in the 1992 Joint Society of Economic Geologists (SEG) / Society of Mining, Metallurgy, and Exploration (SME) geology program, at the Annual Meeting of the SME, a member society of the American Institute of Mining, Metallurgy and Petroleum Engineers, Inc. (AIME). The meeting will be held in Phoenix, Arizona from Monday February 24 through Thursday February 27, 1992. Technical sessions will be at the Phoenix Civic Plaza and SME Headquarters will be at the adjacent Hyatt Regency. There will be a one day field trip to the Jerome massive sulfide camp on Friday the 27th. This trip will be sponsored by the SEG with support from SME.

The focus of the program is quite broad and sessions are planned to cover general topics, specific deposits, description, and operational support geology. Both theoretical and/or practical aspects will be covered on porphyries, skarns, bulk mineable gold, SMS, and VMS deposits in the cordillera form Chile to Alaska. Thirty six papers are anticipated and thirty two authors, including yourself, have indicated a desire to provide a presentation.

Your paper on the *Yarnell Gold Deposit - Arizona* will form an important technical contribution to the members of the two societies and the overall success of the program. We thank you in advance for your support. Please provide a proposed title and sign and date the enclosed Speaker Form and return to A. J. Erickson, Jr, in the envelope provided, at your earliest convenience, hopefully no later than December 1, 1990.

You will be contacted directly by the SME and provided with a Suggestion to Authors guide, Abstract form, and appropriate Preprint forms for the Preprint Manuscript. Preprints tend to average about ten typed pages, including illustrations and bibliography, but their is no set minimum or maximum. Preprints are an important source of technical information interchange, and are in heavy demand by the membership. If the author desires the preprint will be reviewed for possible publication by the SME in other of its technical publications. Preprints also serve as a distillation of information on the topic at the time and hence serve as a basis for more extensive publications by the author at a later date. Your preparation of the preprint is therefore strongly urged.

Key dates are as follows:

- December 1, 1990 — Speaker Form to AJE, Jr., Houston
- August 1, 1991 — Abstract due SME, Headquarters, Denver
- November 1, 1991 — Preprint Manuscript due SME, Headquarters, Denver
- February 24 - 27, 1992 — Oral Presentation, Phoenix

All of these dates are extremely important particularly the August 1, 1991 date as abstracts are needed for advance program printing. (Abstracts require only a minimal effort.) Please abide by these dates, or if possible supply the appropriate item in advance of the stated date.

Again, we thank you for your support.

A. J. Erickson

A. J. (Joe) Erickson, Jr.
Program Cochairman - SEG

for Dieter A. Krewedl

Dieter A. Krewedl
Program Cochairman - SME

## SPEAKER FORM

SEG / SME
1992 Annual Meeting
February 24 - 27
Phoenix, Arizona

A. J. Erickson, Jr.
Exxon Coal and Minerals Company
2401 South Gessner
Houston, TX 77063-2005

The title of the paper I/we wil be presenting at the 1992 Annual Meeting in Phoenix will be: THE GEOLOGY AND GOLD MINERALIZATION OF THE YARNELL MINE YAVAPAI CO, ARIZONA

The author(s) will be: TENCH PAGE, MARK MILLER

The paper will be presented by: MARK MILLER

I/we will ____/will not ____ be providing a manuscript for Preprint publication.

Signed: [signature]

Print Name: MARK MILLER

Date: 11-13-90

The Yarnell gold deposit is located within a structurally controlled hydrothermally altered zone within a PreCambrian granodioritic intrusive. Mineralization occurs along and within the hanging wall of the low-angle Yarnell fault where extensive fracturing, and shearing allowed influx of hydrothermal fluids. Intense sericitization was accompanied by deposition of multiple quartz ± adularia veins and stockworks, and disseminated and fracture controlled specularite and pyrite. K/Ar dating of illite suggests that hydrothermal activity occurred prior to 69 Ma.

Ninety six reverse-circulation drill holes and four diamond drill holes have identified a bulk-mineable reserve of 6.8 million tons at a grade of 0.038 opt gold with a 1.45:1 waste to ore ratio. Estimated heap leach recoveries exceed 70%.

JDS

ASARCO

Southwestern Exploration Division

October 11, 1991

F.T. Graybeal

AZ Geological Society Digest
Yarnell Gold Deposit paper
Yavapai County, Arizona

Dear Fred:

Thank you for the critique on the Yarnell paper. I believe the refocus of thoughts has improved the paper and the eliminated sections can be brought out after further studies in future publications by Page, Bema, and others.

I attach a copy of the Discussion page as you have requested.

Sincerely,

Jim

James D. Sell

JDS:mek
Att.

cc: W.L. Kurtz
M.A. Miller
T.C. Page

## DISCUSSION

The Yarnell gold deposit is somewhat unique when compared to other deposits of west-central Arizona. As at Yarnell, deposits of the Weaver and nearby Martinez mining districts (ie. at the Alvarado, Octave, and Congress mines) occur in felsic to intermediate intrusive rocks, are located in low-angle fault zones, and are principally gold-rich precious metals deposits. The Yarnell deposit differs in that it is more extensively altered, not confined within and along narrow quartz veins, and is of lower base metal content. Stockwork formation is believed to have been facilitated by premineral faulting and fracturing which allowed influx of hydrothermal fluids through relatively large thicknesses of rock. Although the mechanisms involved in development of wide areas of brecciation are not fully understood, inferences concerning the development of the Yarnell fault can be made. The 69 Ma. K/Ar age obtained from undeformed illite (Shafiqullah, 1990) suggests that mineralization and the Yarnell fault structure are of Laramide or earlier age. Although fault displacements are unknown due to lack of marker horizons, the pre-Tertiary age of faulting suggests that fault development occurred in response to compressional forces. ~~Although~~ no fluid inclusion data is currently available for the Yarnell deposit, however, the general lack of common epithermal trace-elements (ie. Hg, As, Sb), combined with a hypogene mineral assemblage compatible with formation at moderate depths and temperatures suggests that ore deposition occurred within a mesothermal or deep epithermal environment. Laramide (Cretaceous) intrusives such as the intrusive at Bagdad are known to occur within the general region and some are related to precious metals deposits that are peripheral to the intrusive centers (Titley, 1986). The more felsic dikes and sills found within the area of the Yarnell deposit suggest that Yarnell may be peripheral to a deep-seated intrusive. Fluid inclusion studies, further petrography, and data from additional drilling should help to further define the setting and characteristics of mineralization.

## ACKNOWLEDGEMENTS

Appreciation is extended to the staff and management of Asarco Inc., Norgold Resources Inc., and Bema Gold Inc. for permission to publish this paper. A number of company reports were used and we would collectively thank those who contributed to the project. We would also thank Bill Gay, Steve Keehner, John Malusa, and Jim Rasmussen for their contributions.

10/91
1st Submitted
without some Figures, Tables

# Geology and mineralization at the Yarnell gold deposit, Yavapai County, Arizona

MARK A. MILLER *Asarco Inc., P. O. Box 5747, Tucson, AZ 85703*
TENCH C. PAGE *Consultant, 13935 Chamy Drive, Reno, NV 89511*
JAMES D. SELL *Asarco Inc., P. O. Box 5747, Tucson, AZ 85703*

## ABSTRACT

The Yarnell gold deposit, located in the Weaver mining district of Yavapai County, Arizona is found within a structurally controlled, hydrothermally altered zone that occurs within a 1700 Ma granodioritic intrusive. Both potassic and sericitically altered rock that occur around and above the low-angle northeast striking Yarnell fault are known to host economic gold mineralization; a wider envelope of weakly-altered (propylitic?) rock also occurs in this area. During mineralization, strong sericitization accompanied several stages of quartz ± adularia veining, stockwork formation, and localized silicification and potassic replacement, in association with deposition of specularite, pyrite (now oxidized), and gold. The footwall of the fault is also sericitically altered but poorly mineralized. Mineralization along the Yarnell fault continues both northeast and southwest from the main deposit although the thickness of the zone and associated alteration envelope diminish away from the orebody. A sample of undeformed illite taken from the Yarnell fault zone was K/Ar dated at 69 ± 1.6 Ma.

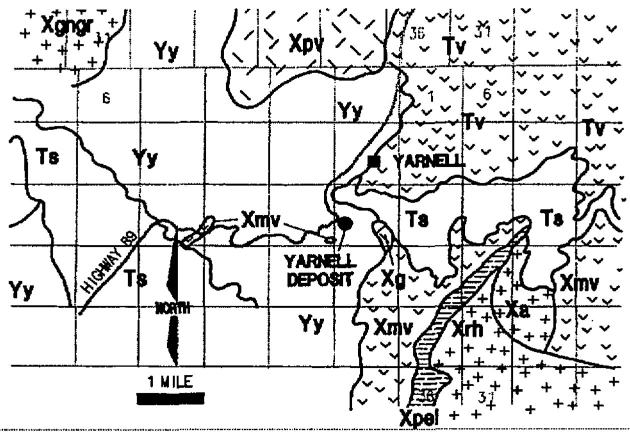
Ninety-six reverse-circulation holes and four diamond drill holes outline a bulk-minable mineral reserve of 4.1 million tons at 0.051 opt gold. An additional 2.7 million tons at 0.017 opt gold occurs in a low grade zone above and subparallel to the main mineralized zone. Total calculated mineral inventory stands at 6.8 million tons at a grade of 0.038 opt gold with a waste to ore ratio of 1.45:1. Column leach tests indicate that cyanide heap leach gold recoveries should exceed 70%.

## LOCATION AND HISTORY

The Yarnell gold deposit, located in the Weaver mining district on the southwest side of the Weaver Mountains, Yavapai County, Arizona (Fig. 1), is one mile south of the town of Yarnell. Elevations within the area of the deposit range from 4650 to 5100 feet above MSL.

Historic production from the Yarnell deposit was principally from underground but included limited production from the open cut on the top of Yarnell hill. Winslow Mining Company operated the property from 1939 through 1942 and mined the majority of the total estimated production of 200,000 tons. Average grade of the ore was reported to be 0.2 to 0.3 opt gold. The mine closed in 1942 due to the Federal gold mine closure order.

The Yarnell property was leased by Norgold Resources Inc. in 1988 and joint ventured with Asarco in the same year. Asarco drilled 25,662 feet in 96 reverse-circulation and 4 diamond drill holes and identified the gold reserve. Bema Gold Inc. now holds the property as a result of their acquisition of Norgold Resources Inc. in early 1991.




TERTIARY
Ts - META SEDIMENTARY / META VOLCANICS (MIOCENE)
Tv - VOLCANICS, PREDOMINATELY BASICS AND ANDESITES (MIOCENE)

PRECAMBRIAN Y
Yy - YARNELL GRANODIORITE

PRECAMBRIAN X
Xg - UNDIFFERENTIATED GRANODIORITE
Xa - ANTELOPE CREEK GRANITE
Xrh - RICH HILL GRANITE
Xpv - PEOPLES VALLEY GRANODIORITE
Xmv - META VOLCANIC ROCKS, EARLY PROTEROZOIC
Xgngr - SYNTECTONIC LEUCO GRANITE
Xpel - PELITIC METASEDIMENTARY ROCKS, EARLY PROTEROZOIC

**Figure 1. Modified from - unpublished mapping, Ed Dewitt 1991**

## REGIONAL GEOLOGIC SETTING

The Yarnell gold deposit occurs within a granite/granodiorite intrusive body formally called the Yarnell granodiorite by Anderson (1989) and designated the granodiorite of Yarnell by DeWitt (1989). The intrusive occurs within a sequence of Precambrian metavolcanics and metasedimentary rocks (DeWitt, 1991; Fig. 1). Xenoliths and roof pendants of country rock are common and probably resulted from stoping and rafting during intrusion. Anderson (1989) describes the Yarnell granodiorite as follows:

> "a foliated, coarse-grained porphyritic granodiorite to monzogranite . . . . (that) follows the northwest edge of the Stanton-Octave metavolcanic-metasedimentary screen to as far north as Wilhoit, where dikes of unfoliated Yarnell Granodiorite intrude foliated granodiorite of the Wilhoit batholith . . . . The Yarnell Granodiorite is distinctly coarse-

grained and weakly foliated, with large pinkish-tan K-feldspar phenocrysts in an equigranular matrix with biotite, plagioclase, uncommon hornblende, and abundant sphene . . . . Chemically the Yarnell body is metaluminous high-K, calc-alkaline, high Fe-Ti, and high total-alkali rock . . . . "

The Yarnell granodiorite has not been dated, but DeWitt (1989) places the age of the Yarnell pluton in the 1730 to 1710 Ma range based on lithologic similarity to other dated granites in Arizona.

Mid-Tertiary flows of andesitic and basaltic composition unconformably overlie both the intrusive and metamorphic rock and flow remnants cap the hills and ridges to the north and northeast of the deposit.

## LOCAL GEOLOGY

### Rock types

The Yarnell gold deposit is structurally controlled and wholly contained within the granodiorite at Yarnell. Petrographic studies by Honea (1990) and Page (1989) were used to identify rock types and alteration characteristics of the deposit.

The granodiorite at Yarnell is generally uniform in composition within the area of the deposit, contains microcline as the dominant K-feldspar, lacks hornblende and is generally granitic in composition. Table 1 compares the major element chemistry of three samples of the Yarnell granodiorite reported by DeWitt (1989) with two samples of relatively fresh granodiorite taken from both above and below the Yarnell fault in the vicinity of the deposit. DeWitt's samples, taken one mile north of the mine area (#72), one mile to the west (#73), and more than five miles distant at the base of Weaver Mountain (#74), although slightly less silicic, are geochemically similar to those samples collected by Malusa (1990a) and suggest overall uniformity of composition throughout the Yarnell pluton.

Other felsic intrusive rocks that occur within the area of the deposit, though volumetrically of small significance, have been identified petrographically and include rocks of syenitic composition (Table 2). These may represent either a late differentiate of the main intrusive, a separate intrusive phase, or an altered variant of the original host rock. Both the geometry and origin of these more felsic rocks are obscured by the alteration common to the area of the deposit although some are known to occur in small volume as lenses subparallel to the Yarnell fault.

Restricted amounts of andesitic to dioritic rock are found as dikes and sills of the area. The largest of these approaches 50 feet in thickness, trends N10 W and dips 80 SW; this dike neither offsets or is offset by the Yarnell fault and is not generally mineralized. Smaller discontinuous sills of similar composition occur subparallel to the Yarnell fault zone.

Small amounts of coarse pegmatite occur above mineralized rock and near the crest of Yarnell hill; lack of exposure precludes identification of the geologic setting in which these rocks formed.

**Table 1. Major element chemistry of the Yarnell pluton, Yavapai County, AZ**

| | Granodiorite (DeWitt) | | | Biotite Granite (Malusa) | |
|---|---|---|---|---|---|
| | # 72 | # 73 | # 74 | HW | FW |
| $SiO_2$ | 67.4 | 66.3 | 65.1 | 70.0 | 69.8 |
| $Al_2O_3$ | 14.5 | 14.1 | 14.3 | 14.3 | 14.4 |
| $Fe_tO_3$* | 4.98 | 5.45 | 6.65 | 4.76 | 5.02 |
| MgO | 1.17 | 1.22 | 1.52 | 1.00 | 1.10 |
| CaO | 2.57 | 2.84 | 3.43 | 2.60 | 2.30 |
| $Na_2O$ | 3.08 | 3.10 | 3.14 | 3.20 | 3.10 |
| $K_2O$ | 4.18 | 4.33 | 3.78 | 4.10 | 3.90 |
| $TiO_2$ | 0.80 | 0.79 | 1.02 | 0.70 | 0.85 |
| $P_2O_5$ | 0.27 | 0.34 | 0.39 | 0.45 | 0.55 |
| MnO | 0.12 | 0.11 | 0.13 | 0.11 | 0.13 |
| Total | 99.07 | 98.58 | 99.72 | 101.22 | 101.15 |

* $Fe_tO_3$ is total iron as $Fe_2O_3$.

### Structure

Structural relations within the Yarnell deposit area have been generally identified during reconnaissance and mapping of both underground and field exposures and from logging of core. Only the most obvious and important structural elements that relate to mineralization are considered.

The most distinctive structural element within the deposit area is the N 30-50 E striking, 30-50 NW dipping Yarnell fault (Figs. 2 and 3). The zone varies from three to more than seven feet in thickness and consists of intensely sheared and hydrothermally altered gouge, mylonite, and micro-breccia that commonly localized quartz veining. Within the deposit area, broken and sheared rock related to the fault may persist for more than 80 feet into the hanging wall of the fault, but locally thins to less than ten feet both along strike and downdip of the known deposit.

Several northwest dipping, northeast striking quartz veins occur along hanging wall structures and have been mapped both on the surface and where they have been mined from underground; the steeper veins appear to flatten and roll, may merge with the Yarnell fault at depth, and are suggestive of a listric configuration.

Many of the fractures within the hanging wall are oriented subparallel to and mimic the trend of the underlying Yarnell fault. Felsic dikes, as mapped in the footwall, also subparallel the Yarnell fault in both strike and dip and show similar but much restricted alteration and mineralization.

Intensity of alteration and mineralization conform closely to areas of greatest permeability provided by structural disruption along the Yarnell fault and within the hanging wall rocks. The Yarnell fault has been traced two miles to the southwest where it disappears under desert pediment, and to a point 1500 feet to the northeast from the top of Yarnell hill where it is concealed by alluvium and debris from hills and ridges to the north and east.

### Alteration

Hypogene alteration associated with the Yarnell gold deposit varies from weak propylitic to sericitic to potassic (Figs. 2 and 3). The strongest alteration is centered about the Yarnell fault zone and decreases outward in intensity into the footwall and hanging wall. Petrographic studies examining alteration characteristics have been completed by Page (1989) and Honea (1990; Table 2).

Weak propylitic alteration is characterized by formation of minor chlorite, epidote, and calcite (as preserved in the unoxidized footwall) with weak sericitic dusting and replacement by sericite and iron oxides along biotite edges and within plagioclase feldspars. Weak propylitic alteration commonly persists for more than 100 feet above the sericitic envelope and locally contains small quartz veinlets. In the footwall, the weak propylitic zone is thinner and is usually marked by calcite veins. This assemblage grades directly into sericitic alteration towards the deposit.

Sericitic alteration is characterized by complete replacement of biotite and plagioclase by sericite and may contain quartz veinlets and/or stockwork. Specularite and/or pyrite commonly form in conjunction with replacement of biotite by sericite. Strong sericitic alteration extends from 30 to more than 100 feet into the hanging wall above the potassic zone and 10 to 45 feet into the footwall.

Potassic alteration is strongest adjacent to the Yarnell fault where abundant quartz-adularia veins and veinlets, quartz-adularia replacement, and sericite occur. X-ray diffraction studies (Malusa, 1990) suggest that the intensely crushed clay size fraction of the fault zone is primarily fine-grained sericite ± illite and adularia. Chalcedony locally occurs as infill in fractures and vugs within the fault zone but is thought to have formed following hypogene mineralization. The potassic zone outward from the Yarnell fault zone is defined where adularia occurs as phenocrysts within and selvages to quartz stockwork and quartz veinlets often accompanied by replacement of matrix minerals with quartz-adularia and recrystallization of preexisting feldspars. Hand specimens from this alteration zone commonly contain pink selvages and rimming within the proximity of and along quartz veinlets. Potassic alteration is generally restricted to sericitically altered and/or silicified rock and may occur as much as 50 to 80 feet into the hanging wall of the Yarnell fault, and up to 25 feet below the fault.

Both sericitic and potassic altered zones within the hanging wall have been oxidized by meteoric waters following their formation. Unaffected altered rocks occur below the Yarnell fault, contain fresh pyrite and specularite, and are distinctively green-hued (due to sericite) in respect to hanging wall rocks.

## MINERALIZATION STYLE AND OCCURRENCE

### Description

Gold mineralization is associated with several stages of hypogene quartz with iron sulfides (predominantly pyrite) and iron oxides (predominantly specularite). Specularite and pyrite associated with quartz veins were apparently formed from remobilized iron from within the host rock and/or from introduced iron carried by the hydrothermal fluids. Trace amounts of base-metal sulfides and arsenopyrite have been seen in polished section and trace amounts of copper minerals including azurite and malachite occur in association with quartz-hematite veinlets found within the deepest part of the underground workings. Minor amounts of manganese oxide (including psilomelene) and titanium oxide (leucoxene) are also associated with mineralization. Pseudomorphs of goethite after pyrite, and earthy goethite and hematite are common within the hanging wall rocks, along the main Yarnell fault zone, and locally within fractures below the Yarnell fault.

The Yarnell fault and subsidiary structures were the primary control on movement of hydrothermal fluids. Successive movements along the Yarnell fault are interpreted to have crushed, sheared, and possibly remobilized silica, iron, and other elements. Lack of shear and/or brecciation within the small amounts of banded chalcedonic quartz observed within the fault zone suggest that chalcedony deposition occurred following latest fault movements possibly as the hydrothermal system waned. Goethite psudomorphs after pyrite and earthy iron-oxides formed as a result of the influx of meteoric waters after the period of hypogene mineralization.

### Quartz veins

At least five generations of hypogene quartz ± adularia veining have been identified through both petrographic and megascopic study of core and rock samples.

1. Early grey quartz associated with specularite in vugs parallel to quartz veins.

2. Dark grey quartz with some brecciation in the vein; dark color is probably due to fine-grained specularite.

3. Lighter grey quartz with disseminated limonite pseudomorphic after pyrite commonly found along the margin of the vein.

These three generations of quartz usually occur as fine-grained small veinlets on the order of 0.25 inches thick, less commonly are 0.5 inches thick, and have been noted up to 3 inches thick in drill core. At least one generation of grey quartz with specularite and grey quartz with pyrite are associated with appreciable gold content (including some visible gold).

4 and 5. White quartz veins; generally coarser grained with local cockscomb texture.

At least two stages of white quartz cut across the first three generations of quartz. The white quartz veins have been measured from less than 0.25 inches to over 1 foot in drill core; one exposure in the field has an apparent thickness that approaches twenty feet. White quartz veins consistently are of significant to high gold content and visible gold has been identified from within these veins.

### Gold occurrence

Gold is generally found associated with iron oxides (some pseudomorphic after pyrite) and/or quartz veining. Total combined iron-oxide and iron-sulfide mineral concentrations are generally low (Table 2) and only very locally exceed 4 to 5% beyond the immediate mineralized Yarnell fault. Economic grades and widths of gold mineralized rock occur within both the potassic and sericitic altered zones; within weakly altered rock similar grades occur only within occasional thin quartz veinlets.

Examination of core shows that coarse visible gold is associated with quartz stockwork containing grey quartz and quartz-specularite veins that occur relatively high in the hanging wall of the deposit; geochemical analysis of these rocks indicated only low to moderate gold content (less than 0.04 opt gold) and may suggest erratic distribution of gold from within this part of the deposit. Moderate to high gold content is commonly related to quartz stockwork with adularia, silicification and potassic replacement, and to occurrences of earthy red hematite and pseudomorphs of pyrite. Highest gold content (up to 1 opt) is related to abundant red hematite and quartz that occurs along the Yarnell fault. This zone accounted for most of the historic production.

Polished section studies (Honea, 1990) revealed the setting of native gold within mineralized rocks. The polished sections show native gold peripheral to and/or within goethite pseudomorphs after pyrite, and in association with grains of quartz. Native gold is also associated with goethite that occurs as fracture/vein filling, fracture coatings, and as discrete patches associated with pseudomorphs after pyrite.

Silver analyses, where available, indicate that silver content is closely associated with gold and eight ore-grade samples average at an approximate 2:1 gold to silver ratio. Small amounts of native silver associated with goethite occur within polished sections (Honea, 1990).

## MINERAL INVENTORY

Ninety-six reverse circulation drill holes have defined a mineral inventory for the deposit. The gold inventory is contained within two zones. The main zone is 20 to 155 feet thick and is closely coincident to the Yarnell fault. The mineral reserve within this zone is 4.1 million tons at 0.051 opt gold using a 0.02 opt gold cutoff. This reserve is outlined on the attached geologic map and sections (Figs. 2 and 3). A lower grade zone occurs above and subparallel to the main zone and contains 2.7 million tons at 0.017 opt gold using a 0.01 opt gold cutoff. The two zones together inventory at 6.8 million tons at a grade of 0.038 opt gold with a 1.45:1 waste to ore ratio.

## METALLURGY

Numerous bottle roll tests and column leach tests were completed on the deposit. A fifteen ton sample was mined from the ore zone exposed in the open cut to provide a run of mine sample for cyanide column leach testing. Results of the column testing are summarized in Table 3.

**Table 3. Column leach data**

| 80% Passing size | Column size | Leech Time Days | Head Assay Opt Au | Tail Assay Opt Au | Extraction |
|---|---|---|---|---|---|
| 6 inch | 24" dia. X 18 ft. | 111 | 0.046 | 0.022 | 52.2% |
| 2 inch | 15" dia. X 18 ft. | 102 | 0.051 | 0.015 | 70.6% |
| 3/8 inch | 12" dia. X 18 ft. | 79 | 0.055 | 0.013 | 76.4% |

Cyanide consumptions ranged from 0.56 to 0.79 pounds per ton and consumption rates were fairly constant throughout the leaching cycles. The ten pounds of lime and cement (at 3/8 inch feed) per ton of ore added to the ore charges as the columns were filled was sufficient to maintain protective alkalinity at above pH 10.5 throughout the test period.

Flotation and fine-grind cyanide leach tests were conducted by Asarco on a composite sample prepared by McClelland Laboratories of Sparks, Nevada. This 35 pound sample assayed at 0.031 opt Au and 2.35% Fe. In the two flotation tests, ground to -200 mesh, the recoveries were 75 to 76% in the final concentrate and 79 to 80% in the rougher concentrate. In the two fine-grind cyanide leach tests, also ground to -200 mesh, the recoveries were 97% in 22 hours of agitated leach. The cyanide consumption was 0.21 pounds per ton of ore and the lime used was 3.3 pounds per ton of ore.

## DISCUSSION

The Yarnell gold deposit is somewhat unique when compared to other deposits of west-central Arizona. As at Yarnell, deposits of the Weaver and nearby Martinez mining districts (ie. at the Alvarado, Octave, and Congress mines) occur in felsic to intermediate intrusive rocks, are located in low-angle fault zones, and are principally gold-rich precious metals deposits. The Yarnell deposit differs in that it is more extensively alterred, not confined within and along narrow quartz veins, and has a lower base metal content. Stockwork formation is believed to have been facilitated by premineral faulting and fracturing which allowed influx of hydrothermal fluids through relatively large thicknesses of rock. Although the mechanisms involved in development of wide areas of brecciation are not fully understood, inferences concerning the development of the Yarnell fault can be made. The 69 Ma. K/Ar age obtained from undeformed illite (Shafiqullah, 1990) suggests that mineralization and the Yarnell fault structure are of Laramide or earlier age. Although fault displacements are unknown due to lack of marker horizons, the pre-Tertiary age of faulting suggests that fault development occurred in response to compressional forces. Although no fluid inclusion data is currently available for the Yarnell deposit, the general lack of common epithermal trace-elements (ie. Hg, As, Sb), combined with a hypogene mineral assemblage compatible with formation at moderate depths and temperatures suggests that ore deposition occurred within a mesothermal or deep epithermal environment. Laramide (Cretaceous) intrusives such as the intrusive at Bagdad are known to occur within the general region and some are related to precious metals deposits that are peripheral to the intrusive centers (Titley, 1986). The more felsic dikes and sills found within the area of the Yarnell deposit suggest that Yarnell may be peripheral to a deep-seated intrusive. Fluid inclusion studies, further petrography, and data from additional drilling should help to further define the setting and characteristics of mineralization.

## ACKNOWLEDGEMENTS

Appreciation is extended to the staff and management of Asarco Inc., Norgold Resources Inc., and Bema Gold Inc. for permission to publish this paper. A number of company reports were used and we would collectively thank those who contributed to the project. We would also thank Bill Gay, Steve Keehner, John Malusa, and Jim Rasmussen for their contributions.

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# Geology and mineralization at the Yarnell gold deposit, Yavapai County, Arizona


**MARK A. MILLER** *Asarco Inc., P. O. Box 5747, Tucson, AZ 85703*
**TENCH C. PAGE** *Consultant, 13935 Chamy Drive, Reno, NV 89511*
**JAMES D. SELL** *Asarco Inc., P. O. Box 5747, Tucson, AZ 85703*



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The Yarnell gold deposit, located in the Weaver mining district of Yavapai County, Arizona is found within a structurally controlled, hydrothermally altered zone that occurs within a 1700 Ma granodioritic intrusive. Both potassic and sericitically altered rock that occur around and above the low-angle northeast striking Yarnell fault are known to host economic gold mineralization; a wider envelope of weakly-altered (propylitic?) rock also occurs in this area. During mineralization, strong sericitization accompanied several stages of quartz ± adularia veining, stockwork formation, and localized silicification and potassic replacement, in association with deposition of specularite, pyrite (now oxidized), and gold. The footwall of the fault is also sericitically altered but poorly mineralized. Mineralization along the Yarnell fault continues both northeast and southwest from the main deposit although the thickness of the zone and associated alteration envelope diminish away from the orebody. A sample of undeformed illite taken from the Yarnell fault zone was K/Ar dated at 69 ± 1.6 Ma.

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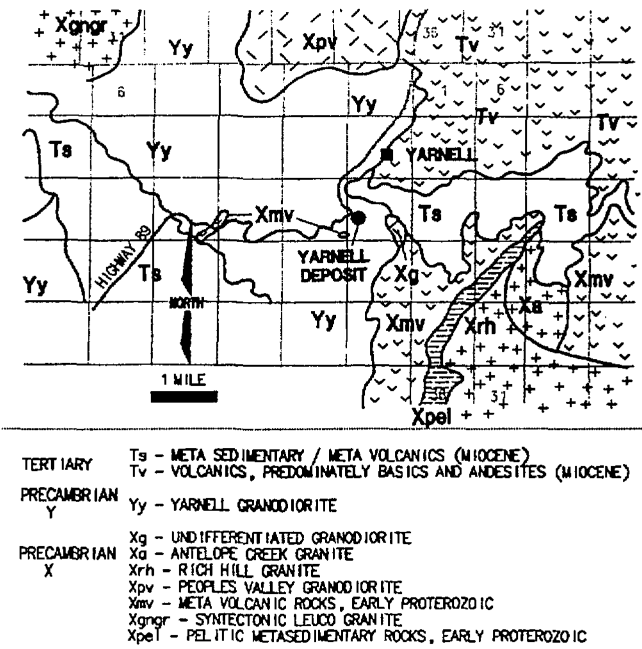


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| $P_2O_5$ | 0.27 | 0.34 | 0.39 | 0.45 | 0.55 |
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The most distinctive structural element within the deposit area is the N 30-50 E striking, 30-50 NW dipping Yarnell fault (Fig. 2). The zone varies from three to more than seven feet in thickness and consists of intensely sheared and hydrothermally altered gouge, mylonite, and micro-breccia that commonly localized quartz veining. Within the deposit area, broken and sheared rock related to the fault may persist for more than 80 feet into the hanging wall of the fault, but locally thins to less than ten feet both along strike and downdip of the known deposit.

Several northwest dipping, northeast striking quartz veins occur along hanging wall structures and have been mapped both on the surface and where they have been mined from underground; the steeper veins appear to flatten and roll, may merge with the Yarnell fault at depth, and are suggestive of a listric configuration.

Many of the fractures within the hanging wall are oriented subparallel to and mimic the trend of the underlying Yarnell fault. Felsic dikes, as mapped in the footwall, also subparallel the Yarnell fault in both strike and dip and show similar but much restricted alteration and mineralization.

Intensity of alteration and mineralization conform closely to areas of greatest permeability provided by structural disruption along the Yarnell fault and within the hanging wall rocks. The Yarnell fault has been traced two miles to the southwest where it disappears under desert pediment, and to a point 1500 feet to the northeast from the top of Yarnell hill where it is concealed by alluvium and debris from hills and ridges to the north and east.

### Alteration

Hypogene alteration associated with the Yarnell gold deposit varies from weak propylitic to sericitic to potassic (Fig. 2). The strongest alteration is centered about the Yarnell fault zone and decreases outward in intensity into the footwall and hanging wall. Petrographic studies examining alteration characteristics have been completed by Page (1989) and Honea (1990; Table 2).

Weak propylitic alteration is characterized by formation of minor chlorite, epidote, and calcite (as preserved in the unoxidized footwall) with weak sericitic dusting and replacement by sericite and iron oxides along biotite edges and within plagioclase feldspars. Weak propylitic alteration commonly persists for more than 100 feet above the sericitic envelope and locally contains small quartz veinlets. In the footwall, the weak propylitic zone is thinner and is usually marked by calcite veins. This assemblage grades directly into sericitic alteration towards the deposit.

Sericitic alteration is characterized by complete replacement of biotite and plagioclase by sericite and may contain quartz veinlets and/or stockwork. Specularite and/or pyrite commonly form in conjunction with replacement of biotite by sericite. Strong sericitic alteration extends from 30 to more than 100 feet into the hanging wall above the potassic zone and 10 to 45 feet into the footwall.

Potassic alteration is strongest adjacent to the Yarnell fault where abundant quartz-adularia veins and veinlets, quartz-adularia replacement, and sericite occur. X-ray diffraction studies (Malusa, 1990) suggest that the intensely crushed clay size fraction of the fault zone is primarily fine-grained sericite ± illite and adularia. Chalcedony locally occurs as infill in fractures and vugs within the fault zone but is thought to have formed following hypogene mineralization. The potassic zone outward from the Yarnell fault zone is defined where adularia occurs as phenocrysts within and selvages to quartz stockwork and quartz veinlets often accompanied by replacement of matrix minerals with quartz-adularia and recrystallization of pre-existing feldspars. Hand specimens from this alteration zone commonly contain pink selvages and rimming within the proximity of and along quartz veinlets. Potassic alteration is generally restricted to sericitically altered and/or silicified rock and may occur as much as 50 to 80 feet into the hanging wall of the Yarnell fault, and up to 25 feet below the fault.

Both sericitic and potassic altered zones within the hanging wall have been oxidized by meteoric waters following their formation. Unaffected altered rocks occur below the Yarnell fault, contain fresh pyrite and specularite, and are distinctively green-hued (due to sericite) in respect to hanging wall rocks.

## MINERALIZATION STYLE AND OCCURRENCE

### Description

Gold mineralization is associated with several stages of hypogene quartz with iron sulfides (predominantly pyrite) and iron oxides (predominantly specularite). Specularite and pyrite associated with quartz veins were apparently formed from remobilized iron from within the host rock and/or from introduced iron carried by the hydrothermal fluids. Trace amounts of base-metal sulfides and arsenopyrite have been seen in polished section and trace amounts of copper minerals including azurite and malachite occur in association with quartz-hematite veinlets found within the deepest part of the underground workings. Minor amounts of manganese oxide (including psilomelene) and titanium oxide (leucoxene) are also associated with mineralization. Pseudomorphs of goethite after pyrite, and earthy goethite and hematite are common within the hanging wall rocks, along the main Yarnell fault zone, and locally within fractures below the Yarnell fault.

The Yarnell fault and subsidiary structures were the primary control on movement of hydrothermal fluids. Successive movements along the Yarnell fault are interpreted to have crushed, sheared, and possibly remobilized silica, iron, and other elements. Lack of shear and/or brecciation within the small amounts of banded chalcedonic quartz observed within the fault zone suggest that chalcedony deposition occurred following latest fault movements possibly as the hydrothermal system waned. Goethite psudomorphs after pyrite and earthy iron-oxides formed as a result of the influx of meteoric waters after the period of hypogene mineralization.

### Quartz veins

At least five generations of hypogene quartz ± adularia veining have been identified through both petrographic and megascopic study of core and rock samples.

1. Early grey quartz associated with specularite in vugs parallel to quartz veins.

2. Dark grey quartz with some brecciation in the vein; dark color is probably due to fine-grained specularite.

3. Lighter grey quartz with disseminated limonite pseudomorphic after pyrite commonly found along the margin of the vein.

These three generations of quartz usually occur as fine-grained small veinlets on the order of 0.25 inches thick, less commonly are 0.5 inches thick, and have been noted up to 3 inches thick in drill core. At least one generation of grey quartz

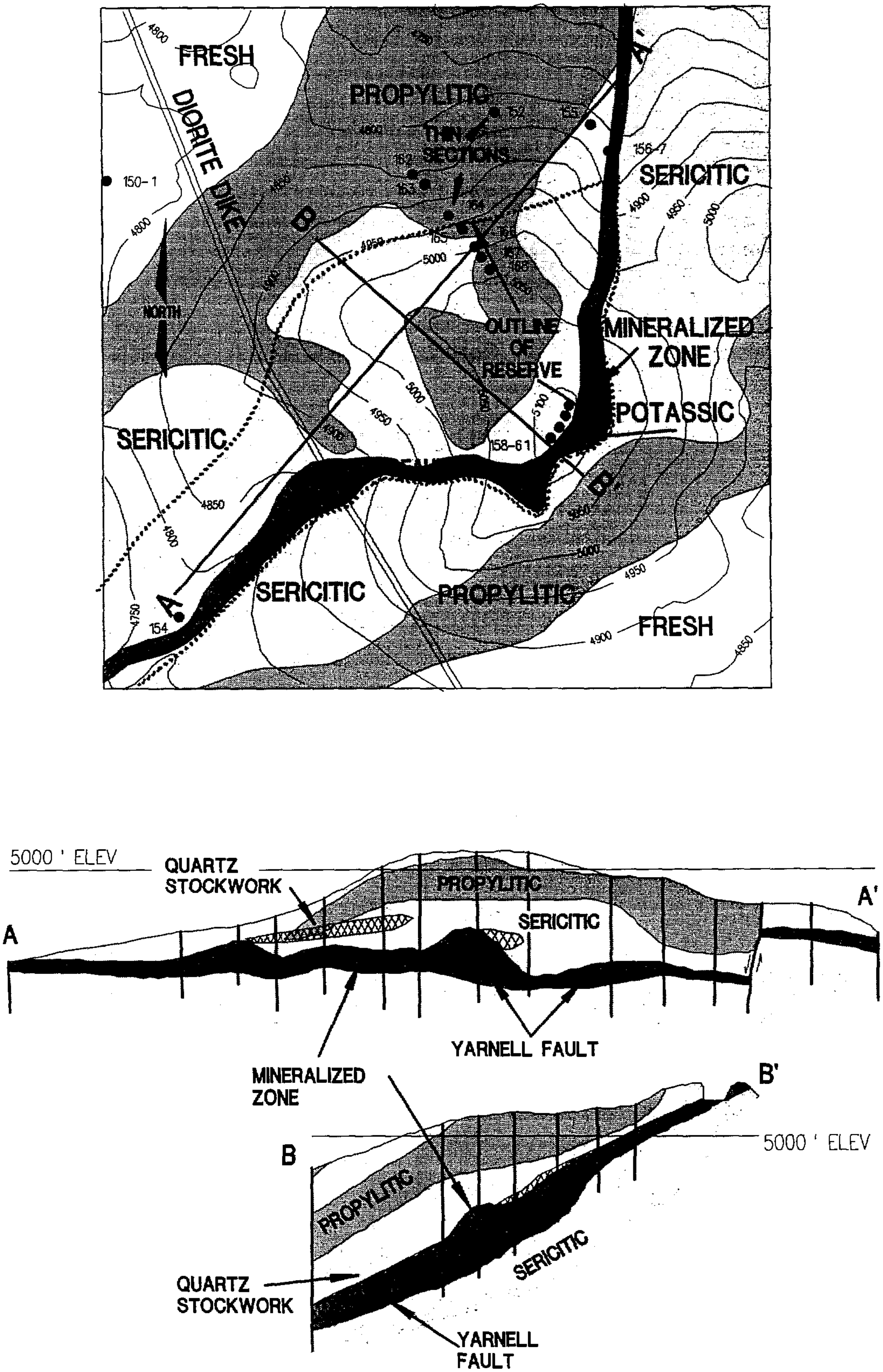


**Figure 2. Geologic map and cross-sections of the Yarnell Deposit...**

with specularite and grey quartz with pyrite are associated with appreciable gold content (including some visible gold).

4 and 5. White quartz veins; generally coarser grained with local cockscomb texture.

At least two stages of white quartz cut across the first three generations of quartz. The white quartz veins have been measured from less than 0.25 inches to over 1 foot in drill core; one exposure in the field has an apparent thickness that approaches twenty feet. White quartz veins consistently are of significant to high gold content and visible gold has been identified from within these veins.

### Gold occurrence

Gold is generally found associated with iron oxides (some pseudomorphic after pyrite) and/or quartz veining. Total combined iron-oxide and iron-sulfide mineral concentrations are generally low (Table 2) and only very locally exceed 4 to 5% beyond the immediate mineralized Yarnell fault. Economic grades and widths of gold mineralized rock occur within both the potassic and sericitic altered zones; within weakly altered rock similar grades occur only within occasional thin quartz veinlets.

Examination of core shows that coarse visible gold is associated with quartz stockwork containing grey quartz and quartz-specularite veins that occur relatively high in the hanging wall of the deposit; geochemical analysis of these rocks indicated only low to moderate gold content (less than 0.04 opt gold) and may suggest erratic distribution of gold from within this part of the deposit. Moderate to high gold content is commonly related to quartz stockwork with adularia, silicification and potassic replacement, and to occurrences of earthy red hematite and pseudomorphs of pyrite. Highest gold content (up to 1 opt) is related to abundant red hematite and quartz that occurs along the Yarnell fault. This zone accounted for most of the historic production.

Polished section studies (Honea, 1990) revealed the setting of native gold within mineralized rocks. The polished sections show native gold peripheral to and/or within goethite pseudomorphs after pyrite, and in association with grains of quartz. Native gold is also associated with goethite that occurs as fracture/vein filling, fracture coatings, and as discrete patches associated with pseudomorphs after pyrite.

Silver analyses, where available, indicate that silver content is closely associated with gold and eight ore-grade samples average at an approximate 2:1 gold to silver ratio. Small amounts of native silver associated with goethite occur within polished sections (Honea, 1990).

## MINERAL INVENTORY

Ninety-six reverse circulation drill holes have defined a mineral inventory for the deposit. The gold inventory is contained within two zones. The main zone is 20 to 155 feet thick and is closely coincident to the Yarnell fault. The mineral reserve within this zone is 4.1 million tons at 0.051 opt gold using a 0.02 opt gold cutoff. This reserve is outlined on the attached geologic map and sections (Fig. 2). A lower grade zone occurs above and subparallel to the main zone and contains 2.7 million tons at 0.017 opt gold using a 0.01 opt gold cutoff. The two zones together inventory at 6.8 million tons at a grade of 0.038 opt gold with a 1.45:1 waste to ore ratio.

## METALLURGY

Numerous bottle roll tests and column leach tests were completed on the deposit. A fifteen ton sample was mined from the ore zone exposed in the open cut to provide a run of mine sample for cyanide column leach testing. Results of the column testing are summarized in Table 3.

**Table 3. Column leach data**

| 80% Passing size | Column size | Leach Time Days | Head Assay Opt Au | Tail Assay Opt Au | Extraction |
|---|---|---|---|---|---|
| 6 inch | 24" dia. X 18 ft. | 111 | 0.046 | 0.022 | 52.2% |
| 2 inch | 15" dia. X 18 ft. | 102 | 0.051 | 0.015 | 70.6% |
| 3/8 inch | 12" dia. X 18 ft. | 79 | 0.055 | 0.013 | 76.4% |

Cyanide consumptions ranged from 0.56 to 0.79 pounds per ton and consumption rates were fairly constant throughout the leaching cycles. The ten pounds of lime and cement (at 3/8 inch feed) per ton of ore added to the ore charges as the columns were filled was sufficient to maintain protective alkalinity at above pH 10.5 throughout the test period.

Flotation and fine-grind cyanide leach tests were conducted by Asarco on a composite sample prepared by McClelland Laboratories of Sparks, Nevada. This 35 pound sample assayed at 0.031 opt Au and 2.35% Fe. In the two flotation tests, ground to -200 mesh, the recoveries were 75 to 76% in the final concentrate and 79 to 80% in the rougher concentrate. In the two fine-grind cyanide leach tests, also ground to -200 mesh, the recoveries were 97% in 22 hours of agitated leach. The cyanide consumption was 0.21 pounds per ton of ore and the lime used was 3.3 pounds per ton of ore.

## DISCUSSION

The Yarnell gold deposit is somewhat unique when compared to other deposits of west-central Arizona. As at Yarnell, deposits of the Weaver and nearby Martinez mining districts (ie. at the Alvarado, Octave, and Congress mines) occur in felsic to intermediate intrusive rocks, are located in low-angle fault zones, and are principally gold-rich precious metals deposits. The Yarnell deposit differs in that it is more extensively altered, not confined within and along narrow quartz veins, and has a lower base metal content. Stockwork formation is believed to have been facilitated by premineral faulting and fracturing which allowed influx of hydrothermal fluids through relatively large thicknesses of rock. Although the mechanisms involved in development of wide areas of brecciation are not fully understood, inferences concerning the development of the Yarnell fault can be made. The 69 Ma. K/Ar age obtained from undeformed illite (Shafiqullah, 1990) suggests that mineralization and the Yarnell fault structure are of Laramide or earlier age. Although fault displacements are unknown due to lack of marker horizons, the pre-Tertiary age of faulting suggests that fault development occurred in response to compressional forces. Although no fluid inclusion data is currently available for the Yarnell deposit, the general lack of common epithermal trace-elements (ie. Hg, As, Sb), combined with a hypogene mineral assemblage compatible with formation at moderate depths and temperatures suggests that ore deposition occurred within a mesothermal or deep epithermal environment. Laramide (Cretaceous) intrusives such as the intrusive at Bagdad are known to occur within the general region and some are related to precious metals deposits that are peripheral to the intrusive centers (Titley, 1986). The more felsic dikes and sills found within the area of the Yarnell deposit suggest that Yarnell may be peripheral to a deep-seated intrusive. Fluid inclusion studies, further petrography, and data from additional drilling should help to further define the setting and characteristics of mineralization.

## ACKNOWLEDGEMENTS

Appreciation is extended to the staff and management of Asarco Inc., Norgold Resources Inc., and Bema Gold Inc. for permission to publish this paper. A number of company reports were used and we would collectively thank those who contributed to the project. We would also thank Bill Gay, Steve Keehner, John Malusa, and Jim Rasmussen for their contributions.

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## Table 2. YARNELL GOLD DEPOSIT PETROGRAPHIC DESCRIPTIONS - RUSS HONEA

| Thin Section Location and Sample No. | Sample Description | Primary Minerals % | | | | Secondary Minerals % | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Plagio-clase | Micro-cline | Quartz | Biotite | Sericite | Clay | Chlorite | Epidote | Leuco-xene |
| 150 | Fresh (Weathered) | 25 | 50 | 16 | 7 | 6 | - | 1+ | 3 | - |
| 151 | Fresh (Weathered) | 25 | 45 | 18 | 10 | - | 3 | 3 | - | - |
| 152 | Weak Propylitic | 30 | 44 | 15 | 9 | 9 | - | - | 2* | <1 |
| 162 | Weak Propylitic | 28 | 38 | 20 | 8 | 18 | - | - | - | 1 |
| 163 | Weak Sericitic | (35) | 40 | 15 | ( 8) | 17 | - | - | -1 | 1 |
| 164 | Weak Sericitic | (32) | 43 | 16 | ( 6) | 16 | - | - | - | 2 |
| 165 | Sericitic | (44) | 29 | 20 | ( 5) | 28 | - | - | - | <1 |
| 166 | Sericitic | (30) | 55 | 10 | ( 3) | 8 | - | - | - | 1 |
| 154 | Sericitic (Unoxid) | (35) | 45 | 12 | ( 6) | 20 | 4 | 2 | - | 1 |
| 155 | Sericitic (Oxid) | (35) | 41 | 12 | (10) | 20 | - | - | - | 1 |
| | Yarnell Fault Zone | | | | | | | | | |
| 157 | Syenite? | (27) | 66 | 3 | ( 2) | 2 | 3 | 2 | - | <1 |
| 161 | Potassic Rims | (24) | 66 | 5 | ( 2) | 7 | - | - | - | 1 |
| 158 | Quartz Stockwork | (36) | 40 | 15 | ( 8) | 27 | - | - | - | 1 |
| 159 | Potassic | (38) | 28 | 25 | ( 7) | 35 | 2 | - | - | 1*** |
| 160 | Potassic/ Quartz Veins | (20) | 62 | 12 | ( 5) | 10 | 10 | - | 1* | <1 |
| 167 | Sericitic | (39) | 32 | 20 | ( 7) | 20 | - | - | - | 2 |
| 168 | Sericitic/ Siliceous | (39) | (33) | 20 | ( 6) | 12 | - | - | - | 1 |

(27) - Original mineral now altered to Sericite

*(Clinozoisite)
**Pseudomorphs
***Rutile

**Table 2. YARNELL GOLD DEPOSIT**
**PETROGRAPHIC DESCRIPTIONS - RUSS HONEA**

| Thin Section Location and Sample No. | Sample Description | Silica % | | Iron Oxides % | | | |
|---|---|---|---|---|---|---|---|
| | | Quartz/ Adularia | Chalcedony/ Opal | Hematite/ Magnetite | Limonite/ Pyrite(Fresh) | Goethite | Fe Oxide (Undiff.) |
| 150 | Fresh (Weathered) | - | - | 1/1 | - | - | - |
| 151 | Fresh (Weathered) | - | - | - | -/<1 | - | - |
| 152 | Weak Propylitic | - | - | - | - | - | 1+ |
| 162 | Weak Propylitic | 4 | - | - | - | 3+ | - |
| 163 | Weak Sericitic | 3 | - | - | - | - | 3 |
| 164 | Weak Sericitic | 2 | - | - | 1+/- | - | 1+ |
| 165 | Sericitic | 5 | - | <1 | - | 2 | - |
| 166 | Sericitic | 15 (Veins) | - | 2 | - | 2 | - |
| 154 | Sericitic (Unoxid) | - | - | 1 | -/2 | - | - |
| 155 | Sericitic (Oxid) | - | - | - | - | 1** | 2 |
| | Yarnell Fault Zone | | | | | | |
| 157 | Syenite? | - | - | - | - | 1 | 2+ |
| 161 | Potassic Rims | 10/15 | - | <1 | - | - | - |
| 158 | Quartz Stockwork | 5 | - | - | - | 2 | 3+ |
| 159 | Potassic | 15 | - | - | - | - | 2 |
| 160 | Potassic/ Quartz Veins | 22 | <1/<1 | - | - | 2 | 4 |
| 167 | Sericitic | 3 | - | - | - | 3(Hm) | - |
| 168 | Sericitic/ Siliceous | 4 | - | 1 | 1 | 2 | - |

**Pseudomorphs

JDS

ASARCO

Southwestern Exploration Division

December 2, 1991

Dr. F.T. Graybeal
New York Office

AIME Preprint Paper for Approval
Yarnell Mine, Yavapai Co., AZ

I send a copy of the FAX copy of the paper to be submitted for a preprint which will be presented at the SME-AIME meeting in Phoenix, Arizona on Thursday, February 27, 1992.

The paper is the lead off paper for Geology V - Western and Southwestern US Ore Deposits, with other papers being given on the Mesquite District, CA, Helvetia copper, AZ, Santa Cruz copper, AZ and two papers on Lakeshore deposit, AZ.

I believe you will find the bulk of the paper a rehash of the previously approved Yarnell publications with the added geochemistry and fluid inclusion study (FAX pages 10 and 11).

Thank you for obtaining the permission for the paper.

James D. Sell

James D. Sell

JDS:mek
Att.

cc: W.L. Kurtz (w/o att.)

VESTERN
STATES
MINERALS
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# Geology and geochemistry of stockwork gold mineralization at the Yarnell mine, Yavapai County, Arizona

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TENCH C. PAGE *Consultant, 13935 Chamy Drive, Reno, NV 89511*
MARK A. MILLER *Asarco Inc., P. O. Box 5747, Tucson, AZ 85703*
JAMES D. SELL *Asarco Inc., P. O. Box 5747, Tucson, AZ 85703*
PETER CRAIG GIBSON *Mackay School of Mines, UN-R, Reno, NV 89557*

Abstract. The Yarnell gold deposit, located in the Weaver mining district of Yavapai County, Arizona is found within a structurally controlled, hydrothermally altered zone that occurs within a 1700 Ma granodioritic intrusive. Both potassic and sericitically altered rock that occur around and above the low-angle northeast striking Yarnell fault are known to host economic gold mineralization; a wider envelope of weakly-propylitic alterred rock also occurs in this area. During mineralization, strong sericitization accompanied several stages of quartz ± adularia veining, stockwork formation, and localized silicification and potassic replacement, in association with deposition of specularite, pyrite (now oxidized), and gold. The footwall of the fault is also sericitically altered but poorly mineralized. Mineralization along the Yarnell fault continues both northeast and southwest from the main deposit although the thickness of the zone and associated alteration envelope diminish away from the orebody.

A sample of undeformed illite taken from the Yarnell fault zone was K/Ar dated at 69 ± 1.6 Ma; this date reflects a minimum age for both mineralization and latest movement on the fault. Both $CO_2$- and $H_2O$-rich fluid inclusions were studied and suggest mesothermal pressures and temperatures of formation for the deposit.

Ninety-six reverse-circulation holes and four diamond drill holes outline a bulk-minable mineral reserve of 4.1 million tons at 0.051 opt gold. An additional 2.7 million tons at 0.017 opt gold occurs in a low grade zone above and subparallel to the main mineralized zone. Total calculated mineral inventory stands at 6.8 million tons at a grade of 0.038 opt gold with a waste to ore ratio of 1.45:1. Column leach tests indicate that cyanide heap leach gold recoveries should exceed 70%.

## Location and history

The Yarnell gold deposit, located in the Weaver mining district on the southwest side of the Weaver Mountains, Yavapai County, Arizona (Fig. 1), is one mile south of the town of Yarnell. Elevations within the area of the deposit range from 4650 to 5100 feet above MSL.

Historic production from the Yarnell deposit was principally from underground but included limited production from the open cut on the top of Yarnell hill. Winslow Mining Company operated the property from 1939 through 1942 and mined the majority of the total estimated production of 200,000 tons. Average grade of the ore was reported to be 0.2 to 0.3 opt gold. The mine closed in 1942 due to the Federal gold mine closure order.

The Yarnell property was leased by Norgold Resources Inc. in 1988 and joint ventured with Asarco in the same year. Asarco drilled 25,662 feet in 96 reverse-circulation and 4 diamond drill holes and identified the gold reserve. Bema Gold Inc. now holds the property as a result of their acquisition of Norgold Resources Inc. in early 1991.

## Regional geologic setting

The Yarnell gold deposit occurs within a granitic to granodioritic intrusive body formally called the Yarnell granodiorite by Anderson (1989) and designated the granodiorite of Yarnell by DeWitt (1989). This intrusive outcrops over an area of more than 35 square kilometers and occurs within a sequence of Proterozoic metavolcanics and metasedimentary rocks (DeWitt, 1991; Fig. 1). Xenoliths and roof pendants of country rock are common and probably resulted from stoping and rafting during intrusion. Anderson (1989) describes the Yarnell granodiorite as "a porphyritic granodiorite to monzogranite . . . distinctly coarse-grained and weakly foliated, with large pinkish-tan K-feldspar phenocrysts in an equigranular matrix with biotite, plagioclase, uncommon hornblende, and abundant sphene . . . (that) is metaluminous, high-K, calc-alkaline, high Fe-Ti, and high total-alkali rock". The Yarnell granodiorite has not been dated, but DeWitt (1989) places the age of the Yarnell pluton in the 1730 to 1710 Ma range based on lithologic similarity to other dated granites in Arizona.

Mid-Tertiary flows of andesitic and basaltic composition unconformably overlie both the intrusive and Proterozoic metamorphic rock. Remnants of these flows cap the hills and ridges to the north and northeast of the deposit (Fig. 1).

## Local geology

### Rock types

The Yarnell gold deposit is structurally controlled and wholly contained within the granodiorite at Yarnell. Petrographic studies by Honea (1990) and Page (1989) were used to identify rock types and alteration characteristics of the deposit.

The granodiorite at Yarnell is generally uniform in composition within the area of the deposit, contains microcline as the dominant K-feldspar, lacks hornblende and is generally granitic in composition. Table 1 compares the major element chemistry of three samples of the Yarnell granodiorite reported by DeWitt (1989) with two samples of relatively fresh granodiorite taken from both above and below the Yarnell fault in the vicinity of the deposit. DeWitt's samples, taken about 1.5 kilometers north of the mine area (#72), 1.5 kilometers to the west (#73), and 8 kilometers distant near the base of Weaver Mountain (#74), although slightly less silicic, are geochemically similar to those samples collected by Malusa (1990) and suggest overall uniformity of composition throughout the Yarnell pluton.

Other felsic intrusive rocks that occur within the area of the deposit, though volumetrically of small significance, have been identified petrographically and include rocks of syenitic composition (Table 2 - in appendix). These may represent either a late differentiate of the main intrusive, a separate intrusive phase, or an altered variant of the original host rock. Both the geometry and origin of these more felsic rocks are obscured by the alteration common to the area of the deposit although some are known to occur in small volume as lenses subparallel to the Yarnell fault.

**Table 1. Major element chemistry of the Yarnell pluton, Yavepai County, AZ**

| | Granodiorite (DeWitt) | | | Biotite Granite (Malusa) | |
|---|---|---|---|---|---|
| | # 72 | # 73 | # 74 | HW | FW |
| $SiO_2$ | 67.4 | 66.3 | 65.1 | 70.0 | 69.8 |
| $Al_2O_3$ | 14.5 | 14.1 | 14.3 | 14.3 | 14.4 |
| $Fe_tO_3$* | 4.98 | 5.45 | 6.65 | 4.76 | 5.02 |
| MgO | 1.17 | 1.22 | 1.52 | 1.00 | 1.10 |
| CaO | 2.57 | 2.84 | 3.43 | 2.60 | 2.30 |
| $Na_2O$ | 3.08 | 3.10 | 3.14 | 3.20 | 3.10 |
| $K_2O$ | 4.18 | 4.33 | 3.78 | 4.10 | 3.90 |
| $TiO_2$ | 0.80 | 0.79 | 1.02 | 0.70 | 0.85 |
| $P_2O_5$ | 0.27 | 0.34 | 0.39 | 0.45 | 0.55 |
| MnO | 0.12 | 0.11 | 0.13 | 0.11 | 0.13 |
| Total | 99.07 | 98.58 | 99.72 | 101.22 | 101.15 |

* $Fe_tO_3$ is total iron as $Fe_2O_3$.

Restricted amounts of andesitic to dioritic rock are found as dikes and sills of the area. The largest of these approaches 50 feet in thickness, trends N10 W and dips 80 SW; this dike neither offsets or is offset by the Yarnell fault and is not generally mineralized. Smaller discontinuous sills of similar composition occur subparallel to the Yarnell fault zone.

Small amounts of coarse pegmatite occur above mineralized rock and near the crest of Yarnell hill; lack of exposure precludes identification of the origin or mode of emplacement of this pegmatite.

## Structure

Structural relations within the Yarnell deposit area have been generally identified during reconnaissance and mapping of both underground and field exposures and from logging of core. Further detail of structural relations within the deposit area may better define secondary structural controls related to mineralization.

The most distinctive structural element and the primary control on gold mineralization within the deposit area is the N 30-50 E striking, 30-50 NW dipping Yarnell fault (Fig. 2). The immediate fault varies from three to more than seven feet in thickness and consists of intensely sheared and hydrothermally altered gouge, mylonite, and micro-breccia that commonly localized quartz veining. Within the deposit area, broken and sheared rock related to the fault may persist for more than 80 feet into the hanging wall, but locally thins to less than ten feet both along strike and downdip of the known deposit.

Many of the fractures within the hanging wall are oriented subparallel to and mimic the trend of the underlying Yarnell fault. Northwest dipping, northeast striking fractures are also common within the hanging wall. Several quartz veins that occur along northwest dipping, northeast striking structures have been mapped both on the surface and where they have been mined from underground; the steeper veins appear to flatten and roll, may merge with the Yarnell fault at depth, and are suggestive of a listric configuration.

Numerous subvertical fractures not observed from within hanging wall rocks occur beneath the Yarnell fault. Fractures subparallel to the fault also occur in the footwall; several small felsic sills that occur within footwall rocks have been mapped on the surface and appear to have been emplaced along subparallel structures.

A regionally strong set of NNW trending subvertical fractures transect the area in which the deposit has been identified. One of these has controlled the diorite dike which occurs within the deposit area (Fig. 2). The role these structures may have in relation to increased permeability of hanging wall rocks remains conjectural.

Intensity of alteration and mineralization conform closely to areas of greatest permeability provided by structural disruption along the Yarnell fault and within the hanging wall rocks. The Yarnell fault has been traced more than 3 kilometers to the southwest where it disappears under desert pediment, and to a point 450 meters to the northeast from the top of Yarnell hill where it is concealed by alluvium and debris from hills and ridges to the north and east.

Alteration

Hypogene alteration associated with the Yarnell gold deposit varies from weak propylitic to sericitic to potassic (Fig. 2). The strongest alteration is centered about the Yarnell fault zone and decreases outward in intensity into the footwall and hanging wall. Petrographic studies examining alteration characteristics have been completed by the authors and Honea (1990; Table 2).

Weak propylitic alteration is characterized by formation of minor chlorite, epidote, and calcite (as preserved in the unoxidized footwall) with weak sericitic dusting and replacement by sericite and iron oxides along biotite edges and within plagioclase feldspars. Weak propylitic alteration commonly persists for more than 30 meters above the sericitic envelope and locally contains small quartz veinlets. In the footwall, the weak propylitic zone is thinner and is usually marked by calcite veins. This assemblage grades directly into sericitic alteration towards the deposit.

Sericitic alteration is characterized by complete replacement of biotite and plagioclase by sericite and may contain quartz veinlets and/or stockwork. Specularite and/or pyrite commonly form in conjunction with replacement of biotite by sericite. Strong sericitic alteration extends from 10 to more than 30 meters into the hanging wall above the potassic zone and 3 to 15 meters into the footwall.

Potassic alteration, as referred to herein, alludes to hydrothermal alteration that results in formation of K-spar (adularia) either within wallrock or veins; this zone usually is found in conjunction with intense sericitization or silicification. Petrographic studies reveal the occurrence of K-spar crystals within quartz veinlets, local replacement of feldspar margins or of entire feldspars by cloudy K-spar, occasional K-spar overgrowth rimming of preexisting feldspars, and replacement of matrix minerals by extremely fine-grained equigranular generally euhedral rhombs of K-spar or K-spar-quartz mosaics that often are found in conjunction with varying degrees of silicification. X-ray diffraction studies have identified adularia and fine-grained sericite ± illite as the principal constituents of the intensely crushed clay size fraction of the mineralized Yarnell fault zone (Malusa, 1990). The potassic zone outward from the Yarnell fault is locally megascopically identifiable by the occurrence of replaced pink feldspars and/or pink selvages and rimming of feldspars within the proximity of and along quartz veinlets. The small amounts of chalcedony that occur as infill in fractures and vugs within the fault zone is thought to have formed following hypogene mineralization. Potassic alteration may occur as much as 15 to 25 meters into the hanging wall of the Yarnell fault, and up to 10 meters below the fault.

Both sericitic and potassic altered zones within the hanging wall have been oxidized by meteoric waters following their formation. Unaffected altered rocks occur below the Yarnell fault, contain fresh pyrite and specularite, and are distinctively green-hued (due to sericite) in respect to hanging wall rocks.

## Mineralization

General description

Gold mineralization is associated with several stages of hypogene quartz with iron sulfides (predominantly pyrite) and iron oxides (predominantly specularite) that formed veins within and stockworks above the Yarnell fault. Veinlets within stockworks are commonly thin (on the order of 0.5 cm) with several or more orientations, and are locally of high density. Minor to moderate amounts of manganese oxide (including psilomelene) are also visibly associated with mineralization at the top of Yarnell hill. Sericitized and/or potassically altered rock, quartz and iron oxides adjacent to and within the fault are strongly sheared although small amounts of unstrained banded chalcedonic quartz are found as open space fillings locally within the fault zone. Medium to coarse euhedral pyrite or pseudomorphs after pyrite (generally less than 1 cm across) occur locally within wallrock adjacent to the fault. Trace amounts of copper minerals including azurite and malachite occur in association with quartz-hematite veinlets found within the deepest part of the underground workings and trace amounts of base-metal sulfides, arsenopyrite, and titanium oxide (leucoxene) have been seen in polished sections. The small amounts of felsic intrusive rock occurring subparallel to the Yarnell fault and found within the footwall contain similar but much restricted alteration and mineralization. Pseudomorphs of goethite ±

hematite after pyrite, and earthy goethite and hematite are common within the hanging wall rocks, along the main Yarnell fault zone, and locally within fractures below the Yarnell fault. Areas of bulk-minable gold mineralization are confined to the sericitic and potassic altered zones.

Quartz veins

At least five generations of hypogene veins consisting of quartz ± adularia and commonly containing pyrite or specularite have been identified through study of thin sections, polished sections, core and rock samples. Identification of primary pyrite and/or specularite mineralogy was not possible where late oxidation had destroyed pseudomorphs and converted all iron-bearing vein minerals into earthy goethite and/or other iron oxides.

Identified generations of quartz include:

1. Fine-grained early grey quartz associated with specularite in vugs parallel to quartz veins.

2. Fine-grained dark grey quartz with some brecciation in the vein; dark color is probably due to either fine-grained pyrite or specularite.

3. Fine-grained lighter grey quartz with disseminated limonite pseudomorphic after pyrite commonly found along the margin of the vein.

4 and 5. Medium to coarse-grained white quartz with local cockscomb texture and locally containing fine to coarse specularite blades.

The first three generations of quartz usually occur as small veinlets on the order of 0.5 cm thick, less commonly are 1 cm thick, and have been noted up to 6 cm thick in drill core. At least one generation of grey quartz with specularite and grey quartz with pyrite are associated with appreciable gold content (including some visible gold).

At least two generations of white quartz veinlets cut across the first three generations of quartz. The white quartz veins and veinlets have been measured from less than 0.5 cm to over 30 cm in drill core; one exposure in the field has an apparent thickness that approaches 6 m. White quartz veins consistently are of significant to high gold content and visible gold has been identified from within these veins.

## Geochemistry

### Geochemical associations

Two drill holes and a crosscut through the Yarnell deposit were tested at twenty-five foot intervals for anomalous trace-element and base-metal concentrations. The five foot samples were analyzed for As, Cu, Hg, Mo, Pb, Sb, Tl, Zn, Bi, Cd, Ga, Se, and Te, in conjunction with Au and Ag in order to determine the spatial distribution of these trace elements in relation to the Yarnell deposit. The 58 rock chip and reverse-circulation drill samples tested showed only very low to modestly anomalous concentrations of elements other than Au. Only As (4 samples), Cu (1 sample), Pb (1 sample) and Zn (18 samples) exceeded 50 ppm concentration. Sb, Bi, Cd, Ga, and Te were only sporadically detectable and none exceeded 3 ppm concentration. Hg did not exceed 0.2 ppm and Se, and Tl were not detectable (detection limits for Se and Tl were about 1ppm and 0.5 ppm, respectively). Preliminary indications are that Ag, As, and Mo are modestly enriched within the gold mineralized zone while Cu is depleted at higher elevations and modestly enriched at lower elevations within the deposit. The distribution of Ag, As, Au, Cu, and Mo within drill holes YM-6 and YM-26 is presented in Table ?? (in appendix); YM-26 is more than 65 meters (215 ft) downdip of YM-6 and elevations of the Yarnell fault in holes YM-6 and YM-26 are approximately 1437 m (4715 ft) and 1413 m (4635 ft) respectively.

### Fluid inclusion study

Fluid inclusions found within nine different quartz veins and veinlets from the Yarnell deposit were studied to determine physical or chemical constraints that pertained to the hydrothermal fluids at the time of mineralization. Inclusions observed are generally less than 10 micrometers in largest dimension and consisted of three distinct groups. Abundant secondary inclusions are common in most quartz although pseudosecondary and some apparently primary isolated inclusions also occur. Because some quartz does not contain the abundant secondary inclusions found throughout most quartz of the deposit, it is believed that most secondary inclusions reflect conditions of formation during the period of mineralization (ie. between influx of the first quartz veins and prior to influx of quartz without secondary inclusions). Homogenization and freezing point studies on the inclusions were done on a modified USGS-type gas-flow heating-freezing stage. Microthermometric data obtained from the more than 50 tested inclusions is presented in Fig. ??

$H_2O$-rich inclusions were studied from within fine-grained quartz veins that often contained very fine-grained pyrite. These inclusions generally contained 30 volume-percent vapor at room temperature and most homogenized to a single phase at 205 to 250 degrees centigrade. These inclusions yielded ice-melting temperatures of -7.4 to -6.4 degrees centigrade suggesting salinities of 11 to 9.7 weight percent NaCl equivalent. However, the formation of clathrate ($CO_2$-hydrate) upon freezing in some of these inclusions indicates that actual salinities may be significantly lower than the uncorrected salinities suggested above.

$CO_2$-rich inclusions were common within the coarser-grained white quartz veins containing specularite. Most of these contain variable but less than 40 volume percent liquid $CO_2$ at room temperature and occurred with or without a $CO_2$-rich vapor bubble. $CO_2$-rich vapor bubbles homogenized to liquid $CO_2$ at 7 to 30 degrees centigrade with populations centered at about 10 and 28 degrees centigrade. Final homogenization to the aqueous phase was variable ranging from about 200 to 350 degrees centigrade with the largest cluster occurring between 290 and 320 degrees centigrade.

Less abundant $CO_2$-rich inclusions contain 75 to 90 volume percent liquid $CO_2$ at room temperature. These inclusions homogenized by disappearance of the aqueous phase above 280 degrees centigrade; determination of precise homogenization temperatures was not possible as many of these decrepitated before homogenization occurred.

Measurement of the triple point of $CO_2$ at about -56 degrees centigrade indicates that the $CO_2$ within inclusions from the Yarnell deposit is relatively pure. The $CO_2$ content (ranging from about 10 to more than 60 mole percent) indicates formation in a relatively high-pressure environment, estimated at a minimum of 500 bars to 1 kbar (generally equivalent to ???? m of depth); precise estimate of the pressures is difficult because the composition and temporal relationships of the fluids are not precisely known (Roedder, 1984). The temperatures reported in this study are not corrected for pressure (actual pressures remain unknown) and these reported temperatures are consequently less than the actual temperatures of formation.

Gold occurrence

Gold is generally found associated with iron oxides (some pseudomorphic after pyrite) and/or quartz veining.

Total combined iron-oxide and iron-sulfide mineral concentrations are generally low (Table 2) and only very locally exceed 4 to 5% beyond the immediate mineralized Yarnell fault. Economic grades and widths of gold mineralized rock occur within both the potassic and sericitic altered zones; within weakly altered rock similar grades occur only within occasional thin quartz veinlets.

Examination of core shows that coarse visible gold is associated with quartz stockwork conteining grey quartz and quartz-specularite veins that occur relatively high in the hanging wall of the deposit; geochemical analysis of these rocks indicated only low to moderate gold content (less than 0.04 opt gold) and may suggest erratic distribution of gold from within this part of the deposit. Moderate to high gold content is commonly related to quartz stockwork with adularia, silicification and potassic replacement, and to occurrences of earthy red hematite and pseudomorphs of pyrite. Highest gold content (up to 1 opt) is related to abundant red hematite and quartz that occurs along the Yarnell fault. This zone accounted for most of the historic production.

Polished section studies (Honea, 1990) revealed the setting of native gold within mineralized rocks. The polished sections show native gold peripheral to and/or within goethite pseudomorphs after pyrite, and in association with grains of quartz. Native gold is also associated with goethite that occurs as fracture/vein filling, fracture coatings, and as discrete patches associated with pseudomorphs after pyrite.

Silver analyses, where available, indicate that silver content is closely associated with gold and eight ore-grade samples average at an approximate 2:1 gold to silver ratio. Small amounts of native silver associated with goethite occur within polished sections (Honea, 1990).

## Mineral inventory

Ninety-six reverse circulation drill holes have defined a mineral inventory for the deposit. The gold inventory is contained within two zones. The main zone is 20 to 155 feet thick and is closely coincident to the Yarnell fault. The mineral reserve within this zone is 4.1 million tons at 0.051 opt gold using a 0.02 opt gold cutoff. This reserve is outlined on the attached geologic map and sections (Figs. 2 and 3). A lower grade zone occurs above and subparallel to the main zone and contains 2.7 million tons at 0.017 opt gold using a 0.01 opt gold cutoff. The two zones together inventory at 6.8 million tons at a grade of 0.038 opt gold with a 1.45:1 waste to ore ratio.

## Metallurgy

Numerous bottle roll tests and column leach tests were completed on the deposit. A fifteen ton sample was mined from the ore zone exposed in the open cut to provide a run of mine sample for cyanide column leach testing. Results of the column testing are summarized in Table 3.

**Table 3. Column leach data**

| 80% Passing size | Column size | Leach Time Days | Head Assay Opt Au | Tail Assay Opt Au | Extraction |
|---|---|---|---|---|---|
| 6 inch | 24" dia. X 18 ft. | 111 | 0.046 | 0.022 | 52.2% |
| 2 inch | 15" dia. X 18 ft. | 102 | 0.051 | 0.015 | 70.6% |
| 3/8 inch | 12" dia. X 18 ft. | 79 | 0.055 | 0.013 | 76.4% |

Cyanide consumptions ranged from 0.56 to 0.79 pounds per ton and consumption rates were fairly constant throughout the leaching cycles. The ten pounds of lime and cement (at 3/8 inch feed) per ton of ore added to the ore charges as the columns were filled was sufficient to maintain protective alkalinity at above pH 10.5 throughout the test period.

Flotation and fine-grind cyanide leach tests were conducted by Asarco on a composite sample prepared by McClelland Laboratories of Sparks, Nevada. This 35 pound sample assayed at 0.031 opt Au and 2.35% Fe. In the two flotation tests, ground to -200 mesh, the recoveries were 75 to 76% in the final concentrate and 79 to 80% in the rougher concentrate. In the two fine-grind cyanide leach tests, also ground to -200 mesh, the recoveries were 97% in 22 hours of agitated leach. The cyanide consumption was 0.21 pounds per ton of ore and the lime used was 3.3 pounds per ton of ore.

## Discussion and Interpretation

The Yarnell gold deposit is somewhat unique when compared to other deposits of west-central Arizona. As at Yarnell, deposits of the Weaver and nearby Martinez mining districts (ie. at the Alvarado, Octave, and Congress mines) occur in felsic to intermediate intrusive rocks, are located in low-angle fault zones, and are principally gold-rich precious metals deposits. The Yarnell deposit differs in that it is more extensively alterred, not confined within and along narrow quartz veins, and has a lower base metal content.

The Yarnell fault and subsidiary structures were the primary control on movement of hydrothermal fluids through areas of greatest permeability. Formation of stockworks by distinct generations of quartz ± adularia veining occurred where premineral faulting and fracturing allowed influx of hydrothermal fluids through relatively large thicknesses of rock. Specularite and pyrite associated with quartz veins and gold mineralization were apparently formed either from remobilized iron from within the host rock and/or from introduced iron carried by the hydrothermal fluids. Gold mineralization was accompanied by modest increases in Ag, As, Cu, and Mo content. Successive movements along the Yarnell fault are interpreted to have crushed, sheared, and possibly remobilized silica, iron, and other elements. Quartz lacking secondary inclusions and the presence of undeformed pyrite and pyrite pseudomorphs within the vicinity of the fault suggest that mineralization continued following latest movements on the fault. Lack of shear and/or brecciation within the small amounts of banded chalcedonic quartz combined with its lower temperature countenance suggest that chalcedony deposition occurred following latest fault movements possibly as the hydrothermal system waned. Goethite psudomorphs after pyrite and earthy iron-oxides formed as a result of the influx of meteoric waters after the period of hypogene mineralization; some of the Ag and most of the Cu that accompanied mineralization may have been flushed from the uppermost parts of the exposed Yarnell deposit by these same meteoric waters.

Inferences concerning the development of the Yarnell fault and source of the mineralizing fluids can be made. The 69 Ma. K/Ar age obtained from undeformed illite (Shafiqullah, 1990) suggests that mineralization and the Yarnell fault structure are of Laramide or earlier age. Although fault displacements are unknown due to lack of marker horizons, the pre-Tertiary age of faulting suggests that fault development occurred in response to compressional forces.

Fluid inclusion data currently available for the Yarnell deposit, the general lack of any strong epithermal trace-element content (ie. Hg, As, Sb), combined with a hypogene mineral assemblage compatible with formation at moderate depths and temperatures strongly suggests that ore deposition occurred within a mesothermal environment. Salinities of 10 weight percent or less are far below those expected from more nearly pristine magmatic fluids yet are higher than salinities common to most epithermal environments. The actual origin of the mineralizing fluids and the source of the gold found within the deposit remains conjectural.

The large variations in composition of the fluid inclusions from the Yarnell deposit are similar to variances described for mesothermal gold deposits in which fluctuations in pressure are thought to have resulted in the unmixing of immiscible $H_2O$- and $CO_2$-rich fluids from a $CO_2$-rich parent fluid (Robert and Kelly, 1987; Goldfarb, et al., 1988). The deposition of relatively high concentrations of gold without deposition of more than modest amounts of associated elements suggests that the fluids involved may have been highly evolved. Either unmixing, or fluctuation between dominantly reducing and dominantly oxidizing conditions (as evidenced by deposition of both pyrite and specularite) may have resulted in gold deposition within this part of the system. ~~More work is clearly needed in relation to this aspect of the min-~~

Mineralization that occurred both during and after fault movement suggests that Laramide (Cretaceous) intrusives such as the intrusive at Bagdad that occur within the general region may have either provided magmatic components and/or increased geothermal gradients that focused the hydrothermal system. Several of these intrusives are related to precious metals deposits that are peripheral to the intrusive centers (Titley, 1986). The more felsic dikes and sills found within the area of the Yarnell deposit also suggest that Yarnell may be peripheral to a deep-seated intrusive. More work is clearly needed if the actual origin and chemical constitution of the mineralizing fluids, and the physical and chemical processes involved in deposition of gold and other elements is to be understood.

## Acknowledgements

Appreciation is extended to the staff and management of Asarco Inc., Norgold Resources Inc., and Bema Gold Inc. for permission to publish this paper. A number of company reports were used and we would collectively thank those who contributed to the project. We would also thank Bill Gay, Steve Keehner, John Malusa, and Jim Rasmussen for their contributions.

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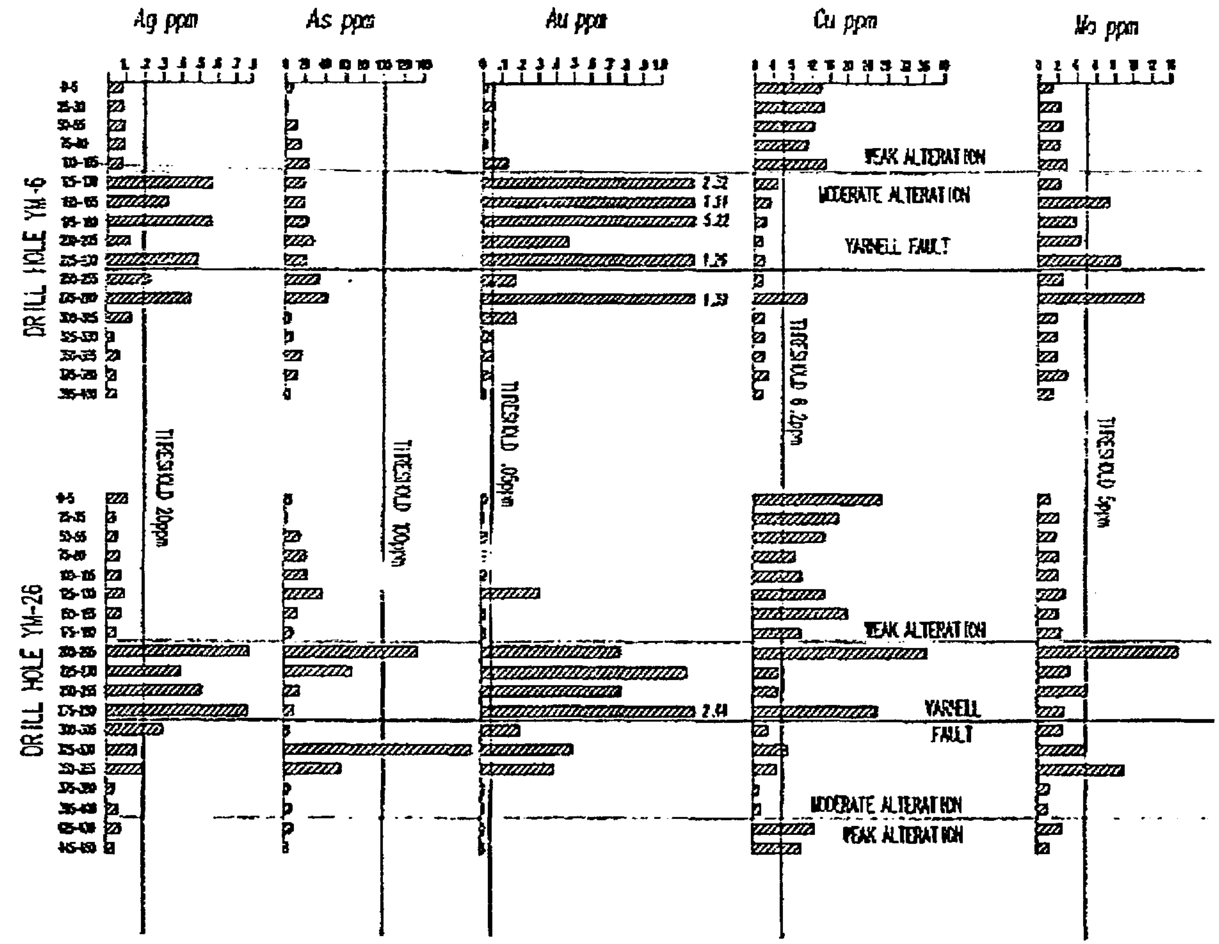
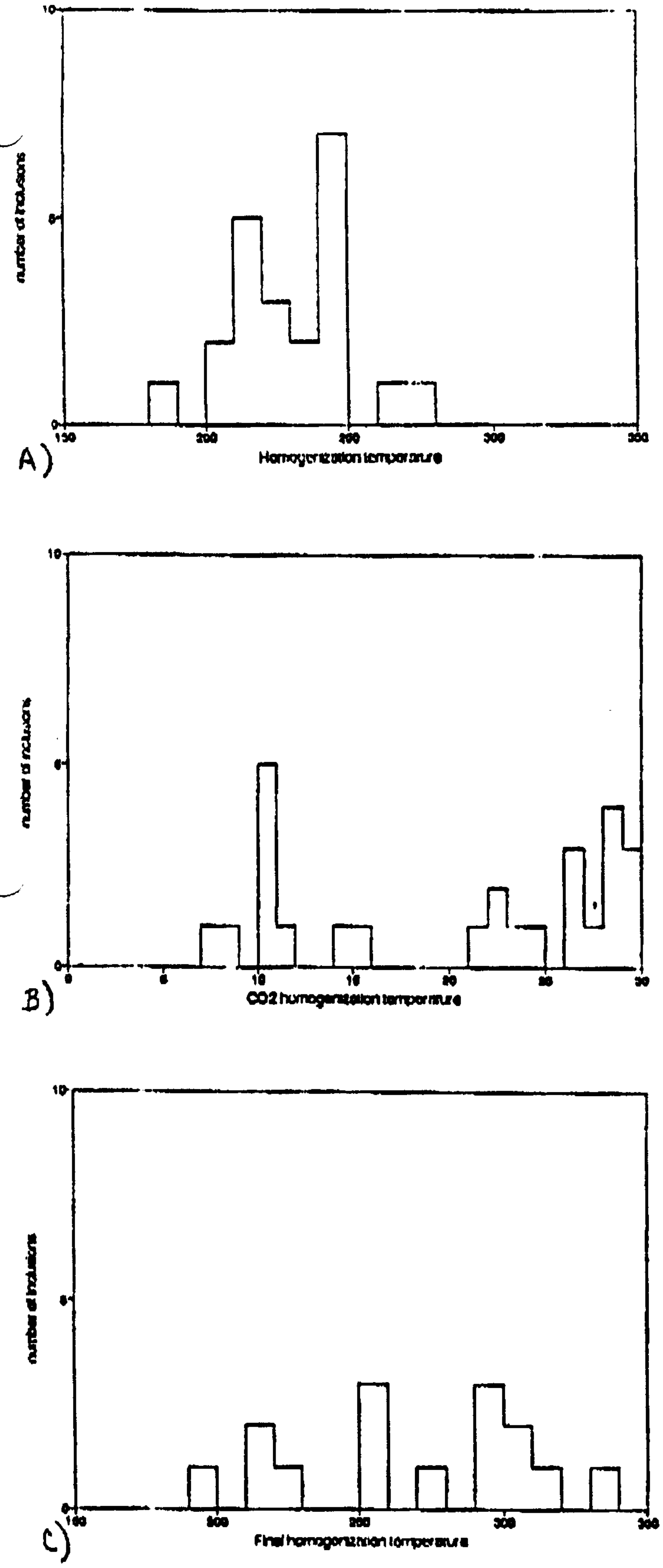



Fig. Comparison of Ag, As, Au, Cu and Mo concentrations found within reverse-circulation drill holes YM-6 and YM-26.




$H_2O$-rich

$T_h$ $CO_2$

$CO_2$-rich

hom $CO_2$ liq + $H_2O$

Fig ?? Distribution of homogenization temperatures of A) vapor and aqueous ($H_2O$) phases found within $H_2O$-rich inclusions, B) $CO_2$ vapor bubble and $CO_2$ liquid in $CO_2$-rich inclusions, and C) $CO_2$ liquid and aqueous ($H_2O$) phase.

# Yarnell Gold Deposit

## Petrographic Descriptions - Russ Honea

| Thin Section Location and Sample No. | Sample Description | Primary Minerals %: Plagio-clase | Micro-cline | Quartz | Biotite | Secondary Minerals %: Sericite | Clay | Chlorite | Epidote | Leuco-xene |
|---|---|---|---|---|---|---|---|---|---|---|
| 150 | Fresh (Weathered) | 25 | 50 | 16 | 7 | 6 | - | 1+ | 3 | - |
| 151 | Fresh (Weathered) | 25 | 45 | 18 | 10 | - | 3 | 3 | - | - |
| 152 | Weak Propylitic | 30 | 44 | 15 | 9 | 9 | - | - | 2* | <1 |
| 162 | Weak Propylitic | 28 | 38 | 20 | 8 | 18 | - | - | - | 1 |
| 163 | Weak Sericitic | (35) | 40 | 15 | ( 8) | 17 | - | - | -1 | 1 |
| 164 | Weak Sericitic | (32) | 43 | 16 | ( 6) | 16 | - | - | - | 2 |
| 165 | Sericitic | (44) | 29 | 20 | ( 5) | 28 | - | - | - | <1 |
| 166 | Sericitic | (30) | 55 | 10 | ( 3) | 8 | - | - | - | 1 |
| 154 | Sericitic (Unoxid) | (35) | 45 | 12 | ( 6) | 20 | 4 | 2 | - | 1 |
| 155 | Sericitic (Oxid) | (35) | 41 | 12 | (10) | 20 | - | - | - | 1 |
| | Yarnell Fault Zone | | | | | | | | | |
| 157 | Syenite? | (27) | 66 | 3 | ( 2) | 2 | 3 | 2 | - | <1 |
| 161 | Potassic Rims | (24) | 66 | 5 | ( 2) | 7 | - | - | - | 1 |
| 158 | Quartz Stockwork | (36) | 40 | 15 | ( 8) | 27 | - | - | - | 1 |
| 159 | Potassic | (38) | 28 | 25 | ( 7) | 35 | 2 | - | - | 1*** |
| 160 | Potassic/ Quartz Veins | (20) | 62 | 12 | ( 5) | 10 | 10 | - | 1* | <1 |
| 167 | Sericitic | (39) | 32 | 20 | ( 7) | 20 | - | - | - | 2 |
| 168 | Sericitic/ Siliceous | (39) | (33) | 20 | ( 6) | 12 | - | - | - | 1 |

(27) - Original mineral now altered to Sericite

*(Clinozoisite)
**Pseudomorphs
***Rutile

# Yarnell Gold Deposit

## Petrographic Descriptions - Russ Honea

| Thin Section Location and Sample No. | Sample Description | Silica %: Quartz/ Adularia | Silica %: Chalcedony/ Opal | Iron Oxides %: Hematite/ Magnetite | Iron Oxides %: Limonite/ Pyrite(Fresh) | Iron Oxides %: Goethite | Iron Oxides %: Fe Oxide (Undiff.) |
|---|---|---|---|---|---|---|---|
| 150 | Fresh (Weathered) | - | - | 1/1 | - | - | - |
| 151 | Fresh (Weathered) | - | - | - | -/<1 | - | - |
| 152 | Weak Propylitic | - | - | - | - | - | 1+ |
| 162 | Weak Propylitic | 4 | - | - | - | 3+ | - |
| 163 | Weak Sericitic | 3 | - | - | - | - | 3 |
| 164 | Weak Sericitic | 2 | - | - | 1+/- | - | 1+ |
| 165 | Sericitic | 5 | - | <1 | - | 2 | - |
| 166 | Sericitic | 15 (Veins) | - | 2 | - | 2 | - |
| 154 | Sericitic (Unoxid) | - | - | 1 | -/2 | - | - |
| 155 | Sericitic (Oxid) | - | - | - | - | 1** | 2 |
| | Yarnell Fault Zone | | | | | | |
| 157 | Syenite? | - | - | - | - | 1 | 2+ |
| 161 | Potassic Rims | 10/15 | - | <1 | - | - | - |
| 158 | Quartz Stockwork | 5 | - | - | - | 2 | 3+ |
| 159 | Potassic | 15 | - | - | - | - | 2 |
| 160 | Potassic/ Quartz Veins | 22 | <1/<1 | - | - | 2 | 4 |
| 167 | Sericitic | 3 | - | - | - | 3(Hm) | - |
| 168 | Sericitic/ Siliceous | 4 | - | 1 | 1 | 2 | - |

~~(27) *Original mineral now altered to Sericite~~

~~*(Clinozoisite)~~
**Pseudomorphs
~~***Rutile~~

TV-VOWKS ASARCO INCORPORATED PAGE: 01

DEPARTMENT EXPENSE WORKSHEET DATE: DECEMBER 04, 1991

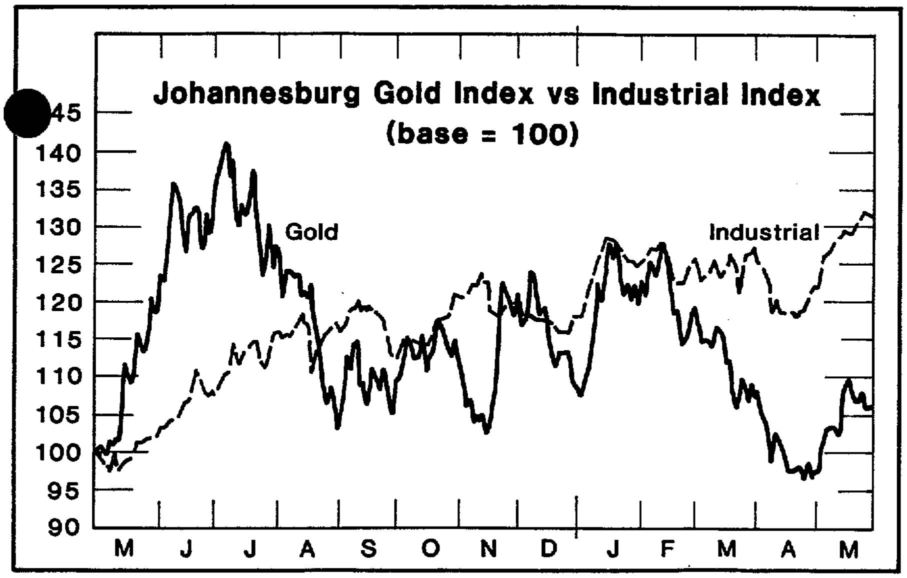
| | | | |
|---|---|---|---|
| 444.04 YARNELL PROJECT | | | MONTH |
| 620 ADMIN., GENERAL | | | |
| 803 TAXES - STATE PROPERTY | | | |
| 11041 1 11/01/91 CORRECT ACCT NOS VO 12-186-90 | | | -2,622.32 |
| | | | -2,622.32 |
| 444.04 YARNELL PROJECT | | GRAND TOTAL | -2,622.32 |

FROM: W. L. KURTZ

TO: JDSell

1 I think Gold Hill needs memo by you ~~eta~~ to include with SEA on why overrun after you told us 10-15,000 for clean-up.

2 Yarnell - needs explanation I thought we had asked for $ for feasibility




produced a record gold output of 119,000 oz as a result of increased mill throughput. Initial results from underground exploration at the Est mine had been encouraging and an investigation of ways to further increase throughput to 2,000 tons/day was under way.

* * *

**Hemlo Gold** reports that detailed studies are planned for this year to determine if the declining grades at the Golden Giant mine can be compensated for by a higher production rate. Gold production in 1991 was 443,400 oz at an average operating cost of $US126/oz. Production in 1992 is expected to be 435,000 oz, with production in 1993 forecast to fall to 375,000 oz and for the remaining life to be 360,000 oz. The average grade of ore mined should continue to be higher than the reserve grade for the next two years, but it is considered to have peaked in 1991.

Meanwhile, at the annual general meeting, Hemlo reported that its two advanced development projects, the Holloway project in Ontario and the New World project in Montana, will increase total gold production by 150,000 oz by 1996, at projected average operating costs of less than $US200/oz.

At the Holloway project, where Hemlo has a 55% interest, reserves are currently estimated at five million tonnes grading 0.27 oz/tonne of gold. A feasibility study completed on the property last July indicated it would cost about $C60 million to establish a 1,500 tonne/day underground operation and Hemlo's share of production is expected to be 70,000 oz/year of gold by 1995. The ore is expected to be toll milled in the area. An underground reserve validation programme will take place this year at a cost of $C12 million.

At the New World project, Hemlo has a 60% interest in **Crown Butte Resources** which wholly-owns the property. The property contains five deposits, three of which contain the majority of mineralisation and are planned to be mined from underground. Drilling in 1991 increased reserves to 2.2 million oz of contained gold. An underground drilling programme is under way and will prove up approximately 2.5 million tons of the total geological reserve in the Homestake deposit. The deposit still remains open on three sides and the potential to increase reserves is reported as excellent. While definition drilling will continue, most of the efforts for 1992 will work towards obtaining the necessary permits. Hemlo expects the project to contribute 80,000 oz to its total output by 1996.

* * *

Results are expected this year from the exploration last year of **Goldex Mines'** property in Dubuisson Township in Quebec. **Agnico-Eagle** has a 49% combined direct and indirect interest in the company. Exploration focused on completing the underground diamond drilling programme which confirmed that the mineralisation remains open to depth and down plunge to the east.

A global mineral inventory of 25.4 million tons grading 0.083 oz/ton of gold has been outlined and a selective mineral inventorty of 5.7 million tons grading 0.146 oz/ton (uncut) has been defined. A preliminary study to explore the potential for commercial production is under way.

* * *

Meanwhile, **Sudbury Contact**, in which **Agnico-Eagle** holds a 34% direct and indirect interest, reports that last year it discovered eight micro-diamonds, four of which are of gem quality, in a kimberlite pipe on the Larder Lake Break. The encouraging discovery will be further evaluated by diamond drilling this year in addition to reconaissance for additional diamond bearing pipes.

* * *

**El Condor Resources** has announced that it plans to offer 1.5 million units and flow-through units at a price of $C4.00 each. Each unit and flow-through unit will consist of one common share and a half warrant exercisable until December 1992, with two such warrants entitling the holder to purchase an additional common share at a price of $C4.25. Proceeds from the offering will be used to conduct the 1992 exploration programme at the Kemess properties, consisting primarily of diamond drilling, bulk sampling, metallurgical test work, deposit modelling and infrastructure studies (*IGMN* Feb 92, p.20).

* * *

**Rayrock Yellowknife Resources** has further increased its interest in the Marigold mine in Nevada. Rayrock has purchased an additional one-third interest from **Placer Dome** for $US17.5 million. Reserves at the mine are currently estimated at 10 million tons of mill and leach grade ore containing 468,000 oz of gold and Rayrock believes that prospects for reserve growth are good. The purchase is subject to **International Corona**'s right to jointly purchase the one-third interest.

## UNITED STATES

A DISPUTE has arisen over the land purchased by the Cortez joint venture in Nevada from **Gold Fields Mining Company** (*IGMN* May 92, p.70). The Cortez property is owned by **Placer Dome** (60%) and **Kennecott** (40%). The land is believed to contain about 45% of the currently estimated gold resource of the Pipeline deposit.

Gold Fields is claiming the agreement void, based primarily on alleged failure of Placer Dome to fully disclose certain facts. Placer states that it negotiated the agreement in good faith.

* * *

Vancouver-based **Bema Gold** reports that the company has received final government permits to develop the Buffalo Gulch deposit in Idaho, although, due to the depressed share and gold markets, the project is currently on hold. At full scale production, the Buffalo Gulch deposit is projected to produce up to 33,000 oz of gold at an annual operating cost of $US197/oz. The company is continuing to evaluate financing opportunities for the project.

Meanwhile at the Yarnell project in Arizona, a preliminary mineable oxide reserve of 205,000 oz has been outlined, with potential for expansion. The property can be placed into production as a low cost, open pit, heap leach mine operating at a rate of about 33,000 oz/year of gold. The company had hoped to place the property into production this year, but again the depressed equity and gold markets have forced a slowdown of expenditure to conserve cash to concentrate on the Refugio project in Chile (*IGMN* May 92, p.72).

The company currently has an 85% interest in the Champagne mine in Idaho which produced 17,500 oz of gold equivalents in 1991. Subject to financing, Bema's gold production is expected to increase to over 175,000 oz/year over the next two to three years with average operating costs below $US200/oz.

**ASARCO**

Exploration Department

James D. Sell
Manager

August 12, 1993

Dr. John W. Wilson
Chairman, Department of Mining Engineering
University of Missouri - Rolla
226 V.H. McNutt Hall
Rolla, MO 65401-0249

Dear Dr. Wilson:

Your letter of inquiry for exploration data to Mr. R. M. Novotny, Asarco New York, has been retransmitted to the Tucson Office.

I am pleased to send you the raw data on a recently completed project which you may copy and set up various study programs.

Included:

1) A geologic map (Plate 2) showing the Yarnell fault which is the main controlling structure in the deposit.

2) Plate 2 also shows the plots of the 96 rotary reverse-circulation holes drilled at the property.

3a) Assay sheets with footages/assays for the 96 drill holes, with "refirer" assays.

3b) Also on the assay sheets are the check/standard samples sent with the samples. These generally are listed as non-5 foot intervals, such as the series on Assay Report dated 3-28-89, i.e., 103-105, 177-179, etc.

4) A listing of drill hole coordinates and elevations, both rotary and diamond drill holes (Table 5).

ASARCO Incorporated P.O. Box 5747 Tucson, Az 85703-0747
1150 North 7th Avenue FAX (602) 792-3934 Phone (602) 792-3010

5) Plate 5, indicating the previously mined areas in the drilled area.

6) Plan of the open-cut survey; list of coordinates of survey points, where samples were collected; assay sheets with location interval, value at each station; two large sections with sample locations/ values; and a sheet showing the sections 120 and 170 across the open cut.

7) Color Xerox sheets of the four diamond drill holes which twinned rotary holes (see Table 5 for their coordinates), with assay values.

The AIME should have an article out this year on the Yarnell deposit. In the meantime, for your general information, the following pager has been released.

"Miller, MA, Page, TC, and Sell, JD, 1991, Geology and Mineralization at the Yarnell Gold Deposit, Yavapai County, Arizona: in Karlstrom, K.E., editor, 1991, Proterozoic Geology and Ore Deposits of Arizona, Arizona Geological Society Digest 19, p. 301-308.

Sincerely,

James D. Sell

JDS/mck
attachs.

cc: FTGraybeal (letter only)